

Statistical analysis and simulation of the parameters of survival of Ukrainian population

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Abstract

The process of the second demographic transition in Ukraine is going under conditions of the narrowing mode of reproduction. Reproductive resources of the population over the next twenty five years will be very limited. This happens, because the childbearing activity ages enter small cohorts, who were born in the period of aggravated demographic crisis. The following two factors are able to contain the process of depopulation: reduction of mortality and migration inflow.

This work presents the results of statistical analysis of modern trends in total mortality, infant and child mortality. Separately investigated the change of age-sex profile of the regime survival of the population taking into account regional specifics. Differentiation of regime survival had been considered in the multy-optional forecast scenarios for the reproduction rates in Ukraine in the nearest future. Simulation results can be used as a warning example of possible consequences of the pension and health care reform in Ukraine.

Keywords: mortality, survival regime, forecast scenarios.

JEL Classification: J 110

1. Introduction

The current regime of replacement imposes certain restrictions on the parameters of population recovery. This is especially true of countries that have already made the second demographic transition or are entering this stage of demographic development. Ukraine, like most Eastern European countries has relatively limited demographic resources of reproductive cohort, the number of which has already reached its peak and over the next 15 years it will only keep shrinking. It is expected that the probable reduction in the number of births will partially be offset by intensification of childbearing. The second reserve for the population of Ukraine, like for most EU-28 countries, is the so-called positive "migration balance" (*Russian Population 2010-2011*, 2013). In Ukraine the problem of migration growth can be resolved not so much due to international immigrants, but due to its employment and education immigrants returning home. The third source of saving Ukraine from depopulation is improvement of the survival regime and reduction of mortality. For Ukraine this reserve is perhaps the most significant. Against the background of a long-term reduction in life

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expectancy, there have been significant improvements in infant and child mortality rates, as well as in juvenile mortality over the last five years. Over a relatively short time the maternal mortality rates have rapidly reduced, while the life expectancy of elderly people has considerably increased. On the other hand, premature mortality of Ukrainian people aged up to 65 is unreasonably high, especially among men of reproductive and active working age. Thus, the problem can be outlined as follows: how important the current regime of survival and mortality as a regulator of the demographic prospects in Ukraine is going to be, and what are the ways to improve it? With this in mind, the purpose of the paper is to analyze the recent trends in the survival parameters of the Ukrainian population, to determine their forecast levels and to evaluate the hypothetical and expected changes in the population size and age structure.

2. Analysis of the components of mortality trends in Ukraine

Throughout the history of sovereign Ukraine mortality has performed a destabilizing role in the reproduction of the population, while its dynamics had an uneven recurring nature. Waves of mortality growth and its slight reduction were observed between 1991 and 2007.

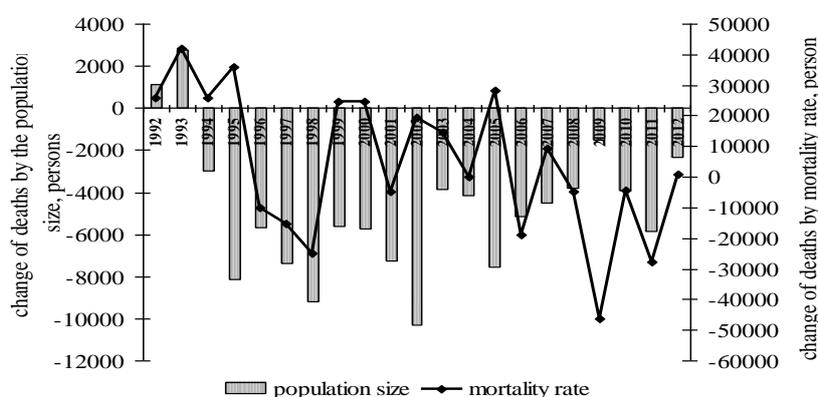


Fig. 1. Annual absolute change the deaths in Ukraine due to population size and mortality rate, 1992-2012.

