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ARTICLE IN THE SPECIAL SECTION

Regional Differences in Life Expectancy in Russia Through the Lens of Epidemiological Transition

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ABSTRACT
An immense territory of Russia with several climatic zones and, accordingly, a fundamentally different styles of life, inevitably results in pronounced varieties in the levels and structure of mortality across the regions of the country. Since the scale and sustainability of differences in mortality in Russia can be considered an entire epidemiological epoch, the evaluation of them through the lens of epidemiological transition seems methodologically appropriate. Regional differences are regarded as a kind of projection of evolution in time, though taking into account modern realities. The analysis of regional differences in mortality is based on such indicators as life expectancy, structure of mortality, i.e., predominantly endogenous to exogenous causes of death ratio, as well as the average age of death from predominantly endogenous causes calculated on the basis of life tables by cause of death. The study showed that according to the periodization of

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epidemiological transition only Moscow and St. Petersburg are at the final phase of the 3rd stage and are moving to the 4th stage of epidemiological development. Meanwhile, the burden of exogenous and preventable pathologies precludes the completion of the 3rd stage in the regions with high life expectancy according to Russian criteria. The stadial nature of epidemiologic development of Russian regions is currently conditioned by socio-economic and medical determinants, with more pressing medical determinants in regions with high and medium levels of life expectancy and socio-economic factors prevailing in regions with low life expectancy.

KEYWORDS
epidemiological transition, stages of transition, mortality patterns, age, nosology, cause of death, preventable mortality

Introduction

Among the most discussed topics in the Russian demographic literature is the regional variation of mortality in Russia. An equally relevant is the search for determinants that explain this variation and contribute to the development of effective policies for its overcoming. Evidently, reducing losses from premature mortality will decrease the scale of depopulation and loss of labor potential, along with cutting socio-demographic costs caused by the breakup of marriages as a result of widowhood and an increase in the number of single-parent families, etc.

However, the policies being developed have no reliable scientific substantiation. A significant number of explanatory hypotheses are based on socio-economic, climatic, and geographical factors, availability and quality of medical care, alcoholization, etc., thus indicating that the situation is assessed rather by external manifestations. Consequently, this situation needs to be analyzed within the framework of theoretical approaches to the evolution of mortality and its explanatory determinants, namely the concept of epidemiological transition proposed by Abdel Omran (1971).

This article aims to define the stages of epidemiologic development of Russian regions as well as to identify its main problems in the context of preventable mortality.

Theoretical Framework

The scale and sustainability of differences in life expectancy in Russia (more than 15 years for men and ten years for women in 2022), which constitute two stable vectors, the European, that is, favorable South—unfavorable North, and trans-Russian, favorable West—unfavorable East, represent an entire epidemiological epoch. Therefore, the analysis of these differences through the prism of epidemiological transition seems methodologically appropriate, with regional differences considered a projection of evolution in time, though taking into account modern realities.

Omran (1971) has originally identified three stages of the epidemiological transition. They are the age of plague and famine (when mortality remained very high for thousands of years), the age of declining pandemics, and the age of degenerative and man-made diseases.

Some researchers believe that other living conditions associated with an appropriative economy ("hunter-gatherer economy") existed prior to the age of plague and famine. The mobility of our Paleolithic ancestors, small populations, and low densities would not have allowed infectious diseases to acquire the scale of a mass epidemic (Harper & Armelagos, 2010). The conditions favorable for the spread of infectious diseases appeared after the Neolithic Revolution characterized by the transition to a productive economy, when groups of people began to live in settled communities based on agriculture and domestication of animals. Moreover, the Neolithic Revolution was marked by social stratification, producing a significant difference in disease risk within a community (Armelagos & Harper, 2005). Therefore, the first epidemic transition, which took place about 10,000 years ago, could be associated with the Neolithic Revolution (Barrett et al., 1998).

Accordingly, the second epidemiological transition included the transition from infectious diseases to mortality from chronic diseases (Omran's first epidemiological transition). This was a period when better nutrition and improved living standards, public health measures, and possibly new health practices resulted in a significant reduction in infectious diseases and mortality.

The modern stage of epidemiologic development (the period of degenerative and occupational diseases) began with the discovery and extensive use of antibiotics. Due to this, mortality was first associated with the modern triad of circulatory diseases, neoplasms, injuries and poisonings.

We are believed to be experiencing the third epidemiological transition, where the re-emergence of familiar infections (now resistant to antibiotics) is accompanied by the emergence of a number of new diseases with a high risk of rapid spread due to globalization (Mercer, 2018).

The studies by Olshansky and Ault (1986), as well as by Rogers and Hackenberg (1987) proposed the fourth stage, based primarily on the experience of the United States, where mortality trends in the last third of the 20th century clearly indicated a new stage associated with the postponement of degenerative and occupational diseases. The same diseases that defined the third stage remain relevant, but death occurs at much older ages. Mortality is already very low at young ages, declines rapidly in old age, and mass deaths are postponed until old age. This fourth stage, referred to by Rogers and Hackenberg as the hybrid stage, is increasingly being affected by individual behavior and lifestyle.

At the end of the last millennium, Omran (1998) noted profound epidemiological changes, albeit occurring at different rates and times in different populations. This prompted him to move from a three-step/three-model to a five-step/five-model formulation of the epidemiologic transition theory (Omran, 1998). In this new version, Omran emphasized that the epidemiological transition, driven by economic and social development, included changes in fertility and age structure of the population leading to population ageing (part of the demographic transition), lifestyle changes (lifestyle transition), changing health care models (health transition), medical and technological evolution (technological transition), and environmental and ecological changes (ecological transition). He rejected the leading role of infections in the change of epidemiologic stages and emphasized the greater impact of social factors, lifestyle, personal hygiene, nutritional quality, and environmental factors. For the next transition, Omran outlined the following prerequisites: control of risk factors, high quality of life, equity, development, and social justice for all. Although outbreaks of new pathogens are among the least predictable threats to public health and global security (Drake et al., 2019), modern advances in medical technology are mitigating the role of infections in mortality patterns.

Omran (1998) also noted the possibility of reversal trends in the epidemiological transition, citing the example of the USSR collapse. The reverse epidemiological transition in Russia, where stressful economic problems halted the progress in healthcare thus putting back to agenda extremely high mortality in young ages from causes, which are typical for previous epidemiological stages, was convincingly shown in research by Semyonova (2005).

For developing countries, Omran identified fundamental differences caused by poverty, limited education, low status of women, and slow development. However, new discoveries in health care as well as technological development cause a layering of stages of epidemiologic transition in these societies (Omran, 1983). The result is at least three major overlapping problems: unresolved health problems, the emergence of new health problems, and unprepared health systems.

