# ASSESSMENT OF ECONOMIC LOSSES CAUSED BY MORTALITY OF RURAL POPULATION AT WORKING AGE IN RUSSIA

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## Abstract

The purpose of this study is to quantify the cost equivalent of economic losses from mortality of the rural population of working age in Russia (2012-2017). The size of the economic losses caused by the mortality of the rural population is measured by the scale of agricultural products potential underproduction. The approaches that exist in the scientific literature to measuring the economic losses from mortality and assessing the economic equivalent of the cost of living are reviewed and summarized. On the basis of the calculations carried out, the variants of quantitative estimation of economic losses scale from mortality of the rural working age population are proposed.

The results of the study showed that significant interregional differences in economic losses from mortality of the rural population of the Russian Federation of working age remain. The estimation of interregional differentiation of indicators of economic losses for 2012-2017 years is carried out. It is shown that the greatest economic losses is recorded from external causes of death, diseases of the digestive system, tumors, as well as some infectious and parasitic diseases.

The date base of our study include: the Rosstat data posted on the official website of the Federal State Statistics Service and Russian Fertility and Mortality Database (Center for Demographic Research, Moscow). The results can be used to develop preventive measures aimed at reducing the mortality of the rural population of working age, increase life expectancy, the formation of regional strategies for socio-economic development of rural areas.

**Keywords:** rural population, working age, mortality, economic losses, assessment, interregional differences, Russia

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## 1. Introduction

Reducing mortality and increasing life expectancy are priority areas of socio-demographic policy pursued in the Russian Federation. At present, the mortality rate of the Russian population is higher than the economically developed countries, but its scale is decreasing every year. The number of deaths in Russia in January-November 2018, according to Rosstat, amounted to 1672 thousand people. [Information on the socio-economic situation, 2018: 120]. In the structure of the main classes of causes of death, it is necessary to allocate the circulatory system diseases (46.3%), neoplasms (15.9%), external causes (7.2%). The Russian economy suffers huge losses from an unjustifiably high level of premature mortality, especially of the working age population.

The assessment of economic losses from mortality, as well as the assessment of the cost of living are the subject of numerous studies and calculations presented in the literature [Ashenfelter, 2006; Evans and Smith, 2006; Kniesner et al, 2012; Aldy and Smyth, 2014; Viscusi and Masterman, 2017]. Some authors [Evans and Schaur, 2010; Boarini et al, 2012] used a lifetime income approach. Methods of discounting future income are widely used in the literature. Other authors took as a basis an estimate of the value of the average life (VSL) [Prohorov and Shmakov, 2002; Viscusi and Aldy, 2003; Prohorov and Shmakov, 2013; Zubets and Novikov, 2018]. Still others offer approaches based on the assessment of compensation payments [Shipitsina, 2013]. The methods of actuarial expectation performed for insurance companies are also used. Subjective methods for assessing the economic equivalent of the value of human life are based on sociological research and data from public opinion polls.

The researchers conducted a comparative analysis of different approaches to the assessment of economic losses from mortality, identified the advantages and disadvantages of existing methods [Nifantova and Shipitsina, 2012]. On the basis of alternative approaches presented in the literature, calculations of economic

losses from population mortality for different countries, socio-demographic groups, classes of causes of death [Aldy and Viscusi, 2008; Kniesner, 2010; Wang and He, 2010; Value of statistical life, 2014; Majumder and Madheswaran, 2016, 2017] were performed. Much less research is devoted to assessing the mortality of the rural population [Blinova and Bylina, 2013].

The rural areas now cover two thirds of the Russian Federation, with 37.34 million inhabitants (01.01.2009), representing 26% of the country's population [Preliminary estimate of the number and permanent population as of 1 January 2019 and average for 2018]. Predictive modeling of the size and structure of the rural population allows us to assess the strategic demographic risks of the Russian rural development, one of which is the high mortality of people of working age [Blinova and Bylina, 2014]. The implementation of socio-demographic policy aimed at increasing the number and life expectancy of the population involves the assessment of economic losses from mortality, including the working age.

