RELAÇÕES INTERNACIONAIS NO MUNDO ATUAL
CENTRO UNIVERSITÁRIO CURITIBA - UNICURITIBA - VOLUME 1 - NÚMERO 34/2022 CURITIBA/PARANÁ/BRASIL - PÁGINAS 185 A 200 - ISSN: 2316-2880

METHODS FOR ESTIMATING THE HUMAN LIFE VALUE CONSIDERING FUTURE GENERATIONS

Tatiana Tikhomirova[1]
Doctor of Economics, Professor of the Department of Mathematical Methods in Economics
Plekhanov Russian Economic University - Russia
https://orcid.org/0000-0003-3149-7673

Nikolay Tikhomirov[2]
Doctor of Economics, Professor of the Department of Mathematical Methods in Economics
Plekhanov Russian Economic University - Russia
https://orcid.org/0000-0002-0282-1553

ABSTRACT

Objective: The objective of the study was to consider approaches and methods for estimating the human life value and the loss of living years caused by premature mortality in different age individuals. **Methods**: The authors studied approaches and methods based on a comparison of induviduals' economic performance and consumer spending, consumer spending, the willingness to pay for reducing mortality, and to indemnify its consequences. **Results**: The authors suggest the directions of refinement of economic estimates of the consequences of mortality of males and females, related to the differences in their involvement in the formation of future generations, as well as give examples of estimates of living cost of males and females of different ages in Russia comparing with similar indicators in developed countries. The features of the use of these assessments in justifying the effectiveness of various types of measures to ensure human life safety are considered.

Keywords: Annual living cost. Human capital. Exposure fee. Risk-reducing costs. Probability of death and birth.

MÉTODOS PARA ESTIMAR O VALOR DA VIDA HUMANA COM CONSIDERAÇÃO DAS GERAÇÕES FUTURAS

ANOTAÇÃO

Objetivo: O objetivo do estudo era avaliar abordagens e métodos para estimar o valor da vida humana e a perda de anos dela devido à mortalidade prematura em diferentes idades de indivíduos. **Métodos:** Os autores investigaram abordagens e métodos baseados em uma comparação de seu desempenho econômico e gastos dos consumidores, disposição de pagar pela redução da mortalidade e implicações de seguro. **Resultados:** São propostas as direções para o refinamento das estimativas econômicas das conseqüências da mortalidade de homens e mulheres, relacionadas com as diferenças em sua participação na formação das gerações futuras. São dados exemplos de estimativas de custos de vida para homens e mulheres de diferentes idades na Rússia, em comparação com indicadores similares nos países desenvolvidos. As peculiaridades do uso dessas estimativas ao justificar a eficácia de vários tipos de medidas de segurança de vida são consideradas.

Palavras-chave: Custo de um ano de vida; Capital humano; Encargos de risco; Custos de redução de risco; Probabilidade de morte e nascimento; Taxa de fertilidade total; Atividade econômica e consumo.

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

1. INTRODUCTION

Given the resource constraints existing in the countries of the world community, the necessary condition for the economic validity of measures aimed at improving public health, increasing the level of safety in the workplace, transport, social and living environment, of which each contributes to one of the most important goals of social development – increasing life expectancy, is to exceed the levels of established associated costs. At that, in this case, the results are usually understood as the cost of the years of life saved by such measures. At the same time, the scientific community still does not have a single approach to estimating the cost of years of human life, although some of the existing variants have received not only theoretical substantiation but are also used in the practice of preventing and eliminating the consequences of various types of emergencies, as well as paying allowances for damage to human health and life in many developed countries (Tikhomirova & Kamenetskaya, 2020). Among these options, the most well-known are the approaches based on:

- theories of human capital (Bahamonde-Birke, Kunert, & Link, 2015; Mushkin & Collings, 1959);
- assessments of "willingness to pay" for safety and "accept risk fee" (Abelson, 2008; De Blaeij, Florax, Rietveld, & Verhoef, 2003; Elvik, 1995; Miller, 2000; Viscusi & Aldy, 2003);
- payout on insurance claims and some other prerequisites (Baum & Hohnscheid, 1999; Krupp & Hundhausen, 1984).

The concept of human capital, in general, is based on the assumption that the cost of the current year of a person living in the country is equivalent to the economic results of his activities, determined by the average per capita economic productivity, deducting the average per capita consumption. In some cases, related to the payout for the death or illness, disability of specific persons, these average indicators are replaced by individualized ones. At that, the cost of future years of living can be estimated considering the discounting of the expected values of these indicators.

Certain differences in the estimates of the cost of years of human living obtained based on the theory of human capital may be due to differences in the productiveness and consumption structure elements taken into account. The average values of productiveness are usually proposed to be estimated by the value of the average per capita GDP, while that of consumption – by the average per capita expenditure of citizens. Individualized

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

estimates of productiveness can be estimated by the value of the current and expected income of the injured person, the additional costs of his medical treatment and rehabilitation, the lost profit of family members in the event of his illness or death, etc., while estimates of consumption – by the expected expenses estimated based on previous years.