During the transition periods, systematic differences in the nature, pace, determinants, and consequences of changes in health, survival, and population size define several models of epidemiologic transition. Omran identified five models of transition for different societies: the Western, or classical, model; a semi-Western accelerated model for Eastern Europe, the former Soviet Union, and Japan; and three non-Western transition models for Third World countries including a rapid transition model for rapidly industrializing or socially developing countries and territories, an intermediate transition model for middle- and lower-middle-income countries, and a slow transition model characteristic of the least developed countries in Africa, Asia, and Latin America (Omran & Roudi, 1993). The latter model is now less prevalent due to the increasing incidence of non-communicable diseases in sub-Saharan Africa, accounting for 96% of all malaria deaths worldwide. Along with this, the double burden of noncommunicable and communicable diseases is detrimental to the health systems of these countries (Li et al., 2022).

Omran argues that in some multiracial or multicultural societies, more than one model coexists since different population groups may have diverse levels of health and medical care, as well as varying rates of transition within the same country. Differences may be due to geographic divisions (rural and urban areas, mountains and valleys), ethnic clusters, religious minorities, low-resourced areas, and isolated or neglected regions with limited access to education, development, or health services. Although the transition period leads to changes in all social classes, it tends to begin earlier and proceed faster among the wealthier rather than the poor and disadvantaged segments of the same society.

Thus, the theory of epidemiologic transition implies the simultaneous coexistence of different models of mortality (of age and nosology), developed under the influence of epidemiologic, economic, social, environmental, and health factors.

As a logical parallel to Omran's conceptual study, there appears a study by Rutstein et al. (1976), which is aimed at assessing the effectiveness of health care and, at first glance, of a purely practical nature. This approach was later developed in the form of the concept of preventable mortality. Due to this, mortality is considered preventable if the death causes can be eliminated using the modern knowledge and practices of the health care system. Westerling et al. (1996) revealed the level of preventable mortality to be higher in regions with insufficient socio-economic development, among people with low social status and educational level. At that, the contribution of preventable mortality to the overall mortality of the population in developed countries is 10%–30%, and in countries with weak economies, this figure is 40%–50% (Westerling, 2001).

The list of causes of preventable mortality has undergone enormous changes. Nevertheless, they are based on pathologies that medicine has learned to combat both by preventive (a number of diseases of the circulatory system) and clinical (including neoplasms) methods, as well as by complex efforts of social institutions (mainly external causes such as injuries and poisonings). Whereas in Russia the latter approach is still relevant, the European countries no longer consider external causes among those of preventable mortality (Sabgayda, 2017).

Thus, Omran's theoretical studies and Rudstein's practical research have shown how mortality patterns change (or stagnate): the socio-economic breakthrough of the late 18th and early 19th centuries in the most developed European countries contributed to the formation of a middle class, significantly increasing access (primarily material) to all the modern achievements of the time for more segments of society, including decent housing, adequate nutrition, sanitation and hygiene skills, access to medical care and education. This very situation created the conditions for the decline in mortality in the early and mid-19th century, long before the bacteriological revolution.

The consistency of the determinants of epidemiologic transition and preventable mortality ensures the combined use of these conceptual approaches to analyze regional differences in mortality in Russia. Therefore, the stadial nature of epidemiologic development in the vast geographical area of Russia can be determined, along with diseases and factors providing the success or failure of epidemiologic development in Russian regions.

Materials and Methods

Cardiovascular and oncologic diseases seem to be among the inevitable losses. In this approach, the principle is the late age of death, when dystrophic changes in the body are physiologically conditioned. Presently, the fact that deaths from cardiovascular diseases at working ages are mainly caused by behavioral risk factors and, therefore, are exogenous has become axiomatic. However, advances in clinical medicine and earlier detection of oncology can minimize mortality from neoplasms during the same period of life activity.

Meanwhile, infectious diseases, digestive diseases, and external causes should be considered preventable. Moreover, with regard to the developed system of prevention and adequate drug treatment, infectious diseases should be considered preventable regardless of age. Respiratory diseases are scarcely preventable only in old age. As for diseases of the digestive system in Russia, they often have an alcoholic etiology, hence also being assessed as exogenous. Injuries and poisonings are considered to be exogenous by convention, which is why all classifications refer them to causes preventable by a set of preventive measures.

Our study also included causes of death categorized as “Symptoms, signs, and abnormal clinical and laboratory findings, not elsewhere classified” (R00–R99) according to the International Classification of Diseases and Related Health Problems 10^{th} Revision (ICD-10)[1]. They not only account for a significant share in the structure of causes of death in most regions of the country, but also, depending on the average age of death, disguise either diseases of the circulatory system or external causes (Ivanova et al., 2013).

Hence, life expectancy levels (LE), mortality structure, i.e., the ratio of predominantly endogenous and exogenous causes of death, and the average age of death from predominantly endogenous causes are used assess the epidemiological development in the Russian territories.

We used life table data by cause of death as such indicators, namely the probability of death from individual causes, expressed as the share of deaths (SD) from a particular cause and the average age of death (AAD) from these causes. These will enable comparison between regions, regardless of their age structure.

The calculations were performed on the basis of data provided by Rosstat[2] [Federal State Statistics Service] upon request. Forms *Raspredelenie po polu, vozrastu i prichinam smerti* [Distribution by gender, age, and causes of death] and *Srednegodovaia chislennost' naseleniia po polu i vozrastu* [Average annual population by gender and age] for 2019 were used.

Results

For each indicator, the Russian regions have been independently grouped based on the standard deviation of groups with low, middle, and high levels. Based on the distributions obtained, a classification was developed based on male and female life expectancy. Within these classes, representation of regions with various combinations of SD from endogenous and exogenous causes and AAD from

[1] https://icd.who.int/browse10/2019/en#XVIII

[2] https://rosstat.gov.ru/folder/12781

endogenous causes[3] has been considered. Table 1 outlines the selected groups and their limits. The analysis was carried out according to the 2019 indicators to avoid fluctuations caused by the COVID-19 pandemic.

Table 1

Group Limits of the Russian Regions According to the Life Expectancy, Share of Deaths From Endogenous Causes, and Average Age of Death

	Life expectancy	Diseases of the circulatory system		Neoplasms	
		Share of deaths	Average age of death	Share of deaths	Average age of death
			Males		
High	> 68.3	> 48,400	> 71.6	> 18,300	> 68.9
Medium	65.5–68.2	42,501–48,399	69.6–71.5	15,801–18,299	67.4–68.8
Low	< 65.6	< 42,500	< 69.5	< 15,800	< 67.3
			Females		
High	> 78.3	> 56,300	> 79.7	> 15,000	> 70.8
Medium	76.4–78.2	47,501–56,299	78.5–79.6	12,301–14,999	69.2–70.7
Low	< 76.5	< 47,500	< 78.4	< 12,300	< 69.1

The area of well-being, where LE exceeded 68.3 years in males and 78.3 years in females, in 2019 included 22 and 25 regions, respectively.

