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Methodological aspects of the construction of regional mortality tables differentiated by cause of death

Abstract

The need and methodological approaches for the construction of mortality tables differentiated by causes of death at the regional level are discussed. On the basis of the proposed method, the system of regional mortality tables differentiated by causes of death for the population of the Odessa region is built, which allows quantifying of the potential gains in life expectancy through the elimination/reduction of mortality from specific causes, which is very important assuming the extremely high mortality rate in Ukraine.

Keywords reproduction; method; probability; mortality tables; causes of death:
JEL classification: 118; R58

1. Introduction

A modern demographic situation in Ukraine during a few last decades testifies to the presence of deep demographic crisis along with the socio-economic problems. One of the main problems of modern demographic situation is an extraordinarily high mortality which, in the conditions of substantial increase of level of birth-rate in the country, remains the basic factor of depopulation.

The characteristic features of the modern state of mortality are its general extremely high level, considerable differentiation in age and gender and extraordinarily high mortality in comparison with other countries, both in the whole and for separate causes. But the particular concern is caused by substantial differentiation of structure of mortality by cause of death in the separate regions of Ukraine. The same causes of death have a different effect on the average life expectancy depending on a set of socio-economic, demographic and other factors that act in a particular area.

Changes in the structure of mortality differentiated by cause of death necessitate a systematic improvement of methodological approaches to the study and analysis of mortality, in particular, for the causes. In our opinion this implies the obvious conclusion that in the practical work aimed at the protection of life and increase of life expectancy, mortality tables differentiated by cause of death for selected regions can be an effective instrument.

One of the unresolved issues in the study of mortality in modern conditions is the methodological basis and practical recommendations on the construction of mortality tables differentiated by cause of death for certain regions of the country. This question is relevant to Ukraine due to the fact that the laws of survival, mortality and average life expectancy are very different from living and working conditions, employment, geographic location and other factors. Mortality tables differentiated by cause of death in whole in Ukraine give only a general picture that does not characterize fully the actual situation because of significant differentiation in the level of mortality by cause in selected regions.

Therefore, in our research it is suggested to build a complex of multiparameter models, such as mortality tables differentiated by cause of death, as a method of modeling mortality that will enable more fully disclose the nature, patterns and trends inherent in this process, in order to display more adequately features, reserves and prospects of demographic development in the region.

2. Mortality tables and their basic features

Mortality tables differentiated by cause of death are arranged orderly rows of interrelated indicators that characterize the effect of individual causes of death on the intensity of mortality age, survival to a certain age, average life expectancy and other characteristics of mortality.

There are two types of mortality tables differentiated by cause of death in the demographic literature:

- tables, differentiated by cause of death, which are based on the dependent probability of dying and themselves are more detailed design of ordinary mortality tables;

- hypothetical mortality tables, which are based on the probability of full or partial elimination of deaths from certain causes.

For a deeper analysis of influence of the causes of mortality on the dynamics of mortality and average life expectancy of the population in the region we propose a hypothetical table, built on the assumption of the exclusion of some causes of death, to differentiate the remaining reasons. This will greatly expand the range of indicators that characterize mortality and will show to what extent the elimination of one cause will affect not only the general order of extinction but also the deaths from each of the remaining causes. Basis for constructing differentiated tables are the usual indicators of mortality tables, as well as data on the distribution of deaths by cause of death.

Knowing the probability of dying (qx) from ordinary mortality tables, as well as the structure of deaths by cause of death, we can calculate the private probabilities of death from specific causes and construct tables of mortality differentiated by cause of death on their basis. Private probability of death from certain (i) cause at the age of x years old will be equal:

$$q_{xi} = q_x \omega_{xi},$$

where ω_{xi} is the stake of deaths from certain (i) cause in the total number of deaths. .

Similarly, we get the number of deaths:

$$d_{xi} = d_x \omega_{xi}$$

The sum of private probabilities to die from specific cause, as well as the sum of the numbers of deaths from differentiated table on condition of plugging in it the whole complex of causes will be accordingly equal to the total probability to die and to the total number of deaths from ordinary tables.