Only within the last five years the overall mortality rate has shown a regular decrease, albeit with different intensities (Fig. 1). Despite this positive trend, in 2012 the decline in mortality rate has slowed down to 14.6 ‰, and its level did not reach the baseline of 12.9 ‰ of 1991. In general, over 1992-2012 the annual deaths has slightly decreased by 1% (-6.8 thousand persons), but this was due to a catastrophic decline in the overall population size by -84.4 ('000s). If the population remained the same as in the first year of Ukraine's Independence (1991), the number of deaths in 2012 would have increased compared to the

base year by 13.3% (+77.6 thousand persons). Figure 1 show that during the ten years of 1997-2007 the length of mortality rate cycle of growth has decreased from two years to one, which is to some extent a proof of changes in the structure of causes of death, notably, growth of the deaths due to infectious and parasitic diseases and external unnatural causes. The overall mortality rate depends on the age population structure and the intensity of death at every age. Therefore, for the disclosure of the internal mechanism of the formation of trends in mortality and impact of each factor an index factor analysis was used (Table 1). Due to the fact that during the last 22 years the mortality dynamics was multidirectional, it is expedient to conduct a further analysis of changes over the period after census in three distinctive time intervals: 2002-2005 – a recent most powerful increase in mortality, 2005-2012 – a period of gradual decline in mortality, and 2011-2012 – the year of stabilization of the mortality ratio.

Changes of mortality rate	2002-2005	2005-2012	2011-2012
Total	105.9	87.6	100.0
by factors:			
age –specific mortality	102.6	79.5	98.6
age structure	103.3	110.2	101.5

Table 1 Changes in the mortality rate in Ukraine by the factors, %.

It is obvious that the negative dynamics of the overall mortality rate was prevalently supported by an unfavorable age structure of the population. Thus, due to intensive aging of Ukrainians, their mortality has increased by 3.3% from 2002 to 2005. If aging hadn't been the case, the mortality rate would have dropped by 20.5% instead of 12.4 % (2005-2012) in the following years. The powerful influence of the aging factor is connected to a significant increase in the number of retired population, born in the postwar period. Only in the previous year the mortality rate remained almost unchanged due to leveling of the multi-directional impact of the both factors. In general, over the last 7 years Ukraine has made a major step on its way from high to medium mortality of 14.6 ‰, (according to the international rating scale). However, Ukraine still has sufficient reserves to further reduce mortality to the current European (9-10 ‰). It is necessary to point out that in order to make a proper comparison of mortality in Ukraine to that of the EU-28, standardized mortality ratios were used (European standard revised in 2012). It was found that if the standard European age structure was inherent to the Ukrainian population, the overall mortality rate in 2012 would be 1.3 times lower and would amount to 10.9 ‰ against 14.6 ‰ of the real structure. Due to the old age

structure of the female population, the actual mortality rate is by 1.7 higher than the standardized rate of 8 ‰. Moreover, the depth of aging distorts the real intensity of rural female mortality in Ukraine. Thus, in 2012 mortality of women in rural areas with extremely old actual structure was 2.1 times higher than the standardized rate of 8.4 ‰ corresponding to a low mortality rate. Therefore, the demographic aging of Ukrainian population significantly increases its real rate of extinction intensity. Does it mean that in reality the mortality regime in Ukraine corresponds to the European one? To answer this question it is reasonable to analyze and compare mortality of Ukrainian and European population in the context of gender and by causes of death.

Causes of death	Standardized mortality rate, per 100'000 population		Ratio of standardized death rate in Ukraine to EU-28, %	Standardized excess male mortality indices	
	Ukraine*	EU-28**		Ukraine*	EU – 28
Circulatory system diseases	667.1	432.3	154	1.6	1.4
Malignant neoplasms	161.3	273.6	59	2.0	1.8
External causes	83.5	49.5	169	4.5	2.4
Digestive system diseases	52.1	49.6	105	2.4	1.6
Infectious and parasitic diseases	28.8	15.0	192	3.1	1.5
All causes total	10.9	10.8	101	1.9	1.5

Table 2 Standardized cause-specific mortality ratios in Ukraine (for 2012) and the EU-28 countries (on average for 2008-2010).