Estimates of human capital based on the comparison of economic productiveness and consumption were used in the 50s of the last century in the USA and Great Britain when developing and justifying the effectiveness of road safety measures, determined by the ratio of the cost of saved years of living of the population due to these measures, and the associated costs. In 1958-1970, the content of these estimates underwent certain changes, namely, they no longer took into account consumer spending (Fein, 1958). Starting in the 70s, the structure of individualized losses of economic productiveness began to take into account the value-based subjective estimates of the decline in the living quality of the injured person (if he survived) and his family members caused by illness, grief, and suffering (Mushkin & Collings, 1959; OECD, 2012).

The International Commission on Radiological Protection (ICRP) recommends using estimates of the cost of human living, determined by the indicators of per capita GDP when justifying the costs and limits of decontamination of the territory in the event of its radiation pollution. At that, the number of living years saved by reducing the level of radiation exposure to the population from the initial dose of D_O to the residual D_R (Sievert/year), as well as the costs associated with the decontamination, are usually linked to the difference and the ratio of these doses, respectively (Hasemann, 2000; ICRP, 1993).

In the late 80s of the last century, several developed countries, including the USA, Great Britain, New Zealand, Sweden, and Switzerland began to use a more subjective approach to assessing the cost of living, called willingness-to-pay for safety (De Blaeij et al., 2003; Elvik, 1995; Miller, 2000; Rizzi & de Dios Ortúzar, 2006; Viscusi & Aldy, 2003). It is based on the assumption that the contribution of certain funds to measures aimed at reducing the risk of premature death (loss of health, etc.) does not completely exclude such possibility but just reduces the probability of this event. This means that the whole society is divided into three groups. People included in the first group will avoid death due to the implementation of these measures. The members of the second group will save their lives under the previous conditions independently of taken specific measures, while the members of the third group will die (will perish or lose their health) even after the implementation of these measures. However, the matter is that initially none of the

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

investors knows their fate. They only know information about the magnitude of the decrease in the probability of death (loss of health). As a result, according to the Pareto criterion, the implemented measures should be considered effective (none of the investors worsens their condition, while some of them improve it).

Given the uncertainty of the outcome, the question arises of how much money, investors are willing to pay for themselves to reduce the probability of death by a certain value. If for each of the investors this amount is *x* US dollars, and the decrease in the probability of death is ΔP, then the average human life value according to the method based on willingness-to-pay is *x*/ΔP US dollars. For example, if for reducing the probability of death per person by $\Delta P = 2{\cdot}10^{-6}$, every member of society is willing to pay 5 US dollars, then the human life value would be estimated by the society as $5/(2 \cdot 10^{-6}) = 2.5$ million US dollars.

As an example of the practical use of the approach based on willingness-to-pay, to assessing the cost of human living, one can cite data describing the consequences of the legislative speed limit for motor transport on US roads from 70 to 55 miles per hour, which was in effect in 1974-1987 (Jones-Lee & Loomes, 1995; Rizzi & de Dios Ortúzar, 2006a, 2006b). This measure has reduced the number of people who died in car accidents by an average of 2,000 people per year. At the same time, the loss of time caused by slowing down the traffic speed amounted to one billion hours per year, or in the value equivalent – of 10 billion US dollars per year, given that the cost of a working hour was estimated at 10 US dollars at that time. Thus, the cost of the living of a person saved by such a speed limit of automobile traffic was 5 million US dollars. This estimate generally corresponds to the level of indemnity for lost lives in the USA.

On average, in developed countries, estimates of the human life value (and, accordingly, life expectancy) obtained based on the willingness-to-pay and insurance approaches were significantly higher than similar indicators obtained based on income losses (according to available estimates, about 2-5 times) (Jones-Lee, 1994; Jones-Lee, Hammerton, & Abbott, 1987; Jones-Lee & Loomes, 1995; Miller, 2000; Viscusi & Aldy, 2003). In this regard, it should be noted that the allowance for damage paid for the health and lives of citizens lost as a result of emergencies and industrial accidents are still tied to their average income (earnings) if special circumstances are not taken into account. In most of these countries, their value is set at the levels of 50-90% of the average earnings (Roik, 1994). In the case of loss of labor capacity, the degree of this loss is taken into account when determining the allowance for damage. According to the authors, this is

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

because the average estimates of the human life values based on the economic losses are more objective indicators compared to their subjective counterparts obtained based on the willingness-to-pay approach for reducing risks, especially when justifying the effectiveness of general measures aimed at improving the safety of the population in various areas. At the same time, approaches to estimating the human life value in terms of income and expenses can be improved by considering the, for example, the human life value of future generations who could (can) have been produced by individuals in perspective. This may be appropriate in the context of demographic depopulation, since the growth of the economic importance of the population of younger ages due to this consideration contributes to a certain extent to its "saving" and, accordingly, to an increase in the rate of natural reproduction. Moreover, an increase in the objectivity of estimates of the human life value is also associated with differences in the economic activity of people of different ages and possibly with differences in genders, which also should be taken into account. The features and consequences of such accounting for the obtained estimates are considered below in more detail.