As shown in table 1, among the rural population, the number of deaths in working age according to Rosstat decreased from 758.4 (2010) to 615.3 (2016) per 100,000 persons of working age. However, despite the positive dynamics of reducing the mortality rate of the rural population of working age, mortality rates from the main causes remain high. The main classes of causes of death of the rural population of working age are cardiovascular diseases, in second place external, including accidental alcohol poisoning, all types of transport accidents, suicides, murder, the third – neoplasms. However, it should be noted that for a long time, up to 2016, the first place was occupied by external causes of death of the rural population of working age (Table. 1).

The agrarian economy has suffered enormous social, demographic and economic losses from an unreasonably high level of premature mortality, especially among the working-age population. There are still differences in the mortality rates of the able-bodied population both between regions and between Federal districts.

**Table 1 - Mortality Rates of Rural Population at Working Age by Main Chapters of Causes** (number of deaths per 100 000 population at working age)

| **Causes of death** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** |
|---|---|---|---|---|---|---|
| Deaths from all causes, including: | 676,4 | 660,8 | 666,2 | 640,8 | 615,3 | 569,5 |
| Diseases of the circulatory system | 207,2 | 200,2 | 198,4 | 189,1 | 183,5 | 169,0 |
| External causes of mortality | 219,8 | 212 | 209,9 | 194,4 | 181,6 | 163,4 |
| Neoplasms | 94,9 | 95 | 94 | 96,5 | 93,6 | 90,6 |
| Diseases of the respiratory | 32,7 | 32,6 | 33,5 | 29,7 | 28,1 | 24,1 |
| Diseases of the digestive system | 46,6 | 46,3 | 52,5 | 52,5 | 48 | 45,1 |
| Certain infectious and parasitic diseases | 27,8 | 27,7 | 27,4 | 28,8 | 29,5 | 28,5 |

Source: Own design based on Demographic Year book (2017: 188). Russian Fertility and Mortality Database. Center for Demographic Research, Moscow (Russia). Available at http:// demogr.nes.ru/index.php/ru/demogr_indicat/data

At present there are eight Federal Districts in Russia: Central (CFD), Northwest (NWFD), Southern (SNFD), North-Caucasian (NCFD), Volga (VFD), Ural (UFD), Siberian (SFD) and Far East (FEFD). Each of them includes regions of different types (Oblast, Republic, Krai, Autonomous Oblast and etc.).

The highest is the mortality rate of the able-bodied population in the far Eastern Federal district (706.9) and Siberian Federal district (674.3), slightly lower than the value of this indicator in the Ural Federal district (625.2) and North-West Federal district (614.2), and the lowest – in the North Caucasus and southern Federal district (415.5-462.0 deaths per 100,000 persons of working age). In other Federal districts, the rate ranges from 557.7 (CFD) to 575 deaths per 100,000 persons of working age (VFD). Mortality rates of the rural population of working age in subjects of the Russian Federation are presented in Table 2.

**Table 2. - Mortality Rates of Rural Population at Working Age in Federal Districts of Russian Federation (**number of deaths per 100 000 population at working age**)**

| Federal Districts | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| CFD | 673 | 647 | 657 | 625 | 607 | 558 |
| NWFD | 723 | 701 | 699 | 672 | 658 | 614 |
| SNFD | 537 | 521 | 534 | 514 | 496 | 462 |
| NCFD | 479 | 452 | 470 | 460 | 444 | 416 |
| VFD | 693 | 689 | 690 | 663 | 621 | 575 |
| UFD | 725 | 725 | 718 | 708 | 684 | 625 |
| SFD | 789 | 771 | 779 | 749 | 726 | 674 |
| FEFD | 857 | 825 | 827 | 801 | 762 | 707 |

Source: Own design based on Russian Fertility and Mortality Database. Center for Demographic Research, Moscow (Russia). Available at http://demogr.nes.ru/index.php/ru/demogr_indicat/data

As the literature emphasizes, "the economic damage from premature mortality is determined by the irreplaceable losses of the most economically and socially active part of the population, a significant part of the national income, and the decline in the capacity of the national economy and society to sustainably and dynamically develop." [Kozlova et al, 2017: 512]. The Federal State Statistics Service uses the methodology for calculating economic losses from mortality, morbidity, and disability of the population [Methodology of Calculation of Economic Losses, 2012] to estimate economic losses. At the same time, the theoretical, methodological and methodological problems of quantitative measurement of economic loss and its value equivalent remain, the authors in their studies continue to use different approaches to estimating irretrievable losses from mortality.