For males, the most common regions included the ones with high SD and AAD from diseases of the circulatory system: a similar situation was registered in seven out of 22 regions, i.e., 31.8% of the area (Moscow, St. Petersburg, Sevastopol, North Ossetia–Alania, Stavropol Krai, Volgograd and Saratov Oblasts). A combination of high SD and medium AAD is presented with almost the same frequency (six regions out of 22). Mordovia is the only territory of the area of well-being with registered low SD from diseases of the circulatory system and low AAD (Table 2).

Table 2

Typology of the Russian Regions With High Life Expectancy According to Share of Deaths From Diseases of the Circulatory System and Average Age of Death (2019)

SD/AAD	High	Medium	Low
		Males	
High	Moscow, St. Petersburg, Sevastopol, North Ossetia–Alania, Stavropol Krai, Volgograd Oblast, Saratov Oblast	Dagestan, Kabardino-Balkaria, Tatarstan, Khanty-Mansi Autonomous Okrug, Adygea	Krasnodar Krai, Moscow Oblast, Leningrad Oblast

[3] A group with a high share of deaths from external causes includes regions where the required indicators exceed 5.6% and 2.7% for diseases of the respiratory system in males and females, respectively, 6.2% and 5.6% for diseases of the digestive system, and 2.1% and 1.1% for infectious diseases, 12.5% and 4.1% for external causes and 6.9% and 14.4% for symptoms, signs, and ill-defined conditions in males and females, respectively. A group with a low share of deaths from externa causes included regions where the required indicators were lower than 3.7% and 1.4% for diseases of the respiratory system in males and females, respectively, 4.9% and 4.1% for diseases of the digestive system, and 0.75% and 0.4% for infectious diseases, 9% and 2.6% for external causes, and 3.7% and 6.5% for symptoms, signs, and ill-defined conditions in males and females, respectively.

Table 2 Continued

SD/AAD	High	Medium	Low
Medium	Belgorod Oblast	Kalmykia, Rostov Oblast, Kaliningrad Oblast	Karachay-Cherkessia
Low			Mordovia
		Females	
High	Moscow, St. Petersburg, Sevastopol, North Ossetia–Alania, Volgograd Oblast, Penza Oblast	Dagestan, Tatarstan, Khanty-Mansi Autonomous Okrug, Yamalo-Nenets Autonomous Okrug	Mari El, Leningrad Oblast
Medium	Stavropol Krai	Adygea	Kalmykia, Kabardino-Balkaria, Chuvash Republic, Krasnodar Krai, Moscow Oblast
Low		Belgorod Oblast	Karachay-Cherkessia, Mordovia, Voronezh Oblast, Ryazan Oblast, Tambov Oblast

As with cardiovascular diseases, in case of neoplasms, a low AAD is the rarest in the area of well-being (three regions out of 22), almost 60% of the area have high AAD, while the most common are regions with high SD and high AAD (six or 27.3% of regions) such as Moscow, St. Petersburg, Sevastopol, Yamalo-Nenets Autonomous Okrug (AO), Leningrad and Kaliningrad Oblasts (Table 3).

Table 3

Classification of the Russian Regions With High Life Expectancy According to Share of Deaths From Neoplasms and Average Age of Death (2019)

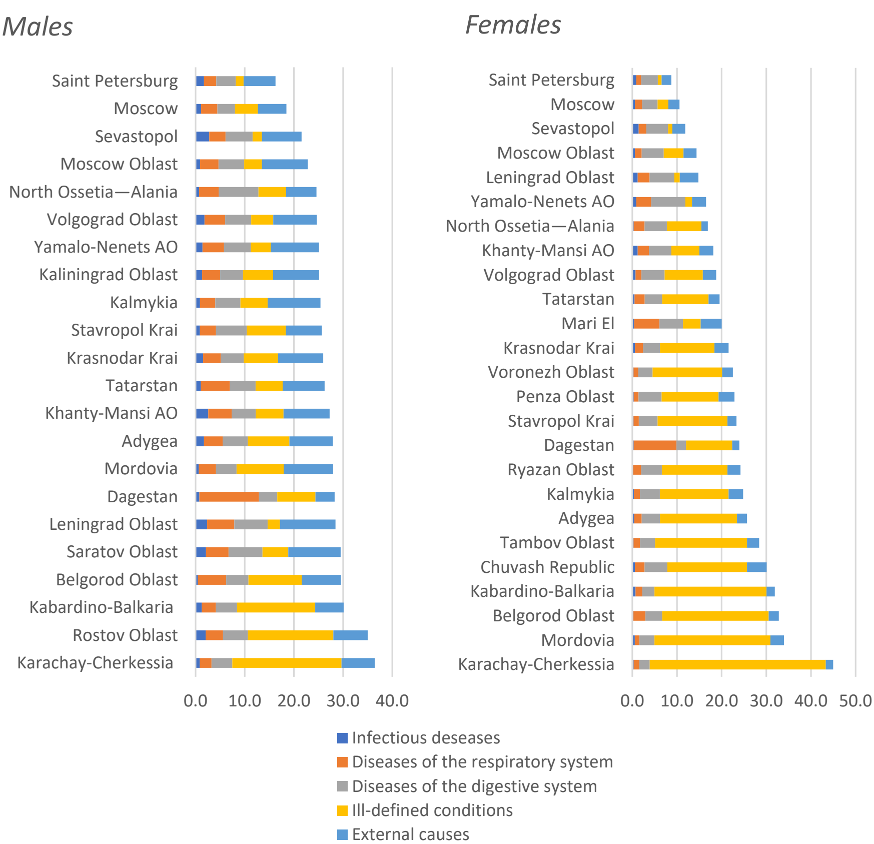
SD/AAD	High	Medium	Low
		Males	
High	Moscow, St. Petersburg, Sevastopol, Yamalo-Nenets AO, Kaliningrad Oblast, Leningrad Oblast	Kabardino-Balkaria, Tatarstan, Khanty-Mansi AO, Volgograd Oblast	Dagestan, North Ossetia–Alania, Moscow Oblast
Medium	Kalmykia	Adygea, Saratov Oblast	Karachay-Cherkessia, Krasnodar Krai, Stavropol Krai
Low			Mordovia, Belgorod Oblast, Rostov Oblast
		Females	
High	Moscow, St. Petersburg, Yamalo-Nenets AO, Sevastopol, Leningrad Oblast	North Ossetia–Alania, Kalmykia, Tatarstan, Moscow Oblast	Mari El, Khanty-Mansi AO
Medium		Adygea, Volgograd Oblast	Kabardino-Balkaria, Chuvash Republic, Ryazan Oblast, Krasnodar Krai
Low			Dagestan, Karachay-Cherkessia, Mordovia, Stavropol Krai, Belgorod Oblast, Voronezh Oblast, Penza Oblast, Tambov Oblast

A characteristic feature of the area of well-being is a fairly low burden of exogenous causes. For example, high SD from preventable diseases is registered in no more than 18% of the area (Figure 1).