2. METHODS

Considering contributions from future generations, human life value of the individual in the age *B*, or the cost of years of life lost in the event of his death at the age of *B*, can be estimated based on the following expression:

$M_B = M_{BC} + M_{BD},$	(1)

where M_B is the estimate of the total value of the future life of the individual in the age of *B*, given his economic activity and involvement in the birth of children; M_{BC} is the estimate of the value of the future life of the very individual at the age of *B*, considering his economic activity; M_{BD} is the estimate of the children's life value who could have been born in the future with the involvement of an individual at the age of *B*.

The classical formula for determining the average human life value M_{OC} from the time of birth, based on estimates of income and expenses has the following form (Brent, 2004; Weisbrod, 1965):

$M_{OC} = \sum_{t=0}^{L} v_t P_t (W_t - R_t),$	(2)

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

where M_{OC} is the human life value since birth; $v_t = (1+r)^{-t}$ is the discount factor; P_t is the probability of surviving to age *t* from the time of birth; $P_t = p_1 \cdot p_2 \cdot \ldots \cdot p_{L-1}$ where p_i is the probability of transition from the *i*-th age group to *i+1*-th; $i = \overline{1, L}$; $p_0 \equiv 1$; W_t is the average annual income of a person aged from *t* to *t +1*; and R_t is average consumer spending of a person aged *t*.

Note that some studies recommend determining the values of W_t and R_t considering the differences in economic activity and the consumption rate of the population at different ages. According to the WHO methodology (Murray & Lopez, 2013), the distribution of economic activity by age can be estimated by the following expression:

$$W_t = d_t \cdot W, \tag{3}$$

where W is the per capita income averaged for the entire population; d_t is the coefficient characterizing the level of economic activity of an individual at the age of *t*; *L* is the life limit.

Possible options of the relationship between the levels of economic activity of an individual in different years of his life are characterized by the graphs presented in Figure 1. They are based on the WHO methodology to assess the patterns of variability of this indicator with age, modified by the authors (Murray & Lopez, 2013).

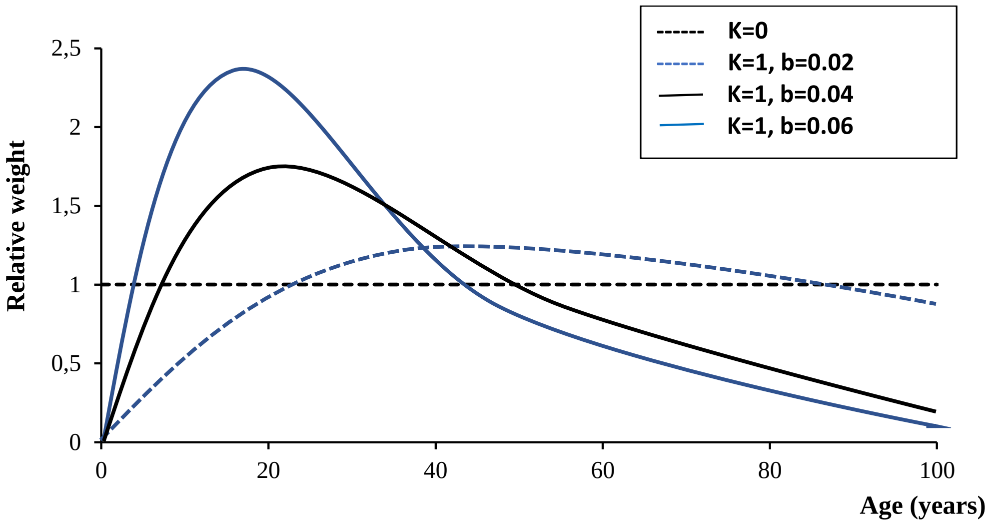

Figure 1. Distribution of the human life value in different ages

The variable *k* is the indicator of the methodology determining the differences in the degree of economic activity of people at different ages. At *k* = 0, activity in all ages is the same, at *k* = 1, the economic activity in younger and older ages decreases compared to

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

this characteristic at middle age; β is the indicator of the methodology that determines the patterns of changes in the economic activity with age.

A similar approach can be applied when assessing the age distribution of consumption levels.

Note that, according to the expression (2), the economic value of human life in the age of *B* years, is determined by the following expression but only in the later period of his life:

$$M_{BC} = \sum_{t=B}^{L} v_{t-B} P_{B,L} (W_t - R_t), \quad (4)$$

where M_{BC} is the human life value in the age of *B*;

$P_{B,L} = p_B \cdot p_{B+1} \cdot \ldots \cdot p_{L-1}$.