The purpose of this study is to quantify the cost equivalent of economic losses from mortality of the rural population of working age and measure the potential scale of underproduction of agricultural products. It is also necessary to

assess the extent of the economic losses caused by the mortality of the rural population of Russia of working age from different classes of causes of death.

Measurement of economic losses from mortality in the rural working-age population implies the solution of the following tasks:

• justification of the theoretical approach to estimating the economic losses from mortality of the population and the choice of the method of its statistical measurement;

• determination of the composition of indicators and the formation of a database of research;

• study of the nozological profile of mortality in the rural working age population;

• quantitative assessment of the value of the economic losses from mortality of the rural working age population;

• analysis of the structure of causes of mortality in the rural working-age population, assessment of their contribution to the volume of economic losses;

• measurement of inter-regional differences in the scale of economic losses from mortality of the rural working-age population.

The date base of our study include: the Rosstat data posted on the official website of the Federal State Statistics Service and Russian Fertility and Mortality Database (Center for Demographic Research, Moscow).

The paper is organized as follows. The second section examines theoretical approaches to assessment of economic losses. The third section describes the methods and information base for the study. The fourth section is devoted to discussing the results of researches. Finally, we present our findings and recommendations in the concluding section.

## 2. Theoretical and empirical approaches

The methodological basis for estimating the value of human life is the theory of human capital [Shultz 1968; Becker 1975], and its quality is considered a key factor in the development of a modern economy. It is assumed that investments in

health increase life expectancy, increase work productivity, which strengthens incentives for the accumulation of human capital [Weil, 2014; Kozlova et al, 2017]. The accumulation of human capital is a basic prerequisite for the sustainable development of rural areas and the growth of life expectancy of the rural population. At the same time, insufficient investment in human capital against the background of a reduction in the rural working-age population generates the risk of a shortage of personnel, which is one of the challenges to ensuring food security in Russia. As a result of the reduction in the number of the rural working-age population, the supply of labor in the agrarian labor market is narrowed and the "shortage of personnel" is aggravated. In addition to the outflow of qualified personnel and youth to the cities, the labor potential of the village deteriorates as a result of mortality of the working age population. Losses caused by mortality of the population have a long-term negative impact on the demographic, economic and social development of rural areas.

The structure of the causes, factors and risks of mortality of the population were studied in detail by researchers in many countries of the world, measures to reduce losses from mortality were considered [French and O'Hare, 2014; Gatzert and Wesker, 2014; Enchev et al, 2017; Bergeron-Boucher et al, 2017; Diaz and Debón, 2018]. Different authors, including Russian ones, carried out calculations based on the methods of potential demography using the indicator "lost years of potential life", which was calculated not only for the population of the country as a whole, but also for individual regions and socio-demographic groups [Prohorov and Shmakov, 2002; Blinova et al, 2014; Morev and Korolenko, 2018]. According to the researchers, the indicator of "lost years of potential life" [Morev and Korolenko, 2018: 116] can serve as a characteristic of demographic losses due to premature mortality. In this case, the methodology for calculating the economic losses from mortality of the population takes into account the conditional time period that the representative of a certain age group is to live with the current mortality rate existing in this group [Kozlova et al, 2017: 512]. In addition, the methods of actuarial calculations were used for the economic assessment of losses,

where risks and the time of death are estimated using mathematical modeling methods [Bykov, 2014]. Estimation of the economic equivalent of the cost of human life is not only theoretical, but applied value. Currently, alternative measurement methods are used to estimate the value of human life. As noted by Zubets and Novikov, in modern socio-economic research, the concept of "value of statistical life, VSL" is widely used to assess the quality of life, plan social policy, determine the material remuneration for families of victims and emergency situations [Zubets and Novikov, 2018: 54]. In the compensation approach, the equivalent of the cost of living is compared with the economic losses caused by the death of people. As the authors emphasize, in this case, the economic equivalent of the cost of living is the amount of compensation payments to the families of the victims or those who have lost their health as a result of disasters [Nifantova and Shipitsina, 2012: 293].