Mortality tables differentiated by cause of death, allow us to calculate the average age of death from specific cause (the average life expectancy of deaths from this cause), which is equal to:

$$E_{0i}^0 = \overline{x_i} = \frac{\sum_0^{\omega} d_{xi}(x+2{,}5)}{D_i} = \frac{\sum_0^{\omega} d_{xi}(x+2{,}5)}{\omega_i l_0} \qquad (1)$$

If we find a middle weighted (weights are the number ωi - the stake of deaths from each cause in the total number of deaths) from the average age of death from each cause, then we will obtain the tabular average age of death from all causes, that is, the average life expectancy of the population.

Thus, the average life expectancy depends on the proportion of deaths from each cause in the total number of deaths and from the average age of death from each cause. Building differentiated mortality tables at the regional level, will assess the contribution of each of these factors in the total difference in life expectancy of the population of the territory. But such tables do not allow to expose the direct influence of individual causes on the size of average life expectancy. This task can be solved by the construction of hypothetical mortality tables, which are of great practical value, since they help to properly assess the effectiveness of struggle against separate causes of death and to choose the best way to increase average life expectancy, which is extremely important at a regional level.

In the basis of mortality tables built on the condition of removing of mortality from any disease, is an indicator that is called independent or net probability of death, and characterizes probability to die only from remaining causes, in the absence of mortality from cause excluded.

In this research we did not specify a thorough analysis of existing methods of calculation of this indicator, since it is quite fully covered in the demographic literature [1, p.134, 2, p.123-129, 3, p.333-342, 4, p.127, 5, p.52]. Our goal is to identify opportunities to further improvement of the technique of construction of mortality tables, and expanding opportunities for their use to analyze the causes of death in Ukraine under long-term demographic crisis. By us in the context of methodological approaches to the calculation of net probability of death, it was suggested to use in the process of development of the hypothetical mortality table of the population at the regional level the method proposed by K. Shaburov, since we believe that it meets most of the assigned tasks [6, p.56]:

$$q_x' = \frac{d_x \omega_{xj}}{l_x - 0{,}5(1-\omega_{xj})d_x} \qquad (2)$$

where ω_{xj} - the stake of deaths from all causes except for certain (i) cause in the total number of deaths at age x;

l_x - a tabular number of individuals who survive to the age of x years old;

d_x - tabular number of individuals who die at age x years old from certain cause.

Calculating the probability of death, provided the removing of mortality from any cause, can not only calculate the remaining functions of the table, but also see how this has affected the death rate from each of the remaining causes.

Elimination of mortality from any cause affects the overall age-specific mortality, id est the total force of mortality is reduced by the force of mortality from being excluded by reason of force as deaths from all causes other groups remain unchanged. Consequently, changes the proportion of each of the remaining groups of causes:

$$\omega'_{xi} = \frac{\mu_{xi}}{\mu_x - \mu_{x(k)}}$$

where μ_{xi} – force of mortality from any of the groups of causes;

ω'_{xi} – stake of each group of causes on condition of removing deaths from any cause;

$\mu_{x(k)}$– force of mortality from the eliminated cause.

Dividing the numerator and denominator of the right-hand side to μ_x, we obtain a convenient formula for calculating the new specific weights of the remaining causes:

$$\omega'_{xi} = \frac{\omega_{xi}}{1 - \omega_{x(k)}} \qquad (3)$$

Calculating new probabilities of death and the distribution of causes of death according to their relative weight in the formula (3), we find the private probabilities of death from the remaining causes for each age group and calculate the new average age of death from each group of causes.

Hypothetical mortality tables based on the assumption of the exclusion of any cause of death and differentiated by the remaining causes, give the opportunity to see how with changing of probability to die will change the tabular average age of death from each of the remaining groups of causes. In general exactly raising of the average age of death from each group of causes and is a major factor in increase of average life expectancy of the population.

Thus, we believe that the construction of complex of regional tables differentiated by cause of death will make it possible to evaluate:

- the role of individual causes of death in the reduction of life expectancy and calculate the average age of death from specific causes;

- possibility of increasing the life expectancy on the condition of limitation (or complete removal) deaths from certain causes;

- how the elimination of specific causes of death affect the mortality from each of the other remaining causes;

- efficiency of fight against certain causes of death and how to choose the best way to increase life expectancy.

3. Mortality tables fur the Odessa region

On the basis of the considered methodological aspects of construction of mortality tables differentiated by cause of death we built these tables for the Odessa region taking into account the inherent characteristics of the territory in the formation, dynamics and structure of mortality differentiated by cause of death.