Symptoms, signs, and ill-defined conditions are the exception to the rule, their low SD in the area of well-being seems rather an exception, registered in only four regions (St. Petersburg, Sevastopol, Moscow Oblast, and Leningrad Oblast), while more than 40% of the area have high SD from these vague causes. However, high SD from ill-defined conditions is registered in the regions with high AAD, which may indicate that mortality from cardiovascular diseases in this class is disguised.

Figure 1

Share of Deaths From Causes Preventable by Modern Medicine and Healthcare in the Russian Regions With High Life Expectancy, % (2019)



In females, like in males, the most typical of the area of well-being is high AAD from diseases of the circulatory system, registered in almost half of the regions within the area (12 out of 25). However, in females, low AAD is much more common than in males (six of the 25 regions within the area of well-being, or 24%), though in this case it is usually accompanied by low SD from cardiovascular diseases (five regions) as shown in Table 2.

A reference combination (high SD–high AAD) is registered in six regions, or 24% of the area of well-being (Moscow, St. Petersburg, Sevastopol, North Ossetia–Alania, Penza Oblast, Volgograd Oblast).

As for neoplasms, high AAD is also the most typical of females died from cancer in the area of well-being (11 regions, or 44% of the area), while, unlike men, a combination of low SD and low AAD, registered in eight regions (32% of the area) seems to be the most typical. The required combination of high SD and high AAD was registered only in 20% of the area of well-being including Moscow, St. Petersburg, Sevastopol, Yamalo-Nenets Autonomous Okrug, Leningrad Oblast (Table 3).

As well as males, females in the area of well-being have a slight burden of exogenous causes: the maximum SD does not exceed 15% if ill-defined conditions are excluded (Figure 1).

As for ill-defined conditions, like in males in the area of well-being, these causes are also widespread in females, while high SD is registered in 44% of the area. However, none of these regions showed low AAD, typical of residents of Moscow, St. Petersburg, Sevastopol, Leningrad Oblast, and Yamalo-Nenets Autonomous Okrug, where SD from ill-defined conditions is minimal. In fact, in regions with high SD from ill-defined conditions, these causes disguise mortality from chronic noncommunicable diseases in both males and females, and most often diseases of the circulatory system. This is evidenced by high AAD from ill-defined conditions in these regions, whereas in the regions with lowest SD and low AAD ill-defined conditions are most likely to disguise injury and poisoning (Ivanova et al., 2013).

Next, let us consider the opposite group of the regions with the lowest life expectancy (65.6 years and below in males and 76.4 years and below in females), which included 22 and 24 regions, respectively.

In this area of distress, the most common is medium SD from diseases of the circulatory system rather than high SD, registered in males and females (nine and 11 regions, 40.9% and 45.8% of the area, respectively) as shown in Table 4. As expected, regions with low AAD prevailed (12 and 15 regions, respectively, or 54.5% and 62.5% of the area). It should be noted that there was not a single region in the area of distress with high AAD in males, high AAD in females was registered in two regions only.

Table 4

Classification of the Russian Regions With Low Life Expectancy According to Share of Deaths From Diseases of the Circulatory System and Average Age of Death (2019)

SD/AAD	High	Medium	Low
		Males	
Medium	Kamchatka Krai, Perm Oblast, Pskov Oblast, Chukotka AO	Komi Republic, Khakassia, Kemerovo Oblast, Magadan Oblast	Buryatia, Tuva
Low	Jewish AO	Karelia, Primorsky Krai, Khabarovsk Krai, Novgorod Oblast, Irkutsk Oblast	Altai Republic, Zabaykalsky Krai, Altai Krai, Amur Oblast, Kurgan Oblast, Sakhalin Oblast

Table 4 Continued

SD/AAD	High	Medium	Low
		Females	
High	Krasnoyarsk Krai, Murmansk Oblast		
Medium	Khakassia, Pskov Oblast, Magadan Oblast	Buryatia, Tver Oblast, Kemerovo Oblast	Sakhalin Oblast
Low	Kamchatka Krai, Jewish AO, Chukotka AO, Irkutsk Oblast	Altai Republic, Tuva, Komi Republic, Karelia, Primorsky Krai, Zabaykalsky Krai, Khabarovsk Krai, Novgorod Oblast	Altai Krai, Amur Oblast, Ivanovo Oblast

As for neoplasms, for men, half of the area consisted of regions with medium SD, a low indicator was registered in 31.8% of the area (Table 5). For females, regions with high and medium SD were distributed almost equally (12 and 11 regions, respectively); low SD was registered in one region only. The medium level of AAD from neoplasms is typical of the area of distress, registered in 13 regions (59.1% of the area in males and 54.2% in females), while AAD was low in seven and nine regions (31.8% and 37.5%, respectively), and high AAD from neoplasms was registered in only two regions in both males and females.

Table 5

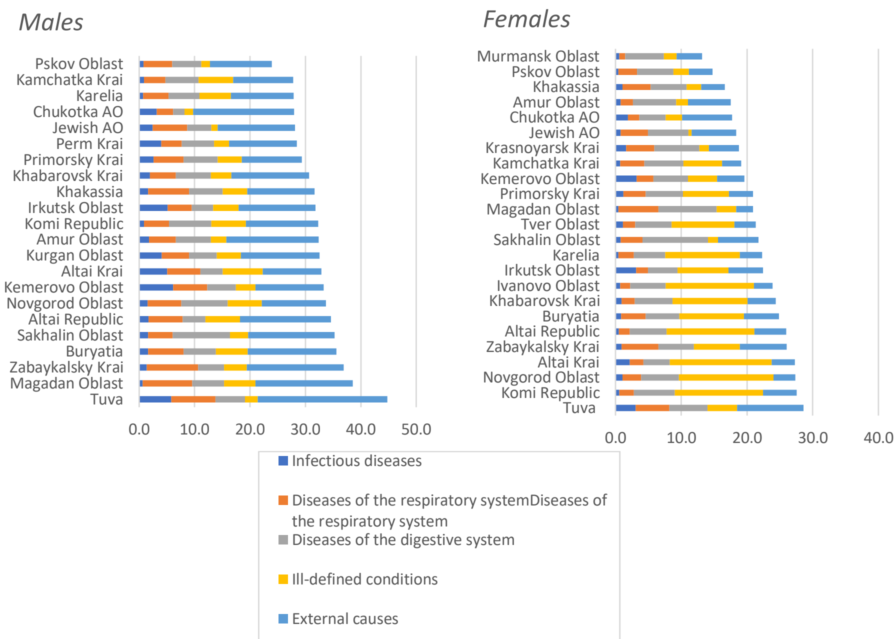
Classification of the Russian Regions With Low Life Expectancy According to Share of Deaths From Neoplasms and Average Age of Death (2019)

