REVIEW

EXPERIMENTAL ONCOLOGY

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VITAL MEASUREMENT OF POPULATION QUALITY OF LIFE

Background. The quality of life (QoL) of the population determines the economic and social (including demographic) behavior of the population. It is a complex concept that has its objective and subjective dimensions. Components of the objective measurement are the individual income of the population and the income of the state. The level of the development of an individual can be determined by the level of education (or the number of years of education). The overall indicator of the country's development is the life expectancy of its citizens. **Aim**. To investigate at the state level the interrelationship and interdependence of such characteristics of the QoL as the level of income, education, and life expectancy. **Information Base and Methods**. As an information base, we used the data from international organizations (the United Nations, the World Bank, the World Health Organization, the State Statistics Service of Ukraine) and the specialized database on mortality (Human Mortality Database) and applied general scientific and statistical research methods. **Results**. The relationship between life expectancy at birth and the duration of education and domestic national income was established based on the analysis of the data of 2022 for 193 countries. The conditionality of cancer mortality from the QoL was identified. Three groups of European countries different in terms of both the QoL and the level of cancer mortality were distinguished. In these groups, the specifics of the distribution of cancer-related mortality by gender and age was analyzed. **Conclusions**. The results of the study evidence that the mortality rate of the population depends on the quality of its life, in particular, well-being and education. The increase in well-being is reflected in the increase in the specific part of those who died from cancer. However, these deaths will peak later, ultimately contributing to population growth.

Keywords: quality of life, life expectancy, well-being, education, cancer mortality.

Practically all demographic processes, in particular demographic behavior and attitudes toward childbirth, welcoming behavior, and the desire to move to a country with more comfortable living conditions and higher incomes, determine the quality of life (QoL) of the population in one way or another. In the formation of such a complex characterization of various aspects of human life, both objective and subjective dimensions are important (Fig. 1).

The objective indicators are based on the statistical data and only in some cases on the results of public opinion research, such as the population's assessment of the effectiveness of governance, se-

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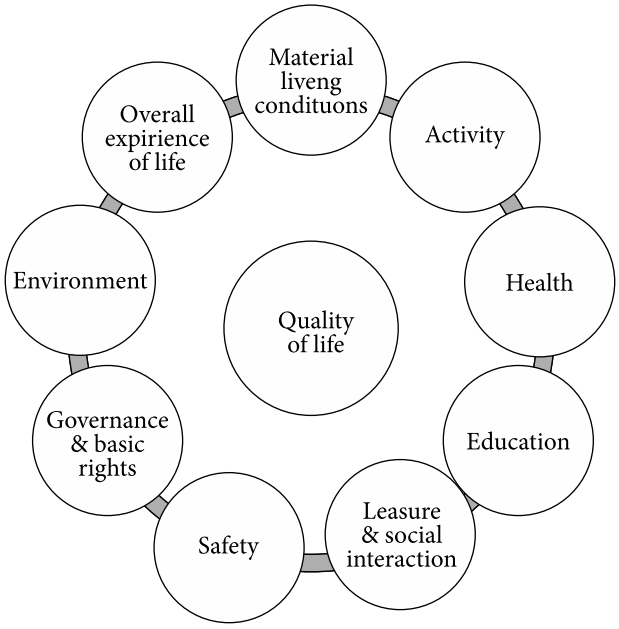


Fig. 1. Components of population QoL
Source: Eurostat [1]

curity, etc. In any case, the estimates of this type play only an auxiliary role and are used when there is not enough statistical data. The subjective indicators reflect the population's assessment of the compliance of certain parameters of the QoL with certain standards; the latter can be artificially overstated or understated due to various reasons.

The vital dimension of the QoL is determined by 3 components: health status, determinants of health and access to healthcare (Table 1).

Thus, the key factors of the vital dimension of QoL are the levels of education and income of the population.