The short tables of average life expectancy in Odessa region in 2008-2009 and age and sex distribution of deaths from specific causes were the information base for the construction of mortality tables, differentiated by the cause of death. Since differentiated tables were calculated for all the reasons adopted by the ICD - 10 would be very cumbersome, for the further research we will use the classes of disease, deaths from which are the highest in our region:

I. Certain infectious and parasitic diseases (class I);

II. Tumors (class II);

III. Diseases of the circulatory system (class IX);

IV. Diseases of the respiratory system (class X);

V. Diseases of the digestive system (class XI);

VI. External causes of mortality (class XX);

VII. Other causes.

Constructed by us mortality tables, differentiated by cause of death for the Odessa region (separately for men and women) have made it possible to analyze the probability of dying and the number of deaths from all causes listed on their basis to calculate the average age of death from specific cause (Table 1).

Table 1

Probability to die during life and average age of death from specific cause in the Odessa region in 2008-2009

Causes of death	Probability to die *(qx*1000)*		The average age at death, years *(xi)*	
	men	women	men	women
Certain infectious and parasitic diseases	58,85	25,57	44,4	41,1
Tumors	133,52	118,57	59,9	60,5
Diseases of the circulatory system	537,14	721,65	70,2	79,4
Diseases of the respiratory system	34,87	13,98	59,6	61,8
Diseases of the digestive system	60,43	41,79	54,3	56,4
External causes of mortality	125,70	39,66	47,5	51,1
Other causes	49,49	38,78	44,8	50,0
All causes	1000	1000	62,0	72,2

As it's evidenced by the data from the table, in the mortality of women much more important place is occupied by cardiovascular disease, whereas the probability of dying from other causes for women is considerably less than for men. Particular attention deserves the fact that from such exogenous causes like infectious diseases probability to die for males is in 2.3 times higher than for women, and probability to die from external causes is higher in more than three times.

However, these data alone do not allow us to give a comparative description of the conditions of mortality for men and women of the Odessa region. The fact that the probabilities of dying from various causes for men and women are different, yet shows nothing. It is

important to know how to relate the cause of death with the age in which death occurs. On the basis of constructed (from the formula (1)) differentiated mortality tables it has been calculated the average age of death from specific causes and results are presented in Table 1.

The level of total life expectancy at birth shows that the age-specific distribution of deaths for men and women is different: e^{00} for men is 62, and for women it is 72,2, id est 10.2 years longer. It is caused, by both a difference in the structure of mortality by cause of death and by the fact that from the same causes of death men die at a younger age. In particular, from cardiovascular diseases, which account for 54,6% of all causes of death for men, they die on average 9.2 years earlier than women. From external causes of death, which took second place in the structure of male mortality, which accounted for 12% of all deaths, men die at 3.6 years earlier.

The next stage of our research is to assess the direct effect of individual causes of death on average life expectancy, with a view to identifying its reserves of increase at the regional level.

There is the highest in Ukraine level of mortality from infectious and parasitic diseases in Odessa region which almost in two times exceeds the average level for the state. The feature of this class of causes of death is that they more than others depend on terms of life and lifestyles of the population and they are largely determined by behavioral factors, people's attitudes towards their health.

Leading place among the causes of death from infectious pathology both in Ukraine in the whole and in the Odessa region is occupied by tuberculosis and AIDS. In 2009 1,4 thousand people died in the region from infectious diseases, of which 0,5 thousand died from tuberculosis and 0.83 thousand - from AIDS, that is, the share of the first cause is 35,8%, and the share of the second is 59,3%.

Unlike AIDS, which is a deadly disease, tuberculosis is curable. There is a very low percent of deaths from tuberculosis in the developed countries, and in the specific Ukrainian terms this in theory not mortal illness takes away a lot of human lives.

We can get some idea about the seriousness of this problem if we estimate the potential effect of eliminating mortality from tuberculosis, especially as that there are significant reserves for this in the Odessa region. In 2009, male mortality from tuberculosis is in 3,3 times higher than female mortality. The proportion of deaths at the age of 15-59 years old in the total number of deaths from tuberculosis was for both men and women about 90%.

With the purpose of deeper analysis we have constructed the hypothetical mortality table for the Odessa region on the condition of removing of mortality from tuberculosis and from all class of infectious and parasitic diseases. The results of calculations are presented in Table 2.

Table 2

A hypothetical increase of life expectancy on the condition of elimination of mortality from tuberculosis and from the whole class of infectious and parasitic diseases in the Odessa region in 2008-2009.