Studies on the economic valuation of the average human life often use methods based on willingness to pay to prevent deadly risks. The authors emphasize that in determining the cost of living, according to this approach, people's readiness to pay for safer equipment or medicines that lower the risk of a certain disease is estimated [Zubets and Novikiv, 2018: 55]. At the same time, the cost of an average person's life is most often estimated as the total loss of gross domestic product (GDP) produced as a result of a person's death.

The Federal State Statistics Service in calculating the economic losses from mortality of the population uses the Methodology for calculating the economic losses from mortality, morbidity and disability of the population [Methodology of Calculation of Economic Losses, 2012]. According to the proposed methodology, the economic losses from the death rate of the population for the reporting year for each differentiating factor are calculated as the product of the number of people who died at the age of 15 years and older and the GDP per 1 employed, adjusted for the employment rate of the relevant age and age group, taking into account averaging the time of death during the year (correction factor 0.5). In addition, reduced working hours and extended leave for persons from 15 to 18 years are

taken into account [Methodology of Calculation of Economic Losses, 2012]. The proposed “Rosstat method” has practical significance, describing in detail the algorithm for calculating the economic losses from mortality of various age groups of the population. In this case, the losses are interpreted as the underproduction of gross domestic product due to the death of a person. They are calculated for Russia as a whole, taking into account sex, age, classes of diseases that caused the death.

## 3. Method and Data Analysis

The information base of our study was created for 79 regions of Russia for 2012-2017 year on the basis of statistical indicators presented in official publications of the Federal State Statistics Service (Regions of Russia 2018; Russian Statistical Yearbook 2018; The Demographic Yearbook 2017; Application to the Demographic Yearbook 2017), a as well as the Central Statistical Data Base of the Federal State Statistics Service (The central statistical database) and Russian Fertility and Mortality Database (Center for Demographic Research, Moscow). The mortality rates of the rural working-age population were measured for each class of leading causes of death in 2012–2017 (Tab. 3).

**Table 3. - Mortality Rate of Rural Working Age Population of Russia by Specific Classes of Death Causes, 2012-2017,** pers. in year.

| **Causes of death** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** |
|---|---|---|---|---|---|---|
| Diseases of the circulatory system | 10851 | 6979 | 5922 | 4018 | 3306 | 2058 |
| External causes of mortality | 13015 | 12001 | 11580 | 9956 | 8714 | 7086 |
| Neoplasms | 5205 | 4361 | 3512 | 3817 | 2943 | 2175 |
| Diseases of the respiratory | 6682 | 6295 | 6293 | 4617 | 3728 | 1956 |
| Diseases of the digestive system | 4643 | 4450 | 6405 | 6193 | 4170 | 2935 |
| Certain infectious and parasitic diseases | 5205 | 4361 | 3512 | 3817 | 2943 | 2175 |

*The cost equivalent of economic losses from mortality.* The economic losses from mortality in this work were estimated using a modified version of the Rosstat method and were calculated using the following formula (1):

$$L_{x,s,d} = M_{x,s,d} \cdot \frac{E_{x,s}}{S_{x,s}} \cdot \frac{GVA}{E} \cdot 0.5k_x \qquad (1)$$