Information Base and Methods

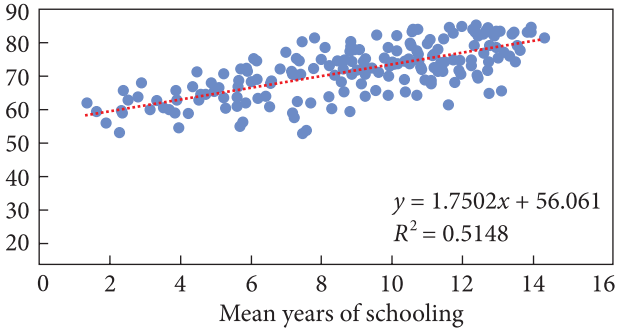
In the research, we used the data from the databases of international organizations:

- United Nations (Department of Economic and Social Affairs, Population Division) — dynamic series of demographic indicators;
- Human Cause-of-Death Data series (HCD), which is based on the Human Mortality Database (HMD) — sex-age structure of the deceased by causes of death, reconstructed to the International Classification of Diseases, 10th Revision;
- United Nations Development Program (UNDP) — components of the Human Development Index (HDI, 2022);

Table 1. **Vital measurement of the QoL**

Health status	Determinants of health	Access to healthcare
Life expectancy by age and sex	Body mass index by sex, age and educational attainment level	Self-reported unmet needs for medical examination by sex, age, main reason declared, and educational attainment level
Healthy life expectancy years by sex	Body mass index by sex, age, and income quintile	
Self-perceived health by sex, age, and educational attainment level	Daily smokers of cigarettes by sex, age, and educational attainment level	
Self-perceived health by sex, age and income quintile	Daily smokers of cigarettes by sex, age, and income quintile	
Current depressive symptoms by sex, age, and educational attainment level	Frequency of heavy episodic drinking by sex, age, and educational attainment level	
Current depressive symptoms by sex, age, and income quintile	Frequency of heavy episodic drinking by sex, age, and income quintile	
	Performing (non-work-related) physical activities by sex, age, and educational attainment level	
	Time spent on health-enhancing (non-work-related) aerobic physical activity by sex, age, and educational attainment level	
	Daily consumption of fruit and vegetables by sex, age, and educational attainment level	

Source: Eurostat [2].



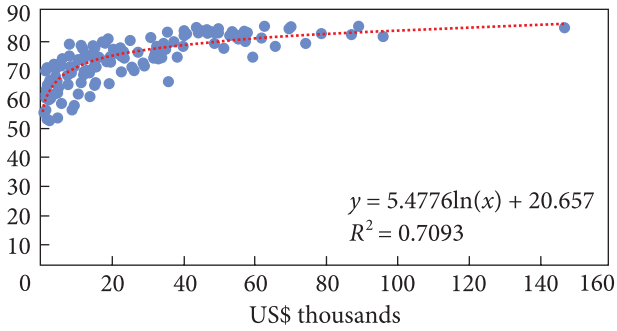


Fig. 2. Life expectancy at birth & mean years of schooling.
Source: calculated by authors based on the data of the Human Development Report 2023—2024 [3]

Fig. 3. Life expectancy at birth gross domestic income per capita, $PPP
Source: calculated by authors based on the data of the Human Development Report 2023—2024 [3]

- World Health Organization (WHO) — mortality by causes;
- World Bank (WB) — gross domestic income per capita, $PPP;
- State Statistics Service of Ukraine (SSSU) — sex-age structure of cancer deaths.

General scientific research methods such as abstract-logical, theoretical, classification-analytical, and content analyses along with the synergistic approach and statistical methods such as correlation-regression and graphic analyses were used in the research.

Results and Discussion

UNDP periodically calculates the HDI for almost all countries of the world. HDI characterizes the level of human development of each country. It is calculated on the basis of a system of indicators, among which is life expectancy at birth. In our opinion, life expectancy at birth is a generalized characteristic of the country's development, and therefore the QoL of its population. It characterizes the country's level of development no worse than the HDI. However, the calculation of HDI includes a number of indicators, which makes it possible to assess their impact on life expectancy at birth.

The key factors of the vital dimension of QoL are the level of education and income of the population. When building regression models, they are used as independent variables; the dependent variable is life expectancy at birth. Modeling is complicated by the inertia of the transformation of QoL — an exception is its sharp decrease during disasters such as war. Accordingly, it is difficult to describe, say, the trends in the QoL of the population of Ukraine and to assess dynamic relationships. Therefore, almost the only possibility for its research is the dependence of life expectancy on the level of education of the population and well-being in statics according to the data of different countries.

Fig. 2 shows the distribution of 193 countries by life expectancy at birth and duration of education according to the data of 2022. The effect of education on life expectancy is best described by a linear regression model: $Y = 1.7502x + 56.01$. It reflects the direct relationship between life expectancy at birth and mean years of schooling at $R^2 = 0.5148$.