$v_{t-B} = (1+r)^{-(t-B)}$, $t = B+1, B+2, \ldots$

From expression (4), in particular, it follows that the human life value after a person has ceased to receive income becomes negative. Expressions (2) and (4) characterize the net life value. Without considering consumption (i.e. when $R_t = 0$), formulas (2) and (3) determine its gross value. In this case, the formula (4) can be represented as follows:

$$M_{BC} = \sum_{t=B}^{L} P_{B,L} W_t (1+r)^{-(t-B)}, \quad (5)$$

Here it should be noted that products of $v_t \cdot W_t$ and $v_t \cdot R_t$, used in expressions (2), (4), and (5) can be considered as modified values of economic activity and consumption, obtained respectively, considering the effects of discounting.

The contribution of the possible emergence of future generations to the assessment of the human life value is quite easy to assess with respect to the female population. Its value for a woman at age *B* is equivalent to the life value of children who may be born during the next years of her life (could have born in the event of her death or disability at age *B*).

For a woman at age *B*, the average expected number of children born in the future period can be estimated using the corresponding age-related birth rates (childbirth probabilities) at ages *B*+1, *B*+2,....

With certain reservations, the same approach can be applied to the male population, if correctly quantifying their contribution to the birth rate. There are two ways to do this approximately.

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

First, one can use age-specific birth rates for the combined age group of males and women. In practice, the values of such coefficients can be estimated as the ratio of the number of children born to females of age group *B* to the total number of females and males belonging to their combined group. Further, these values are attributed to both the female and male combined age groups. In this case, the problem arises: which groups should be merged? Considering the difference in the ages of fathers and mothers, it is advisable to combine the *i*-th female group with the *i*+1 male group. However, this approach reduces the contribution of females to the birth rate, since it is equalized with the contribution of males. At that, a certain "revision" is required in the methodology for estimating birth rates, considering the change in the population of the groups to which their values are attributed.

Secondly, one can try to take into account the contribution of males to the birth rate by dividing its "traditional" age coefficients into "male" and "female" in a certain proportion, for example, attributing 20% of the birth rate of females of age group *B* to males of age group *B*+1, and adjusting this value considering the differences in the numbers of these population groups. So, if the number of the male group was less than that of the female group, then the male birth rate should be estimated as:

$$q_{MB+1} = 0{,}2q_B \cdot x_F/x_M, \quad (6)$$

where x_M and x_F are the numbers of people in the concerned male and female groups, respectively; q_{MB+1} is the birth-rate determined for males of age group *B*+1; q_B is the birth rate of females of age group *B*. In this case, for the female age group *B*, the value of the birth rate is set at the level of $q_{FB} = 0.8\, q_B$.

While considering the contribution of only the female population to the birth rate, then, for example, for a newborn girl within a five-year age structure without dividing children by gender, the value of M_{BD} is determined by the following expression:

$$M_{BD} = P_4 q_4 \sum_{\tau=1}^{L-1} P_\tau W_\tau (1+r)^{-(4+\tau)} + P_5 q_5 \sum_{\tau=1}^{L-1} P_\tau W_\tau (1+r)^{-(5+\tau)} + \dots + \\ + P_{10} q_{10} \sum_{\tau=1}^{L-1} P_\tau W_\tau (1+r)^{-(10+\tau)} = \sum_{i=4}^{10} P_i q_i \cdot \left(\sum_{\tau=1}^{L-1} P_\tau W_\tau (1+r)^{-(i+\tau)} \right), \quad (7)$$

where $P_i = p_1 \cdot p_2 \cdot \ldots \cdot p_{i-1}$ is the probability of living out until the age *i* (the transition factor into age group *i*) from the time of birth;

$p_j,\ j = \overline{1, \imath - 1}$ the probability of transition from age group *j* into group *j*+1;

Relações Internacionais do Mundo Atual Unicuritiba.
[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

q_i, $i = \overline{4,10}$ the probability of having a child (birth-rate) by a woman in the five-year age group *i* (defined for ages from 15 to 49 years);

W_τ is the estimate of the life value of a person at the age of т;

$(1 + r)^{-i}$ is the discount factor of the human life value, where *i* is the number of periods between the considered period (year) and the future period (year);

L is the limit age group, for example, *L*=17 comprising the population aged 80 years and older;

$(1 + r)^{-i}$ is the probability of transition to the age group *т*+1 from the age of zero (from birth).

For females aged *B*, *B* < 4, the expression (7) takes the following form:

$$M_{BD} = \sum_{i=4}^{10} P_{B,i} q_i \cdot \left(\sum_{\tau=1}^{L-1} P_\tau W_\tau (1 + r)^{-(\mathrm{i-B+\tau})}\right), \tag{8}$$

If $4 \leq B < 10$, then the expression (7) is transformed to the following:

$$M_{BD} = \sum_{i=\mathrm{B}+1}^{10} P_{B,i} q_i \cdot \left(\sum_{\tau=1}^{L-1} P_\tau W_\tau (1 + r)^{-(\mathrm{i-B+\tau})}\right), \tag{9}$$

where $P_{B,i} = p_B \cdot p_{B+1} \cdot ... \cdot p_{i-1}$ is the probability of transition from age group *B* to group *i*.