where *Lx,s,d* - economic losses in the production of gross value added of agriculture as a result of mortality in the reporting year at the age of (x) sex (s) due to death (d) in the region; *Mx,s,d* is the number of deaths at the age of (x) sex (s) due to death (d); *Ex,s,d* - the number of employed at the age (x) of the sex (s); *Sx,s,d* - is the population at the age (x) of the sex (s); E - the number of employees; *kx* - correction factor to take into account the reduced working time and the increased duration of leave for persons of age (x) under 18 years old (for x = 15 kx =0.5922, for x = 16 kx =0.8636, for x = 17 kx =0.8636, for x> 17 ); 0.5 is the coefficient taking into account the time distribution of deaths during the year. To calculate the cost equivalent of economic losses from mortality in the rural working-age population, for separate reasons, the Rosstat methodology was supplemented by age and gender coefficients of employment and labor productivity. In addition, for research purposes, instead of the gross domestic product (GDP) indicator, the actual value of agricultural production was used. The calculations were performed using the following formula for each age group and sex of the rural working age population (2).

$$L_j = \frac{1}{2}\sum_j PM \cdot (E \cdot k_e) \cdot (\frac{GVA}{S} \cdot k_w), \qquad (2)$$

where *L* is the annual value of economic damage (economic losses), million rubles; *PM* is the number of people who died at working age for individual causes of death in each year (j), pers.; *E* – Is the employment rate of the working-age rural population (employment rate), adjusted for gender-age employment rates (ke); *GVA* – the actual cost of agricultural products in all categories of farms, million

rubles; *Se* - the average annual number of employed rural residents, pers.; the fraction itself characterizes the level of labor productivity in agriculture for the year; kw – corrective factors of labor productivity (by age and sex), replace the coefficient kx. The factor ½ was introduced in accordance with the Rosstat methodology to account for the distribution of the time of deaths during the year. Based on the main provisions of this methodology, we performed the calculations of economic losses from mortality of the rural population of working age.

## 4. Results and Discussion

The results of the measurement of economic losses (million rubles) from the potential underproduction of agricultural products due to the premature mortality of the rural working age population are presented in Table. 4.

**Table 4 Assessment of Economic Losses Caused by Mortality of Rural Population at Working Age, million rubles.**

| **Causes of death** | **2012** | **2013** | **2014** | **2015** | **2016** | **2017** |
|---|---|---|---|---|---|---|
| Deaths from all causes, including: | 5920 | 4968 | 5364 | 5500 | 5352 | 4077 |
| Diseases of the circulatory system | 1417 | 884 | 886 | 659 | 680 | 438 |
| External causes of mortality | 1664 | 1542 | 1665 | 1722 | 1830 | 1591 |
| Neoplasms | 687 | 556 | 500 | 637 | 595 | 500 |
| Diseases of the respiratory | 871 | 837 | 906 | 789 | 779 | 424 |
| Diseases of the digestive system | 594 | 593 | 908 | 1056 | 874 | 625 |
| Certain infectious and parasitic diseases | 687 | 556 | 500 | 637 | 595 | 500 |

Further, specific indicators of economic losses contribution to underproduction of agricultural products, and, consequently, to a decrease in food

security, were calculated. For these purposes, the actual cost of agricultural production and lost as a result of underproduction (from mortality of the rural population of working age) are summarized, then the economic loss is correlated with the value received. Losses from underproduction of agricultural products as a result of premature mortality in 2012 reached 5.9 billion rubles, then there was an annual decline, reaching 5.5 billion rubles by 2015 and by 2017 - 4.1 billion rubles. This indicates a significant success in reducing the rural mortality of the working-age population in Russia. The results of the study showed that the greatest economic loss was recorded from external causes of death -1.59 billion rubles, diseases of the digestive system - 625 million rubles, and neoplasms -500 million rubles and certain infectious and parasitic diseases -500 million rubles.

The analysis of the regional profile of potential losses is important when analyzing the economic loss from the mortality of the rural working-age population. Differentiation of Russian regions according to the criterion of potential losses of agricultural products as a result of premature mortality of the population of the age is significant. The highest specific indicators of the contribution of economic losses to the underproduction of agricultural products are characteristic of the regions of the Far Eastern, Siberian, and North-West Federal Districts. The lowest specific indicators distinguish the regions of the North Caucasus Federal District and Southern Federal District. The assessment of economic losses from mortality in the rural working-age population was carried out both for the federal districts as a whole and for the regions of Russia individually. Calculations of economic losses from deaths, reflecting the specifics of the territories of Russia, can be used to develop specific measures and select targeted programs aimed at increasing the life expectancy of the rural population.