Both the graph and the specification of the model clearly confirm the high interdependence of the education and the life expectancy. It seems that the increase in the level of education due to a number of other factors (compliance of the rules of a healthy lifestyle, reduction of employment in harmful and dangerous conditions, better nutrition, systematic monitoring of one's health, civic activity, development of democracy, and a safer environment, etc.) eventually leads to a decrease in premature mortality and an increase in life expectancy.

However, most likely, an underlying factor is general socio-economic development, which quite clearly reflects the gross domestic income per capita ($PPP). In economically developed countries with a high GNI per capita, the population as a whole has a higher education, lives in better conditions, has better access to quality public services, including educational and medical ones, intelligently balances the duration of work and leisure, and, as a result, lives longer.

The model was also built based on the data from 193 countries (2022). The logarithmic curve, which

is described by the equation $Y = 5.4776 \ln(x) + 20.6570$ at $R^2 = 0.7093$, reflects a completely obligate close relationship between life expectancy at birth and $PPP (Fig. 3).

The joint influence of these two factors is described by the model $Y = 1.0013 x_1 + 0.0002x_2 + 59.3318$, where x_1 is the mean years of schooling and x_2 is the gross domestic income per capita at $R^2 = 0.6450$. Thus, these two factors together determine two-thirds of the variation in life expectancy at birth.

The next step in the study of the vital dimension of the QoL of the population was an attempt to distinguish cancer mortality and find out its dependence on the QoL. Because of the prevalence of overall premature mortality in less developed countries and the fact that cancer-related mortality occurs predominantly in older age groups, the relationship is not so simple. The higher the QoL and life expectancy of population, the higher the share of deaths from cancer in the total number of deaths, and in some countries (France, Japan, Canada, Great Britain), cancer mortality already exceeds mortality from diseases of the cardiovascular system (Table 2). The table shows the data only for 2019 due to the fact that the structure of the causes of death in subsequent years was significantly affected by the Covid-19 epidemic.

There is also observed a direct relationship between the age of those who died from cancer and QoL: the higher QoL, the later death occurs. In particular, in Europe, 3 groups of countries are distinguished: highly developed countries ("old democracies"), countries that joined the EU relatively recently (former countries of the socialist camp), and countries — former republics of the USSR. Regardless of the gender of the deceased, the shapes of the age curves have clear features according to the selected groups of countries.

In the first group, a noticeable increase in the number of deaths from cancer is observed after the age of 60, and the peak occurs at the age of 85+ (an exception is the cancer-related mortality of men in Germany where most people die from neoplasms

Table 2. **The economical factor of the vital measurement of the QoL, 2019**

State	GNI per capita, PPP$	Life expectancy at birth, years	Share in total number of deaths, %	
			Diseases of the cardiovascular system (I00–I99)	Cancer (C00–D48)
Ukraine	14 560	73.9	67.0	13.5
Estonia	39 070	78.8	51.3	26.2
Latvia	32 810	75.6	55.2	22.5
Lithuania	39 170	76.4	55.2	21.9
Moldova*	12 430	70.2	58.4	16.7
Poland	34 010	77.9	44.8	29.3
Romania	33 070	75.3	56.5	19.7
Czechia	42 150	79.2	42.9	26.1
Slovakia	33 130	77.7	42.3	25.8
United Kingdom	49 860	81.4	24.4	28.5
Spain	43 820	83.5	28.6	27.6
Canada	49 900	82.3	25.7	29.6
Germany	60 430	81.2	36.5	26.7
USA	66 280	78.9	31.0	21.8
France	52 340	82.4	22.7	28.1
Sweden	58 960	82.5	31.9	26.4
Japan	44 350	84.4	28.9	30.8

Note: * 2018.
Source: composed by authors based on the data of UN [4], HCD [5], WHO [6], WB [7], and SSSU [8].