SD/AAD	High	Medium	Low
		Males	
High	Sakhalin Oblast	Magadan Oblast	
Medium	Altai Republic, Khakassia, Primorsky Krai	Buryatia, Karelia, Komi Republic, Kurgan Oblast, Kemerovo Oblast, Irkutsk Oblast, Jewish AO	Tuva, Perm Krai, Khabarovsk Krai
Low		Altai Krai, Pskov Oblast, Amur Oblast	Zabaykalsky Krai, Kamchatka Krai, Chukotka AO, Novgorod Oblast
		Females	
High	Khakassia, Krasnoyarsk Krai		
Medium	Karelia, Komi Republic, Primorsky Krai, Murmansk Oblast, Irkutsk Oblast, Kemerovo Oblast, Sakhalin Krai, Chukotka AO	Tuva, Kamchatka Krai, Khabarovsk Krai, Tver Oblast, Jewish AO	
Low	Buryatia, Magadan Oblast	Altai Republic, Altai Krai, Zabaykalsky Krai, Amur Oblast, Ivanovo Oblast, Pskov Oblast	Novgorod Oblast

A characteristic feature of the area of distress is a wide prevalence of preventable conditions: for example, high SD from infectious diseases in males was registered in nine regions, and in ten regions in females (40.9% and 41.7% of the area, respectively), high SD from diseases of the respiratory system in males was registered in ten regions and in 12 regions in females (45.5% and 50% of the area, respectively) as shown in Figure 2. It is quite unexpected that diseases of the digestive system in the area of distress are rather a female problem: high SD from these diseases was registered in 13 regions or 54.2% of the area, and only in five regions in males (22.7%). Certainly, high SD from external causes is typical of the area of distress, registered in 13 regions (59.1% and 54.2% of the area, respectively). Against this background, it should be noted that high SD from ill-defined conditions in the area of distress is an extremely rare exception, registered in only two regions, while low AAD is typical, especially in males.

Figure 1

Share of Deaths From Causes Preventable by Modern Medicine and Healthcare in the Russian Regions With Low Life Expectancy, % (2019)



The middle area, formed by regions with male life expectancy ranging from 65.6 to 68.2 years, and female life expectancy from 76.5 to 78.3 years, consisted of 38 and 33 regions, respectively.

As expected, the most typical of the middle area were medium levels of SD from diseases of the circulatory system (42.1% of the area in males and 48.5% in females) against the background of medium levels of AAD, registered in two-thirds of the area in males and females (Table 6). High SD from cardiovascular diseases was observed in about a quarter of the regions in the area (26.3% and 24.2%, respectively), high AAD in 13.2% and 18.2%, respectively. At the same time, a combination of these indicators (high SD–high AAD) was registered in only three regions in both males and females.

Table 6

Classification of the Russian Regions With Medium Levels of Life Expectancy According to Share of Deaths From Diseases of the Circulatory System and Average Age of Death (2019)

SD/AAD	High	Medium	Low
		Males	
High	Crimea, Penza Oblast, Ulyanovsk Oblast	Sakha (Yakutia), Oryol Oblast, Kostroma Oblast, Nizhny Novgorod Oblast, Arkhangelsk Oblast, Murmansk Oblast	Vologda Oblast
Medium		Udmurt Republic Krasnoyarsk Krai, Astrakhan Oblast, Bryansk Oblast, Vladimir Oblast, Kaluga Oblast, Kirov Oblast, Novosibirsk Oblast, Orenburg Oblast, Sverdlovsk Oblast, Tyumen Oblast (without AO), Chelyabinsk Oblast	Voronezh Oblast, Kursk Oblast, Smolensk Oblast, Tver Oblast
Low	Tomsk Oblast, Samara Oblast	Bashkortostan, Mari El, Chuvash Republic, Lipetsk Oblast, Ryazan Oblast, Tula Oblast, Omsk Oblast	Ivanovo Oblast, Tambov Oblast, Yaroslavl Oblast
		Females	
High	Crimea, Arkhangelsk Oblast, Vladimir Oblast	Kirov Oblast, Tomsk Oblast	Tula Oblast
Medium	Sakha (Yakutia), Nizhny Novgorod Oblast, Oryol Oblast, Saratov Oblast, Ulyanovsk Oblast	Astrakhan Oblast, Bryansk Oblast, Vologda Oblast, Kaluga Oblast, Kursk Oblast, Kaliningrad Oblast, Kostroma Oblast, Novosibirsk Oblast, Orenburg Oblast, Perm Krai, Sverdlovsk Oblast, Tyumen Oblast (without AO) Chelyabinsk Oblast	Bashkortostan Udmurt Republic, Samara Oblast, Omsk Oblast
Low		Smolensk Oblast	Lipetsk Oblast, Rostov Oblast, Yaroslavl Oblast, Kurgan Oblast

The situation with cancer mortality in the middle area hardly differ from deaths from diseases of the circulatory system (Table 7). It is quite natural that medium values of SD from cancer were the most common, registered in 42.1% of the regions in males and 51.5% in women, while medium levels of AAD were the most typical (60.5% and 45.5%, respectively). Interestingly, the middle area was characterized by a proportional distribution of the regions with high and low SD from neoplasms (28.9% in males and 24.2% in females), while the indicator of AAD showed a similar proportionality between high and low values in females only (27.3% of the regions), For males, regions with low AAD were twice as prevalent (ten vs. five regions with high AAD from neoplasms) resulting in more potential years of life lost with an equal risk of death. A combination of high SD–high AAD was registered in four and six regions in males and females, respectively.