An important indicator is the dynamics of interregional differences, for the evaluation of which the Gini coefficient was used. The next step was to assess the dynamics of interregional differences by the criterion of potential losses of agricultural products as a result of mortality of the working age population using the Gini coefficient.

Differentiation of Russian regions according to the criterion of potential losses of agricultural products as a result of mortality of the working age population is presented in Table 5.

**Table 5. Differentiation of Regions of the Russian Federation by Potential Losses of Agricultural Products as a Result of Mortality of the Working Age Population.**

| Causes of death | 2012 | 2013 | 2014 | 2015 | 2016 | 2017 |
|---|---|---|---|---|---|---|
| Deaths from all causes, including: | 0,352 | 0,352 | 0,342 | 0,349 | 0,335 | 0,330 |
| Diseases of the circulatory system | 0,288 | 0,338 | 0,315 | 0,307 | 0,304 | 0,302 |
| External causes of mortality | 0,349 | 0,340 | 0,342 | 0,336 | 0,328 | 0,322 |
| Neoplasms | 0,363 | 0,344 | 0,343 | 0,302 | 0,332 | 0,351 |
| Diseases of the respiratory | 0,301 | 0,348 | 0,327 | 0,351 | 0,318 | 0,309 |
| Diseases of the digestive system | 0,291 | 0,342 | 0,301 | 0,318 | 0,347 | 0,329 |
| Certain infectious and parasitic diseases | 0,310 | 0,324 | 0,307 | 0,277 | 0,266 | 0,220 |

As the data in the table show, the largest interregional variation in 2017 is characterized by economic losses from neoplasms (0.351), diseases of the digestive organs (0.329) and external causes of death (0.322). Less significant are the interregional differences in economic losses from circulatory system diseases (0.302) and respiratory diseases (0.309). The minimum values of this indicator are characteristic of some infectious and parasitic diseases (0,220). Interregional differences in economic losses from all classes of causes of death of the rural working-age population are also large and amount to 0.330 in terms of the Gini coefficient. It should be emphasized that in this work, the determination of the economic losses from deaths was carried out in the framework of experimental

calculations, which made it possible to obtain estimates of the extent of rural population losses in different federal districts, regions, socio-demographic groups and from different classes of causes of death. The results can be used to develop preventive measures aimed at reducing the mortality of the rural population of working age, increasing the duration and quality of life, the formation of regional strategies for sustainable rural development.

## 5. Conclusion

On the basis of the proposed approach, a cost estimate of the economic damage from the mortality of the rural population of Russia of working age has been made, taking into account the main classes of causes of death. It is taken into account that labor productivity varies depending on a number of factors, it is indicated that it is necessary to take into account the heterogeneity of consumer behavior. The economic assessment of mortality losses in this case is based on the assumption that given the age structure of employment, the potential cost is annually lost, which can be measured by balancing the potential productivity and per capita consumption of the rural working-age population. The methodology of valuation of economic losses from mortality of the rural population presented in this study can be used to determine losses in various regions of the Russian Federation, different age cohorts, taking into account the main classes of causes of mortality and gender specificity.

The results of the study showed that the greatest economic loss was recorded from external causes of death (1.59 billion rubles), diseases of the digestive system (625 million rubles), and neoplasms (500 million rubles) and Certain infectious and parasitic diseases (500 million rubles). An assessment of the interregional differentiation of indicators of economic losses for 2012-2017 years. It is shown that significant interregional differences in economic losses from mortality of the rural population of the Russian Federation of working age remain. Calculations of losses from deaths, reflecting the specifics of the territories, can be used to develop

specific measures and select targeted programs to increase life expectancy in the regions of Russia, as well as justify plans for rural development.

The proposed approach allows us to specify the measures of state policy and the direction of the regional demographic and socio-economic development of the Russian village. This explains the need for the most complete assessment of the economic damage from losses caused by the mortality of the rural working-age population.

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