According to expression (9), for the females of the age groups from 45-49 years and older (*B* ≥ 10), their contribution to children's birth is zero, i.e. $q_B = 0$.

When dividing children by gender, in expressions (7)-(9), it is necessary to use the birth rates and aging factor of the male and female population, as well as possible differences in their economic activity. Then, for example, the expression (7) will have the following form:

$$M_{OD} = \sum_{i=4}^{10} P_i \left[q_i^1 \left(\sum_{\tau=1}^{L-1} P_\tau^1 W_i^1\right) + q_i^2 \left(\sum_{\tau=1}^{L-1} P_\tau^2 W_i^2\right)\right], \tag{10}$$

where q_i^1 and q_i^2 are the probabilities (coefficients) of boys and girls birth, respectively;

P_i^1 and P_i^1 are the probabilities (coefficients) of living out to the age of *т*+1 (transition to the age group *т*+1) of males and females since the time of birth;

W_i^1 и W_i^1 are the indicators of economic activities of males and females at the age of *т*.

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

Let us consider the features and results of estimating the life value of males and females of different ages in Russia, considering and excluding the life value of future generations, using simplified examples with no discounting: a) at a constant cost of five years of their life equal to 50 thousand US dollars, i.e. 10 thousand per year, b) while reducing this five-year indicator for females to the level of 40 thousand US dollars (in practice, the income of an average female is about 20% less than that of a male), and assuming that the birth and living out parameters correspond to the levels of 2019.

3. RESULTS AND DISCUSSION

The obtained estimates of the life value of males and females of different ages at the same annual economic activity equal to 10 thousand US dollars are generally characterized by similar patterns (Figure 2). They show that this indicator decreases almost to zero with age according to a linear relationship (more precisely, according to a weakly expressed exponential law), which is due to not considering the effects of its discounting. If considering these effects, the noted patterns would correspond to more pronounced exponential dependencies. At that, the cost of female years of life is by about 10% or more than that for males of all ages, which is explained by the higher age-related mortality of the male population. In particular, in the first age group of 0-4 years, the life value of girls is estimated at almost 688 thousand US dollars, while for boys – by 65 thousand US dollars less. By the age of 70, these indicators are reduced to 33.8 and 29.6 thousand US dollars, respectively.

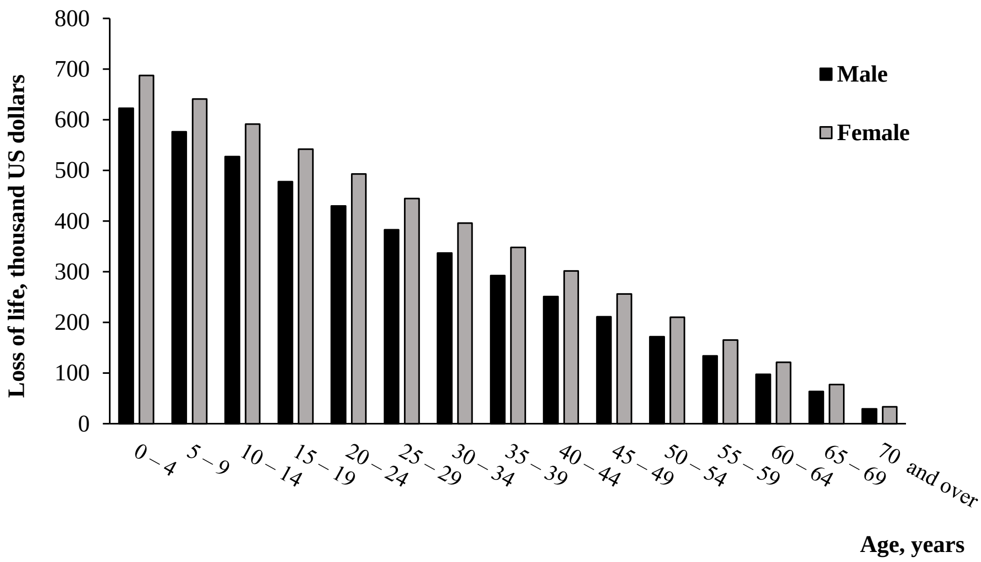

Figure 2. Life value of males and females aged up to 70 years and older at the same economic activity equal to 50 thousand US dollars for five years

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

With a decrease in the economic activity of females at all ages by 20% (i.e. from 50 to 40 thousand US dollars in five years) their life value in all age groups up to 50 years becomes less than that of males. In older age groups, the levels of these indicators are becoming almost equal due to the higher age-related mortality of males (Figure 3).