The data in Table 2 shows a slight discrepancy in the overall mortality rate and almost a complete coincidence in the ranks of death causes of Ukrainian population and the population of the expanded European Union. The most common causes of death are the two classes: the diseases of circulatory system and malignant neoplasms. However, while mortality caused by cardiovascular diseases is 1.5 times higher in Ukraine than in the countries of the EU-28, Ukrainians die 1.7 times less often due to malignant neoplasms. These differences can be

explained not only by the actual structure of the diseases and the extent of their consequences, but also by an excessive diagnostics of the first-class causes and underestimation of the second-rate causes – both conscious or subconscious attributing of malignant tumors to diseases of other systems, including the respiratory and digestive system diseases. However, rather high prevalence of exogenous causes is also characteristic of Ukraine, as of some post-soviet countries, notably, external unnatural deaths (traffic accidents, suicides, homicide and alcohol poisoning) (Vichnevsky, 1998). Due to these causes, Ukrainian people die 1.7 times more often than Europeans. It is due to external causes that Ukrainian men die 4.5 times more than their female compatriots. The extreme prevalence of mortality from infectious and parasitic diseases in Ukraine that is 92% higher than the pan-European level also deserves attention. In particular, mortality from tuberculosis and complications of AIDS gaining an epidemic nature in Ukraine kill three times more men than women. As F. Meslé stressed: “a proportion of deaths registered as due to tuberculosis should be attributed to AIDS, which also rose sharply in the 90s” (Meslé, 2004). So, it is important for Ukraine to curb the well regulated and socially conditioned causes of death associated with lifestyle, sanitary culture and personal hygiene.

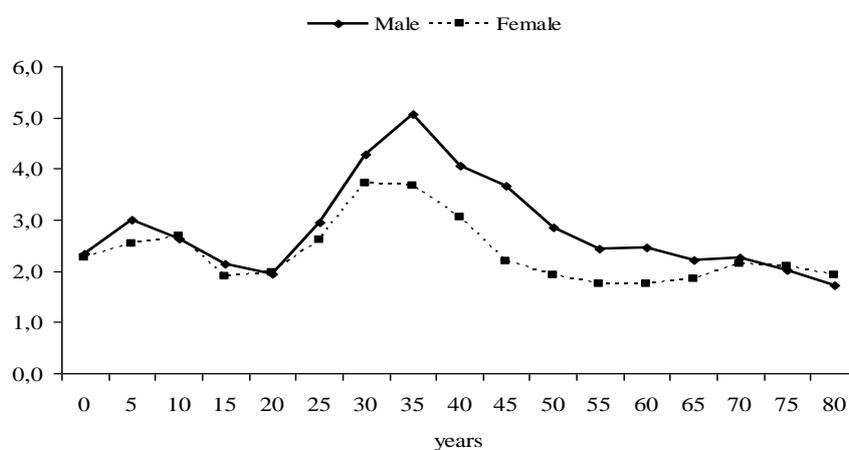


Fig.2. Indices of death probabilities by gender of the Ukrainian and EU-28 population, 2011.

The extreme age differentiation of excess mortality rate of the Ukrainian population as compared to the population of the European Union (EU-28) is shown by the indices of death probabilities at a certain age (Fig. 2). It is obvious that in all age groups of the Ukrainian population death probability is at least 1.7 times higher than that in European countries. Meanwhile, Ukrainian men are distinguished by particularly high indices. The curves of indices of excess the mortality of Ukrainian population in the context of gender have almost the same trajectory. The fivefold excess of probability of death of the most active Ukrainian

men in the working age of 35-40 also attracts attention, while the main causes of death are unnatural: traffic and job-related injuries, accidents, alcohol poisoning, suicide, murder. It is notable that among European men at this age the ranks of death causes slightly change, while the proportion of endogenous factors begins to increase (Meslé, 2004, Vallin& Meslé 2004). In particular, the intensity of deaths from chronic diseases of circulatory and digestive systems doubles. Thus, it is clear that it is the contingent of men aged 25-50 that comprises the main reserve for preservation of life and reduction of excess mortality due to external reasons that can be prevented by following a proper behavior, lifestyle and working conditions. Among women in Ukraine the age range of the triple excess of probability of death is somewhat narrower – 25-40 years, however, the structure of the causes of death is also different, dominated by malignant neoplasms, diseases of the digestive system and infectious diseases. Thus, the control of female mortality at a young age may be effective, provided that regular medical examinations are restored, and early diagnostics of cancer is widely implemented. This particularly applies to establishing an accessible and efficient rural medicine. Taking into consideration the fact that the fourth place in the structure of total mortality and even the third one among women is occupied by diseases of digestive system, the strategic focus should be placed on improvement of the quality of drinking water and food, as well as changes in the diet. According to a sample survey of health self-assessment by the population (2012), in the daily diet of Ukrainians fat exceeds the rational daily limit twice, while the diet lacks protein (30%) and carbohydrates (20%) (*Human development*, 2012, p. 60).