Table 7

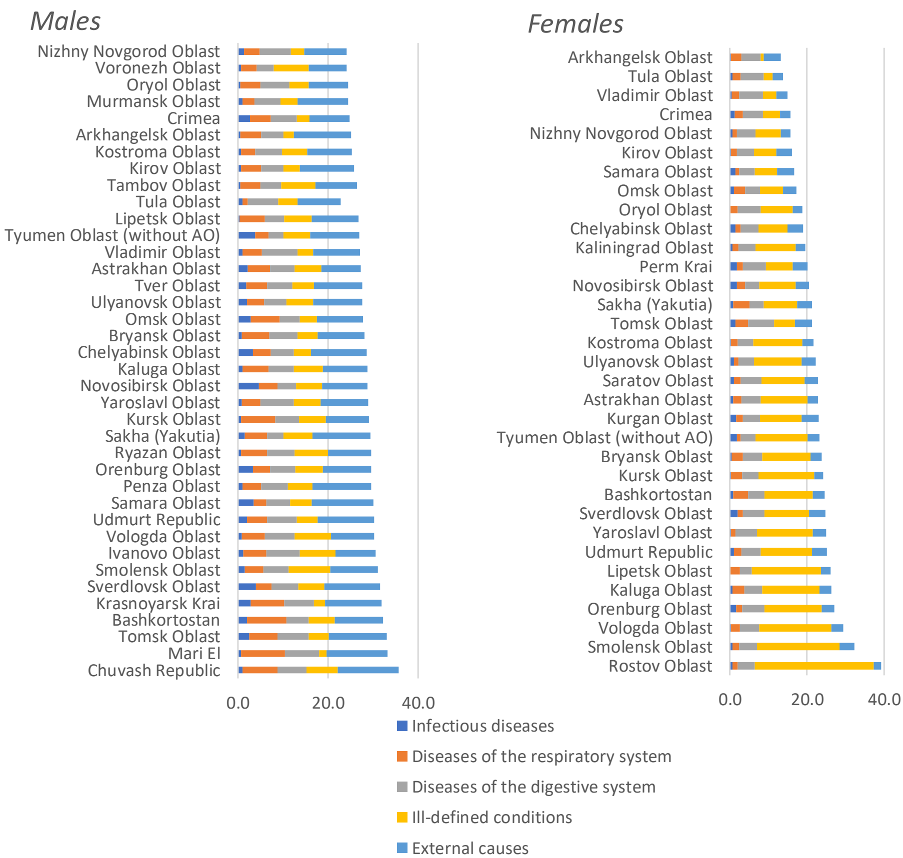
Classification of the Russian Regions With Medium Levels of Life Expectancy According to Share of Deaths From Neoplasms and Average Age of Death (2019)

SD/AAD	High	Medium	Low
		Males	
High	Krasnoyarsk Krai, Tomsk Oblast, Sverdlovsk Oblast, Chelyabinsk Oblast	Sakha (Yakutia)	
Medium	Arkhangelsk Oblast, Bryansk Oblast, Novosibirsk Oblast, Oryol Oblast, Ulyanovsk Oblast, Kostroma Oblast, Orenburg Oblast	Bashkortostan, Crimea, Udmurt Republic, Astrakhan Oblast, Vladimir Oblast, Vologda Oblast, Kaluga Oblast, Kirov Oblast, Murmansk Oblast, Omsk Oblast, Tula Oblast, Tver Oblast, Yaroslavl Oblast	Mari El, Penza Oblast, Samara Oblast
Low		Ivanovo Oblast, Kursk Oblast	Chuvash Republic, Voronezh Oblast, Lipetsk Oblast, Smolensk Oblast, Nizhny Novgorod Oblast, Ryazan Oblast, Tambov Oblast, Tyumen Oblast (without AO)
		Females	
High	Sakha (Yakutia), Tomsk Oblast, Arkhangelsk Oblast, Novosibirsk Oblast, Sverdlovsk Oblast, Chelyabinsk Oblast	Udmurt Republic, Tula Oblast, Astrakhan Oblast	
Medium	Kaliningrad Oblast, Kostroma Oblast	Perm Krai, Bryansk Oblast, Vologda Oblast, Omsk Oblast, Vladimir Oblast, Kaluga Oblast, Kirov Oblast, Kurgan Oblast, Oryol Oblast, Orenburg Oblast, Ulyanovsk Oblast, Yaroslavl Oblast	Bashkortostan
Low		Crimea, Kursk Oblast	Lipetsk Oblast, Nizhny Novgorod Oblast, Rostov Oblast, Samara Oblast, Saratov Oblast, Smolensk Oblast, Tyumen Oblast (without AO)

Regarding exogenous causes, it should be noted that in this area regions with medium values of SD from exogenous causes prevail; however, the ratio of regions with high and low levels of indicators is not in favor of the latter (Figure 3). Thus, high SD from infectious diseases was registered in both males and females in 12 regions vs. nine and seven regions with low indicators, high SD from external causes was registered in more than 20% of the middle area in both sexes. Interestingly, against this background, the distribution of regions with high and low SD from ill-defined conditions turned out to be proportional, equaling to seven vs. seven in males and eight vs. nine in females, while high SD against the background of low AAD from ill-defined conditions was registered only in males in two regions.

Figure 3

Share of Deaths From Causes Preventable by Modern Medicine and Healthcare in the Russian Regions With Medium Levels of Life Expectancy, % (2019)



Discussion

Before discussing the study results, let us once again recall the main approaches and tools.

According to the concept of preventable mortality, with effective health care, mortality from exogenous preventable causes should be rapidly decreasing compared to mortality from inevitable or poorly preventable causes, which, in the course of the epidemiological development, cannot but result in the increased contribution of endogenous causes against the background of the decreased total mortality. On the other hand, high AAD implies concentration of deaths from endogenous causes in old ages.

In this context, it seems important that against the background of post-industrial countries where life expectancy in both men and women is close to 80 years and over, Russia falls behind across all ages, primarily in working ages. This obviously implies a lower average age of death from endogenous causes than in post-industrial countries.

Another important aspect is that classification of the Russian regions according to the level of AAD was carried out statistically. This statement of the current situation does not always coincide with physiologically determined criteria. The most striking example is respiratory diseases: in young ages they are an exogenous pathology and, of course, preventable. Dystrophic age-related changes in the lungs result in heart weakening and deteriorated perfusion. Thus, in senile (precisely senile) ages, obstructive pulmonary diseases should be attributed to endogenous, but AAD should be 80 years and over, which is not observed in Russia, especially in males.