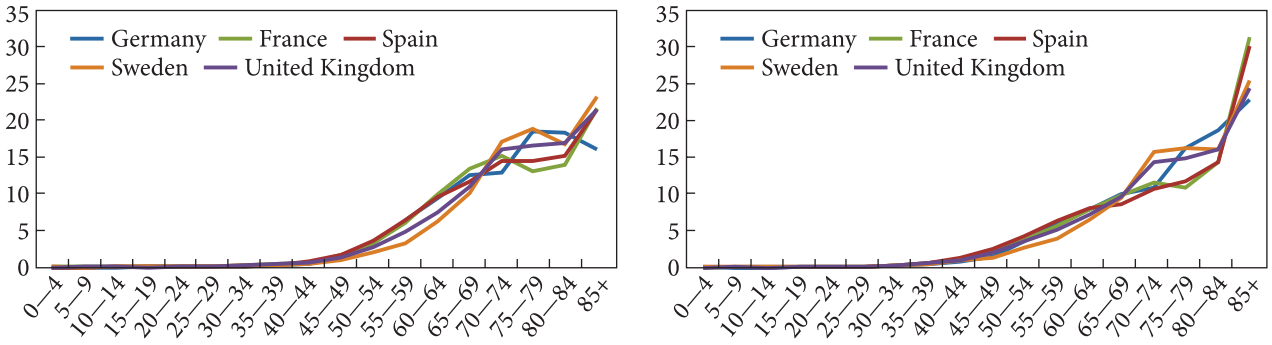


Fig. 4. Distribution by age group of men who died from cancer in some highly developed countries, 2019, %
Source: calculated by authors based on the data of HCD [5] and WHO [6]

Fig. 5. Distribution by age groups of women who died from cancer in some highly developed countries, 2019, %.
Source: calculated by authors based on the data of HCD [5] and WHO [6]

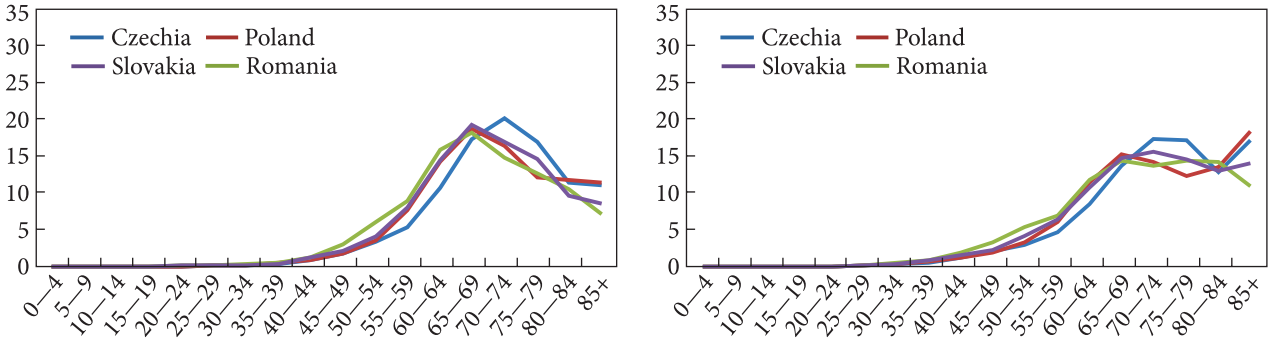


Fig. 6. Distribution by age group of men who died from cancer in some former countries of the socialist camp, 2019, %
Source: calculated by authors based on the data of HCD [5] and WHO [6]

Fig. 7. Distribution by age group of women who died from cancer in some former countries of the socialist camp, 2019, %
Source: calculated by authors based on the data of HCD [5] and WHO [6]

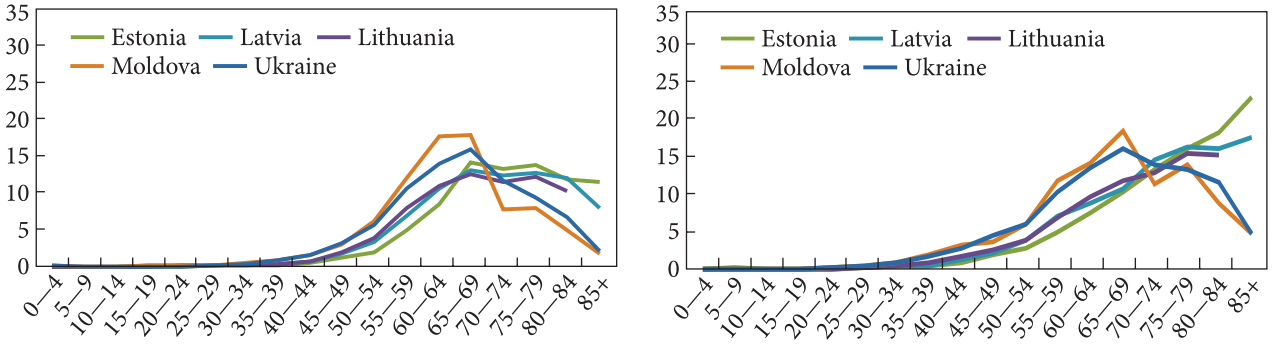


Fig. 8. Distribution by age group of men who died from cancer in some countries — former republics of the USSR, 2019, %
Source: calculated by authors based on the data of HCD [5] and WHO [6]