It is equally important for the population of Ukraine to preserve lives of the youngest groups of its population. Notably, over the period 1991-2012s infant mortality has decreased by 39.6% or on average by 2.4 % annually up to the level of 8.4 ‰. Only in the last 10 years there have been positive changes in the structure of infant mortality under 1 year old, with 62 % of deaths being localized within the neo-natal period (under 28 days). Moreover, 70% of infant deaths in Ukraine are registered at the very early stage of life (under 7 days), when the survival of a baby is predominantly affected by factors of perinatal development and birth defects and abnormalities. This is totally consistent with the modern European tendency for reduction in the number of post-neonatal deaths to 35-30%. The shift of mortality toward an early neo-natal period indicates the effectiveness of modern medical measures, due to establishment of a network of regional perinatal centers. Sustained positive changes in the nature of child and infant mortality have significantly improved life expectancy of the population in general.

3. Statistical characteristics of the survival regime and modeling of its indicators

The key parameters of population survival are the average life expectancy at birth and a lag in life expectancy of men and women at a particular age, as well as exact age and age-specific probability of surviving of the population. An analysis of distribution patterns and dynamics of the age-specific probability of surviving enables us to project of life expectancy at birth and identify the hypothetic population size and age-structure.

Over the period 1991-2012, life expectancy at birth, as well as mortality varied in a wave-like manner and fluctuated from a minimum of 66.9 years in 1996 to the highest level of 71.2 years in 2012. Reasons for these fluctuations were different. If at the beginning of the period (1991-1996) the reduction in life expectancy was due to an increase in the already high rates of child and infant mortality, in the new millennium the regressive role was performed by mortality of middle-aged adults. Since 2006 there has been a steady increase in the life expectancy at birth among men that has reached the level of 1989 in 2012 (66.1 years), while it has constituted the highest historical record of 76 years for women. Over the last 16 years there have been positive changes in Ukraine in the lag of life expectancy between men and women that has decreased by almost two years. The present-day difference in the male and female life expectancy is 9.9 years to the benefit of women (2012) against maximum 11.8 years (1997). A comparison of the lag in life expectancy of Ukrainian and European population that comprises 5.8 years (2011) points out to the actual potential for improving the survival of the Ukrainian population as a whole and for each gender in particular. This is especially true of the life expectancy of young men aged 15 to 40 years, which is on average 10 years less than that of their peers in the EU-28 countries. The trend of the age-specific probability of surviving of the Ukrainian population over the period between censuses (2002-2012) is characterized by a rapid growth of its rates among men over 40 years old and women over 55. Meanwhile, the survival regime of children and youth (15-25 years old) over the last 10 years almost has not changed.

There are a few approaches of estimation the age-specific contribution to general increase of life expectancy (Andreev, 1982, Canudas-Romo & Schoen, 2005, Andersen & Keiding, 2013). A component vertical analysis (see: Stefanovsky, 2002, p.78-88) has shown reformatting of the impact of individual age groups during 2002-2012. Thus, during 2002-2005 a slight decrease in the life expectancy at birth took place (-0.47 years for men, -0.16 years for women) mainly due to an increase in mortality rate at the age of 45-74. The adverse change at that time was subtly offset by an improvement in the survival regime of the children and youth aged 15-29. Since 2005 and until now the average life expectancy has been