The third aspect that cannot be neglected is mortality from symptoms, signs, and ill-defined conditions: deaths from these blurred causes in Russia are due to two diagnoses, which are unspecified cause of mortality (R99) and age-related physical debility (R54). The age-related physical debility is widely diagnosed at the age of 80 and older, while the unspecified cause of mortality is associated with deaths from ill-defined conditions at the ages from one to 79. Previous studies have shown that in working ages, unspecified causes of death turn out to be external, with alcohol and drug poisoning, not excluding suicide and murder (Semyonova et al., 2017), in old ages, this is usually an underestimation of cardiovascular mortality (Semyonova et al., 2016).

Passing to the direct discussion of the results, it should be stressed out that the percentage of regions characterized by high share of deaths from endogenous causes against the background of high average age of death declines with a decrease in life expectancy. Thus, in the area of well-being, the share of regions with high SD from cardiovascular diseases against the background of high AAD equals to 31.8% in males and 24% in females, 7.9% and 9.1%, respectively in middle area, 0.0% in males and 8.3% in females in the area of distress. Similar patterns were noted for neoplasms: the share of regions with high SD from cancer and high AAD in the area of well-being equals to 27.3% and 20.0%, while in the middle area 10.5% and 18.2%, and 4.5% and 8.3% in the regions with low life expectancy, respectively.

To assess status of the Russian regions in the context of the epidemiological transition, let us recall that the 4th, modern, stage is characterized by concentration of mass mortality from endogenous causes in old ages with a combination of these indicators for both causes (cardiovascular diseases and cancer) in one region.

If we consider the selected regions, it turns out that the number of regions characterized by high AAD and high SD from both cardiovascular diseases and cancer is extremely limited. These are Moscow, St. Petersburg, and Sevastopol for both males and females, as well as the Arkhangelsk Oblast and the Krasnoyarsk Krai for females.

It seems significant that in Moscow, St. Petersburg, and Sevastopol, the required combination is registered among the entire population, which is quite predictable, proceeding from high life expectancy in these regions. On the other hand, the presence of the Arkhangelsk Oblast and especially the Krasnoyarsk Krai, where the required combination is noted, first, in females only, and second, it is observed against the background of medium and even low level of life expectancy is rather surprising.

To comprehend this paradox, let us note that even among the three cities, Sevastopol is noticeably lagging behind with its life expectancy being 4.5 year lower in males and 3.1 year lower in females compared to Moscow indicators. In Moscow and St. Petersburg, SD from all exogenous causes is low, Sevastopol shows high SD from infectious diseases (certainly preventable), while its SD from diseases of the digestive system is characterized by medium levels rather than low ones.

As for females in the Arkhangelsk region, the aggravating factor is high SD from the third leading cause, that is, injury and poisoning, which undoubtedly affects life expectancy.

Even more interesting is the picture of female mortality in the Krasnoyarsk Krai, where high SD from all preventable causes is registered, undoubtedly placing the region in the area of distress.

Moreover, even in Moscow and St. Petersburg against the background of favorable all major indicators an abnormally low (especially in males) AAD from ill-defined conditions is noted, suggesting an underestimation of mortality from external causes due to transfer of some deaths to a latent form.

Thus, objective data indicate that currently all regions of Russia are at the 3rd stage of the epidemiological transition, yet at different phases. This conclusion differs somewhat from the one by Shibalkov (2017) that the regions of Russia are at different stages of the epidemiological transition. Perhaps, the years 2016–2019, which were not included in his analysis, have an effect, when there was a steady decline in mortality from almost all causes in all regions of the Russian Federation, which could change the situation. Thus, it was shown that in the context of increasing life expectancy, there was a noticeable convergence of regional indicators driven by the far groups, primarily due to leveling up the lagging regions (Popova & Zorina, 2019).

In general, a shared problem of the Russian regions is a layering of half-solved problems of the previous stages of the epidemiological development (minimization of deaths from exogenous, preventable causes) and modern (endogenous causes) found even in the regions of the area of well-being. Thus, in this group, infectious diseases are extremely important in Sevastopol, the Khanty-Mansi Autonomous Okrug, Leningrad Oblast, and in males in Saratov Oblast; while diseases of the respiratory system are crucial in Dagestan, Belgorod Oblast, in males in Tatarstan and females in Mari El, Yamalo-Nenets Autonomous Okrug, and Leningrad Oblast; diseases of the digestive system in males in the North Ossetia–Alania, Stavropol Krai, Leningrad and Saratov Oblasts and in females in Yamalo-Nenets Autonomous Okrug.

Along with decreasing life expectancy, the burden of these pathologies increases, and almost all regions in the area of distress are characterized by high risks of at least one preventable cause of death or a complex of causes.

It can be stated that the Russian regions in aggregate represent kind of a geographical development of stadial nature of the 3rd stage of the epidemiological transition.

In this context, it seems effective to address to the second part of the Omran's classical concept, namely, to the factors that determine stadial nature of the epidemiological development. Although the stages of the epidemiological transition are widely discussed, the factors are often left aside. Meanwhile, these factors help understand gaps in the epidemiological development, thus having been combined into components by Omran (environmental, medical, socio-economic).

In this regard, regions can be identified where the growth of SPM is determined by the actualization of one or another of the leading components or their complex. These components can be specific even in the context of endogenous pathologies.

As for oncology, the medical component certainly seems to be the leading one here, since in the concept of preventable mortality, early diagnosis and adequate treatment are associated with the reduced mortality from most neoplasm localities. The most obvious marker of distress is high SD with low AAD, which is observed in females in Buryatia and the Magadan Oblast.

Such a combination in the case of circulatory diseases is observed in the population of the Jewish Autonomous Okrug, in males in the Vologda Oblast and females in the Irkutsk Oblast, Kamchatka Krai, as well as Chukotka Autonomous Okrug. That indicates cardiovascular mortality in ages in which these deaths are not physiologically induced, though are rather determined by behavioral risk factors, with alcohol being the leading one. Therefore, prevention of these deaths is defined by prevention in terms of the concept of preventable mortality or a social component in terms of the concept of epidemiological transition.

The hypothesis of a significant contribution of the alcohol factor to premature cardiovascular mortality is also confirmed by other authors. In their study, Gornyi et al. (2022) identified a statistically significant relationship between regional mortality from cerebrovascular diseases and myocardial infarction and alcohol-related situation in these regions. Moreover, Russian data are consistent with the results from other countries. For instance, in the U.S., cardiovascular diseases are more likely to be the main cause of death in low-income counties, and, consequently, are associated with unhealthy behavior, whereas a shift towards cancer as the main cause of death was typical of highest-income counties (Hastings et al., 2018).