Fig. 9. Distribution by age group of women who died from cancer in some countries — former republics of the USSR, 2019, %
Source: calculated by authors based on the data of HCD [5] and WHO [6]

at the age of 80—84). In the countries of this group, there is a large part of people aged 85+ (Fig. 4, 5).

In the second group of countries, at a similar age of the beginning of the increase in mortality, most men die from cancer at the age of 65—69 (Poland, Romania, Slovakia) and 70—74 (Czech Republic), and most women — at the age of 85+ (Czech Republic and Poland), 70—74 years (Slovakia), and 60—65 years (Romania), which is a consequence of a much smaller population in older age groups in these countries (Figs. 6, 7).

In the third group, the age characteristics of cancer-related mortality in the Baltic countries differ significantly from those observed in Ukraine and

Moldova. In the Baltic countries, the age distributions of the deceased from cancer are similar to those in Central Europe, although they are shifted to the left by 5—10 years for men. That is, deaths occur 5—10 years earlier in accordance with a significant reduction in the number of older men. The curves of the mortality rates in Moldova and Ukraine are markedly similar, with peaks at the age of 60—69 with a subsequent significant decrease in the number of deaths as the majority of the population of these countries does not live up to 70 (men) and 80 (women) years (Figs. 8, 9).

The results of our study evidence that the mortality regime of the population depends on its QoL, in particular, well-being and education. This, however, does not guarantee that an increase in the QoL will lead to a decrease in mortality, in particular the cancer-related one. On the contrary, most likely, the growth of well-being will be reflected in the rise of cancer mortality, that is, an increase in the specific part of those who died from cancer in the total number of deaths. But, judging by the built models, the peak of these deaths will come later. Therefore, the growth of well-being ultimately will contribute to the growth of the population and human capital of Ukraine. The influence of the socio-economic system of the country on the structure of the causes of death requires further research.

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ВІТАЛЬНИЙ ВИМІР ЯКОСТІ ЖИТТЯ НАСЕЛЕННЯ

Вступ. Якість життя населення визначає економічну та соціальну, у тому числі демографічну, поведінку населення. Якість життя є комплексним поняттям, яке має об'єктивний та суб'єктивний виміри. Складовими об'єктивного виміру є як індивідуальні доходи населення, так і доходи держави. Рівень розвитку індивіда можна визначати за рівнем освіти (або кількістю років навчання), а узагальнюючим показником розвитку країни є тривалість життя її громадян. **Мета**. Дослідити взаємозв'язок та взаємообумовленість на державному рівні таких характеристик якості життя як рівень доходу, освіта та тривалість життя. **Інформаційна база та методи**. Як інформаційну базу використано дані міжнародних організацій (Організація Об'єднаних Націй (United Nations), Світового банку (World Bank), Всесвітньої організації охорони здоров'я (World Health Organization), Державної служби статистики України (State Statistics Service of Ukraine), а також спеціалізованої бази даних зі смертності (Human Mortality Database). При аналізі використовувались загальнонаукові та статистичні (переважно кореляційно-регресійний аналіз) методи дослідження. **Результати**. З'ясовано взаємозв'язок між очікуваною тривалістю життя при народженні та тривалістю навчання і внутрішнього національного доходу за даними 2022 року для 193 країн. З'ясовано обумовленість онкологічної смертності від якості життя. Виокремлено три групи європейських країн, відмінними як за рівнем якості життя, так і рівнем онкологічної смертності. Досліджено специфіку розподілу смертей від онкологічних захворювань за статтю та віком по трьох групах. **Висновки**. Результати дослідження доводять обумовленість режиму смертності населення якістю його життя, зокрема добробутом і освітою. Щодо питомої ваги померлих від новоутворень, вона зростатиме з ростом добробуту, але пік цих смертей наставатиме пізніше, і в кінцевому підсумку добробут сприятиме зростанню чисельності населення.

Ключові слова: якість життя, тривалість життя, добробут, освіта, онкологічна смертність.