growing due to all age groups. Over the last 10 years the two-thirds of the increase in male life expectancy at birth (+3.4 years) were provided by groups of medium and pre-retirement age (45-59), as well as those of the retirement age of 60-74 years old. Female life expectancy has increased to a lesser extent (+1.9 years), but 75% of the increase were provided by the oldest age groups. The contribution of middle and older reproductive age cohorts into the increase of life expectancy of women (30-44 years old) was twice less than among men. It is also necessary to take into account the existing differentiation between the life expectancy in urban and rural areas. In 2012 city residents had a chance to live 2 years longer than residents of villages, while the life expectancy of the latter has increased over the last 10 years only by 2.1 years vs. +3.2 years of those in urban areas. Clearly, the modern urban medical and social infrastructure and access to it provide urban residents a better quality of life. The 66% of gain in life expectancy of urban residents were secured by middle and senior retirement age groups.

An analysis of current trends in the survival characteristics of the population of Ukraine allows us to determine their projected levels for the short-time (by 2020) in general and by gender (see: Stoeldraijer et al. 2013). To be more precise, there have been developed three options of possible changes in the nature of the survival. According to the first optimistic scenario, the age-specific probability of surviving of each gender will increase with a tendency for the most intense growth that has taken place over the last seven years, and, therefore, the life expectancy at birth will be extended, meanwhile, the lag in female and male life expectancy of urban and rural areas will decrease. According to the second, more likely scenario (medium option), an increase in the age-specific probability of survival will be driven by the trend of the whole period under study (1991-2012), during which the mortality of children under 5 and young people (15-20 years old) decreased to a bigger extent, while the mortality of senior-aged people – to a lesser extent. Under these conditions, the life expectancy at birth will increase, but the lag in female and male life expectancy will return to the baseline of 2012 (9.9 years). The third, medium-pessimistic scenario was based on an assumption about a recurrence of the six-year-long wave of decline in the average life expectancy that took place in 2000-2005. In this case the average life expectancy for men will reduce more – up to 65.1 years, and less for women – up to 75.7 years. As a result, the gap between the life expectancy of men and women will increase again and will constitute 10.6 years.

Thus, if in the short run a favorable survival regime is preserved, in which mortality of young and middle-aged population (30-55 years), including mortality resulted from external

factors and infectious and chronic diseases will be overcome, then the overall mortality rate will drop to 13.7 ‰, and infant mortality – to 6.2 ‰. The male life expectancy at birth will increase more intensively (4.7 years compared to 2012), and therefore the difference in life expectancy between men and women will decrease to 7.6 years. A steady growth of age-specific probability of surviving among senior age groups (65-74 and, especially, 75-84 years old) can lead to a significant increase in the rate of aging up to 17% and, thereby, to a reduction in the portion of the reproductive contingent by 3.2 p.p. All these changes will help to slow down the further depopulation and reduce losses in the quantity of the population by 500 thousand people. According to the second scenario, the life expectancy at birth will increase more slowly. The overall mortality rate (15 ‰) will be determined by the survival regime of the middle-aged population with retaining relatively high mortality rates among men aged 30-45. A further decline in infant mortality to 7 ‰ is also expected. Due to a higher positive impact of the survival of young cohorts, the decline in the proportion of people of childbearing age (15-49 years old) will slow down a bit. The third scenario predicting a possible temporary deterioration in the survival regime warns about the possible decline in male life expectancy by 1 year as compared to the base year. The total mortality rate will significantly increase up to 15.9 ‰ with a slight increase in infant mortality. As a result, the process of aging may slow down, thus leading to an automatic increase in the proportion of the childbearing contingent.

Conclusion

Unstable fluctuating trends in the survival regime indices of the Ukrainian population over the period of its sovereignty largely reflect the instability of social and economic development of the country. Periods of overcoming the crisis, improvements of the material conditions of the population, development of the social infrastructure and its accessibility altogether foster mortality reduction and increase longevity of the population. Survival regime indices of the representatives of less socially protected groups, like children and senior cohorts are usually the first to react to the positive changes. However, the encouraging trends of the decade give reasons to expect further improvements in the survival regime of the population of both genders and types of settlement. The gradual convergence of survival curves of men and women in Ukraine of young and senior age, the fact that they are approaching the European average, as well as reduction of the excess mortality of middle-aged men contribute to the overall prolongation of life expectancy and slowing down of depopulation.

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