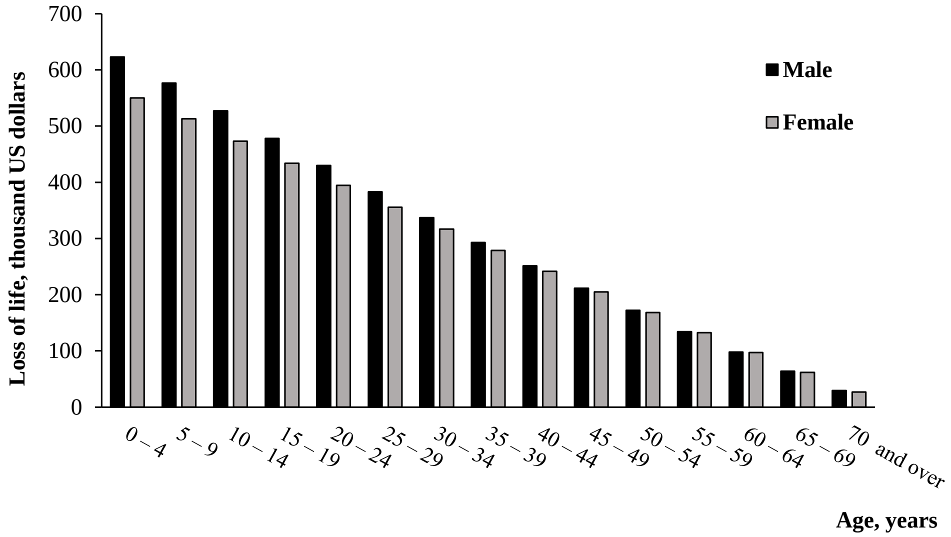

Figure 3. Life values of males and females aged up to 70 years and older, considering the differentiation of economic activity by gender

Compared to the previous version, the life value of the first age group girls decreases from 687.7 to 550.2 thousand US dollars, while for females aged 45-49 years – from 256.0 to 204.8 thousand US dollars, and for 70 years and older – from 33.8 to 27.0 thousand US dollars.

Considering the human life value of future generations in the estimates of similar indicators of the male and female population of childbearing and younger ages significantly increases their magnitudes, especially in the first five age groups younger than 30 years. Figure 4 shows graphical dependences illustrating the age distribution of the human life value of the male and female population, assuming that every five years of their life is estimated at 50 and 40 thousand US dollars, respectively, and the traditional birth-rates of females are distributed between the male and female groups in the proportions of 3:7.

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

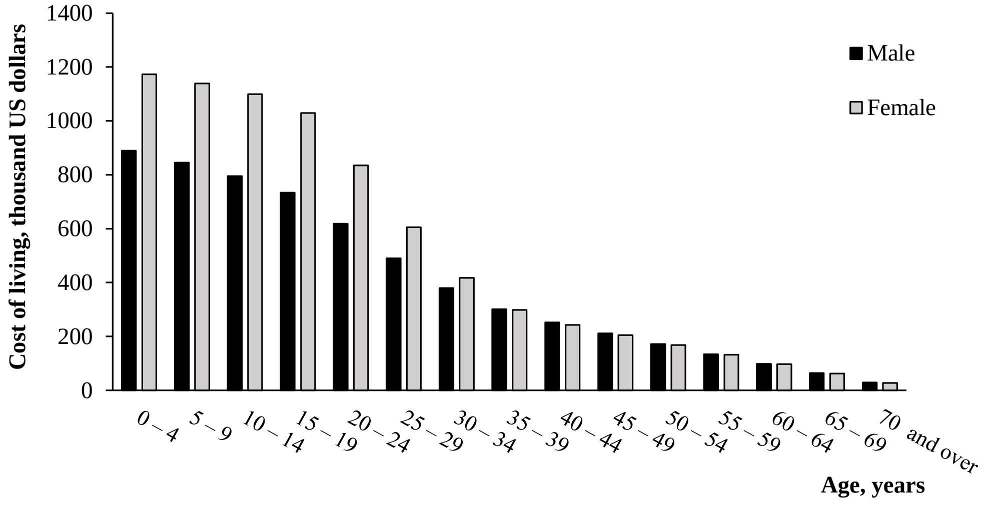

Figure 4. Life values of males and females aged up to 70 years and older, considering the contribution to future generations

As follows from the comparison of the graphs in Figures 3 and 4, under such assumptions, the life value of girls in the age group 0-4 years, considering the contribution of future generations to this indicator, increases from 550.2 to 1173.0 thousand US dollars, while of the same age boys – increases from 622.9 to 889.8 thousand US dollars. In the group of 10-14 years, these indicators increase for females from 473.2 to 1099.4 thousand US dollars, while for males – from 527.2 to 795.6 thousand US dollars. In the group of 25-29 years, the same figures for females increase from 355.5 to 605.3 thousand US dollars, while for males – from 383.0 to 490.0 thousand US dollars. Further, with the increase in age up to 49 years, the difference in these indicators decreases to zero for both males and females.