Indicators	2008-2009	
	men	women
Increase in life expectancy on the condition of elimination of mortality from tuberculosis, years	0,45	0,15
Increase in life expectancy on condition of elimination of mortality from infectious and parasitic diseases, years	1,81	0,75
The share of growth in life due to the elimination of deaths from tuberculosis in the growth of life through the elimination of infectious diseases,%	24,9	20,0

As these tables show, in the Odessa region reserves to increase life expectancy by elimination of mortality from tuberculosis in 2008-2009 made 0,45 years for men and 0,15 years for women. At the same time eliminating the entire class of infectious and parasitic diseases would bring the male population of the region additional 1.8 years and female population - 0,8

years. Thus, the elimination of deaths from tuberculosis would provide 30% increase in life expectancy for men and 20% for women resulting from lack of (or elimination) of infectious diseases in the whole.

With the purpose of estimation how the elimination of mortality from tuberculosis and from class of infectious and parasitic diseases in the Odessa region will affect the mortality from remaining causes, we calculated the hypothetical mortality tables differentiated by cause of death.

As evidenced by these calculations, all the probabilities to die from specific causes on condition of elimination of mortality from tuberculosis will change, both for men and for women, but not to the same extent. As touched to the elimination of mortality from all classes of infectious and parasitic diseases, it mostly will be reflected on multiplying probability to die from cardiovascular disease - for men it will increase on 7,8%, and for women - on 2,8%. This is explained by the fact that the elimination of mortality from infectious diseases play a significant role at a young age. Thereafter, its removal will lead to the fact that people who did not die from it, take a great risk of dying from those causes, which have particularly strong effect in older ages (this refers in particular to diseases of the circulatory system).

Alongside with the change in the probability of death also tabular middle ages of death from remaining reasons will change. But these changes only apply only to the male population of the Odessa region. Neither the elimination of mortality from tuberculosis, or the elimination of mortality from all infectious diseases almost never appear on the average age of death of women from all causes, which confirms the fact that the greatest reserves of the increase in life expectancy are concentrated among the male population.

4. Conclusions

Thus, the constructed mortality tables, differentiated by cause of death allowed us to estimate the role of individual causes of death in the reduction of life expectancy of population in Odessa region. Calculated hypothetical table of mortality have made it possible to quantify the potential gains in life expectancy in the region on the condition of the elimination of mortality from infectious diseases, in particular from tuberculosis. Therefore the main task now should be to ensure appropriate control over this disease to improve the efficiency of treatment and to reduce mortality from it, both at the national and regional levels.

It should be noted that methodological approaches offered in the article to the construction of regional mortality tables differentiated by cause of death on the example of the Odessa region, can be used in other regions of the country which have certain differences in the structure of morbidity and causes of death, that, to our opinion, will provide the deepening of demographic analysis, will extend its possibilities and will assist acceptance at state and regional levels of effective measures for reduction of death rate in a country.

Literature

1. Венецкий И.Г. Вероятностные методы в демографии / И.Г.Венецкий – М.: Финансы и статистика, 1981. – 223 с.

2. Мерков А.М. Демографическая статистика (статистика населения) / А.М.Мерков. – М.: Медгиз, 1959. – 188 с.

3. Бирюкова Р.Н. Таблицы смертности по причинам смерти / Р.Н.Бирюкова // Проблемы демографической статистики. – М, 1959. – С.333-342.

4. Бедный М.С. Продолжительность жизни (статистика, факторы, возможности увеличения) / М.С.Бедный. – М.: Статистика, 1967. – 216 с.

5. Шабуров К.Ю. Таблицы дожития и причины смерти / К.Ю.Шабуров // Модели демографических связей. – М, 1972. – С. 41 – 65.

6. Вітковська К.В. Щодо питання про побудову таблиць смертності за причинами для окремих регіонів України / К.В.Вітковська // Вісник соціально-економічних досліджень. Вип. 25 / Одес. держ. екон. ун-т. – Одеса: ОДЕУ – 2007. - №25. – С. 51 – 57.

7. Смертність населення України у трудоактивному віці / [Е.М.Лібанова, Н.М.Левчук, Н.О.Рингач та ін.]; під ред. Е.М.Лібанової. – К.: Інститут демографії та соц. досліджень НАН України, 2007. – 211 с.