The variability patterns in the estimates of the Russian population's value of different ages presented in Figure 4 are due to age differences in the degree of its involvement in the demographic reproduction process. The most significant role in this process is played by the age groups up to 14 years since they account for the maximum numbers of future generations. Even in the context of depopulation, the increases in their values of life due to accounting for these numbers can significantly exceed the basic estimates of this indicator in these groups, obtained only considering economic activity. Thus, in Russia in 2019, 1.5 children were accounted for per girl under the age of 15, following the total birth rate (the sum of all age-related coefficients). Note that according to demographers' estimates, the depopulation regime is characterized by values of this coefficient less than 2.1-2.2 (Arkhangelsky, Ivanova, & Rybakovsky, 2016; Tikhomirov & Tikhomirova, 2020). In older age groups, the value of the corresponding total birth rate decreases. In Russia in 2019, in the group of 15-19 years, it was

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

already 1.42, in the group of 20-24 years ~ 1.05, in the group of 25-29 years ~ 0.6, and in the group of 30-34 years ~ 0.25, etc.

The estimates of the males' and females' value of life in the corresponding age groups in Russia also increase in proportion to these indicators. Thus, based on the initial information used, in female age groups younger than 15 years these estimates increased by more than 100% compared to their baseline values while in male age groups they increased by 40-50%. The increments of these estimates decrease with age. Thus, in the groups of 30-34 years, in females, they decreased comparing with the corresponding basic indicators by 30%, while in males – by 10%, and became almost zero by 45 years.

4. CONCLUSIONS

Improving the concepts, approaches, and methods for obtaining reliable estimates of the population's life value is an important condition for increasing the socio-economic validity of the feasibility of implementing strategies and measures to reduce the risks of life in various areas, that contributes to a greater or lesser extent to achieving one of the most important goals of social development – reducing mortality and increasing life expectancy of people. The main condition for such expediency is the excess of the effects achieved based on such strategies in the form of the losses of the life values prevented by their implementation over the costs incurred, which usually have specific economic content. In this regard, it seems reasonable to use indicators that objectively express the economic results of individuals' activities as estimates of the human life value and its losses. An example of such indicators is the levels of per capita GDP. Assuming that these indicators are independent of the individual's gender and age, their magnitudes indicate that the human life value decreases over the age approximately linearly in case of the absence of discounting, and exponentially – when discounting future values of per capita GDP. This is due to an increase in GDP losses due to the increased mortality rate of the population with age. Given that the mortality rate of the male population is higher than that of the female population, estimates of the males' life value are lower than those of females for all ages.

Possible approaches to the refinement of estimates of the life value of the population are associated with the differentiation of average per capita GDP indicators by gender and age, and adjustments to reduce their values by the level of average per capita consumption. The obvious consequences of such modifications can be characterized by negative values of years of the life of the older population who have stopped their vigorous

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

economic activity, and by a decrease in this indicator in childhood when this activity has not yet begun. In the authors' opinion, such assessments are incorrect from a social viewpoint.

Considering the differentiation of economic activity by gender (for example, a decrease in the level of per capita GDP for females compared to males) naturally leads to a decrease in the life value at all ages. However, in general, the nature of the dependence of the life value of the female population on age does not change.

According to the authors, the proposal to take into account the population's value of life at different ages, and its contributions to the reproduction of future generations, whose economic estimates can be estimated in practice based on the expected values of the age-specific birth rates of females, is quite reasonable. The main problem is the distribution of estimates of the value of future generations between male and female age groups. Attributing this value only to the female population significantly increases its economic significance (more than twice), especially in the younger age groups up to 15 years, considering the fact that the number of children attributed to them corresponds to the sum of age-specific birth rates, which can significantly exceed unity even in the context of depopulation. In the future, with age, the expected number of children and the corresponding value increments decrease and, starting from the age of 45-49, become zero.

In this regard, considering the role of males in the reproduction of future generations, it seems fairer to distribute the expected generations between male and female groups in a certain proportion (preferably with a larger proportion in the female population).

In general, the implementation of this approach leads to a significant increase in the economic importance of the population under the age of 30, which encourages the preservation of the population and thereby contributes to overcoming depopulation.

ACKNOWLEDGMENTS

The study was carried out with the financial support of the RFBR, project No. 20-010-00307 "Methodology for assessing public health losses and justification of areas improving the efficiency of health systems in the regions of the Russian Federation".

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

REFERENCES

Abelson, P. (2008). *Establishing a monetary value for lives saved: Issues and controversies*. Working papers in cost-benefit analysis. Office of Best Practice Regulation, Department of Finance and Deregulation, Sydney. Retrieved from https://obpr.pmc.gov.au/sites/default/files/2021-06/Working_paper_2_Peter_Abelson.pdf

Arkhangelsky, V. N., Ivanova, A. E., & Rybakovsky, L. L. (2016). *The effectiveness of Russia's demographic policy*. Moscow: Ekon-Inform Publishing House.

Bahamonde-Birke, F. J., Kunert, U., & Link, H. (2015). The value of a statistical life in a road safety context – a review of the current literature. *Transport Reviews, 35*(4), 488–511. http://dx.doi.org/10.1080/01441647.2015.1025454

Baum, H., & Hohnscheid, K. J. (1999). *Volkswirtschaftliche Bewertung von Personenschaden im Strasenverkehr, Fortschreibung für 1994* [Economic assessment of personal injury in road traffic, update for 1994]. Bergisch Gladbach: Bundesanstalt für Straßenwesen.

Brent, R. J. (Ed.). (2004). *Cost-benefit analysis and health care evaluations*. Cheltenham: Edward Elgar Pub.

De Blaeij, A., Florax, R. J. G. M., Rietveld, P., & Verhoef, E. (2003). The value of statistical life in road safety: A meta-analysis. *Accident Analysis & Prevention, 35*(6), 973-986. https://doi.org/10.1016/s0001-4575(02)00105-7

Elvik, R. (1995). An analysis of official economic valuations of traffic accident fatalities in 20 motorized countries. *Accident Analysis and Prevention, 27*(2), 237-247. http://dx.doi.org/10.1016/0001-4575(94)00060-Y

Fein, R. (1958). *Economics of mental illness*. New York: Basic Books.

Hasemann, I. (2000). Model description of the late economics modeling. RODOS (WG3), TN (99)-62, 23 p.

The International Commission on Radiological Protection (ICPR). (1993). *Principles of intervention for the protection of the public in a radiological emergency: A report*. ICRP Publishing, 40 p.

Jones-Lee, M. (1994). Safety and the saving of life: The economics of safety and physical risk. In R. Layard & S. Glaister (Eds.), *Cost-Benefit Analysis* (pp. 290-318). Cambridge: Cambridge University Press. https://doi.org/10.1017/CBO9780511521942.010

Jones-Lee, M., Hammerton, M., & Abbott, V. (1987). The value of transport safety: Results of a national sample survey. *Medicine*. Retrieved from https://www.semanticscholar.org/paper/THE-VALUE-OF-TRANSPORT-SAFETY%3A-RESULTS-OF-A-SAMPLE-Jones-Lee-Hammerton/e42b4b15720a4d7ce628adcde48ae82b44be509a

Jones-Lee, M. W., & Loomes, G. (1995). Scale and context effects in the valuation of transport safety. *Journal of Risk and Uncertainty, 11*(3), 183–203.

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]

Krupp, R., & Hundhausen, G. (1984). *Volkswirtschaftliche bewertung von personenschäden im straßenverkehr* [Economic assessment of personal injury in road traffic]. Bergisch Gladbach: Bundesanstalt für Straßenwesen.

Miller, T. (2000). Variations between countries in values of a statistical life. *Journal of Transport Economics and Policy, 34*(2), 169–188.

Murray, C. J. L., & Lopez, A. D. (2013). Measuring the global burden of disease. *New England Journal of Medicine, 369*(5), 448-457.

Mushkin, S. J., & Collings, F. A. (1959). Economic costs of disease and injury: A review of concepts. *Public Health Report, 74*(9), 795-809. https://doi.org/10.2307/4590578

OECD. (2012). *Mortality risk valuation in environment, health and transport policies*. Paris: OECD Publishing. https://doi.org/10.1787/9789264130807-en

Rizzi, L. I., & de Dios Ortúzar, J. (2006a). Estimating the willingness-to-pay for road safety improvements. *Transport Reviews, 26*(4), 471–485. https://doi.org/10.1080/01441640600602302

Rizzi, L. I., & de Dios Ortúzar, J. (2006b). Road safety valuation under a stated choice framework. *Journal of Transport Economics and Policy, 40*(1), 69-94.

Roik, V. D. (1994). *Social insurance: History, problems, ways of improvement*. Moscow: Research Institute of Labor of the Ministry of Labor of the Russian Federation.

Tikhomirov, N., & Tikhomirova, T. (2020). Methods used to justify strategies of achieving the expanded population reproduction. *Revista Inclusiones, 7*(S3-5), 628-640.

Tikhomirova, T. M., & Kamenetskaya, A. A. (2020). Critical review of approaches and methods for assessing the human life value. *Business. Education. Right, 3*(52), 124-131. https://doi.org/10.25683/VOLBI.2020.52.385

Viscusi, W. K., & Aldy, J. E. (2003). The value of a statistical life: A critical review of market estimates throughout the world. *Journal of Risk and Uncertainty, 27*(1), 5–76. http://dx.doi.org/10.2139/ssrn.362840

Weisbrod, B. A. (1965). Burial costs and premature death. *Journal of Political Economy, 73*, 504-508.

[Received/Recebido: September 12, 2021; Accepted/Aceito November 13, 2021]