Apart from the real risk factors which can be effectively addressed to reduce preventable losses, the diagnostic accuracy and adequacy of specific causes of death should be considered. According to a study by Drapkina et al. (2021), the greatest regional variations are reported exactly for preventable causes of cardiovascular mortality, as the coefficient of variation of the regional standardized mortality rates from cardiac causes in 2019 equaled to 25.8%, and 64.5% and 122.7% specifically from acute forms of coronary heart disease and causes associated with arterial hypertension respectively. Variations in mortality from preventable causes are manifested even in the context of the federal districts: in the mortality structure among working population, the share of coronary heart disease ranges from 38.1% to 51.9%, the share of cerebrovascular diseases ranges from 16.8% to 21.8% (Usacheva et al., 2021). For malignant neoplasms, regional variations are less pronounced than for cardiovascular diseases, in 2019, the coefficient of variation added up to 26.7%; the authors have explained it by a more accurate diagnosis of the main cause of death, taking into account the accepted standards for cancer diagnosis (Drapkina et al., 2019).

The decrease in life expectancy in the middle area and especially in the area of distress is caused by the accumulation of exogenous pathologies and external causes, which mortality reduction is due to the medical and social components. Moreover, even the mortality of children from external causes in the Russian Federation has an extremely wide variation. So, in 2018, the level of this indicator in children aged 0–14 years differed 18.7 times in various regions and 16.6 times in children aged 0–17 years (Fisenko et al., 2020). This clearly defines the social factor as the leading one to reduce mortality from unnatural causes and increase life expectancy.

When discussing the situation in the Russian regions, the question about a relationship between life expectancy and socio-economic development of the region is natural. Indeed, paradoxically, the North Caucasian national republics with the minimum GDP in Russia (less than 250 thousand per capita) find themselves in the area of well-being, while the Chukotka Autonomous Okrug, Kamchatka Krai, Magadan and Sakhalin Oblasts with GDP per capita about 1 million rubles or over, turn out to be in the area of distress. Tuva with the minimum life expectancy in Russian, has a little higher GDP compared to Dagestan (243 thousand vs. 232 thousand rubles), which was characterized by the maximum levels of life expectancy in Russia. On the other hand, Moscow and the Sakhalin Oblast are included in the richest Russian regions, and in terms of GDP per capita, the Sakhalin Oblast is 1.5 times higher than Moscow (2.4 million vs. 1.5 million rubles). Nevertheless, life expectancy among Muscovites exceeds the indicators of Sakhalin residents by almost ten years in males and six years in females. According to Revich et al. (2019), a rising scale of health expenditures, physical culture, and sports can result in the most pronounced mortality reduction only in the most developed regions, thus suggesting a compelling importance of high quality and favorable living conditions to reduce mortality.

At that, different climatic and geographical conditions in the Russian regions prevent these problems from being solved linearly. This is highly unlikely that the living conditions in Tuva or Buryatia with a heavy continental climate are comparable in terms of living conditions in the North Caucasus, and the climatic and geographical conditions of Chukotka or Sakhalin are less favorable compared to the Central European Russia.

However, in discussing the impact of socio-economic factors, the Tyumen Oblast should be emphasized. It includes the Khanty-Mansi and Yamalo-Nenets Autonomous Okrugs, which are located in the Far North, in absolutely unfavorable climatic and geographical conditions; nevertheless, both regions are characterized by high life expectancy. The Tyumen region without these territories, located in less extreme climatic conditions, is included only in the middle area lagging for 2.5 and 1.5 years in male life expectancy. However, GDP per capita in the Khanty-Mansi Autonomous Okrug exceeds the indicators of the Tyumen Oblast without AO by more than three times, while Yamalo-Nenets Autonomous Okrug exceeds almost seven times, with 2.73 million and 5.7 million rubles vs. 822 thousand rubles, respectively. In this regard, we should mention the study by Nagaeva (2022), which indicates that although morbidity and mortality rates at working age in most resource regions are higher than in non-resource regions, multi-sectoral oil and gas producing regions are an exception, with the highest rates of life expectancy.

Thus, socio-economic factors are universal, but well-being in the regions with extreme climatic and geographical conditions requires investments in human development on a fundamentally different scale than sufficient for the regions with favorable living conditions.

Discussing epidemiological development and its determining components, it is important to dwell on new challenges: for example, the past COVID-19 pandemic showed the return of long-forgotten environmental factors. Moreover, its sudden onset and the scale of deaths make us remain on the alert in terms of possible new infections (or manifestations of the already existing ones) and, as a result, importance of the medical and social components to minimize them.

On the other hand, along with increasing life expectancy in post-industrial countries, endogenous pathologies acquire a different nosological profile: for example, in France, where life expectancy has exceeded the 80-year level, Alzheimer's disease, accompanied by dementia, takes the lead, with the mortality remaining completely unavoidable due to ambiguity of etiology and treatment methods.

Currently, the problem of a certain deadlock of the fourth stage of the epidemiological transition is far from being relevant to our country, however, increasing life expectancy does not exclude its actualization.

Conclusion

In conclusion, we should mention several considerations that represent significant aspects of the study of regional variation in mortality across the Russian regions.

First, based on the level of life expectancy on the one hand, and the triad of leading causes of death on the other, all Russian regions are currently at the third stage of the epidemiological transition.

Second, a combination of SD and AAD from endogenous causes (from life tables with multiple attrition) is a fairly effective tool for assessing stadial nature of the epidemiological development.

Third, in Russia, a simultaneous combination of high SD and high AAD from endogenous causes (diseases of the circulatory system and neoplasms) without any burden associated with exogenous causes is registered only in Moscow and St. Petersburg. Within the framework of the concept of epidemiological transition, this indicates that of all Russian regions only Moscow and St. Petersburg are in the final phase of the 3rd stage transiting to the 4th stage of the epidemiological development.

Fourth, a characteristic feature of the Russian area of well-being, i.e., a group of regions with a relatively high life expectancy (according to Russian criteria), is a low share of death from external causes. At the same time, the burden of exogenous, preventable causes prevents the completion of the 3rd stage of the epidemiological transition in this area.

Fifth, in regions with medium and low levels of life expectancy, there is a high share of deaths from preventable causes, including injury and poisoning, reaching its maximum in the area of distress.

Sixth, stadial nature of the epidemiological development of the Russian regions is currently determined by socio-economic and medical determinants. In the regions with high and medium levels of life expectancy the medical determinant is more relevant, while in the regions with low life expectancy socio-economic factors are also associated with mortality from exogenous, preventable causes. A combination of these factors helps to minimize behavioral risks related to both deaths from external causes and early deaths from leading somatic causes, such as cardiovascular diseases and diseases of the digestive system.

As a result of the study, the following conclusion can be made. The theory of epidemiological transition allows us to conceptually assess the general problems of Russian regions, taking into account the main determinants of epidemiological development. This suggests that in regions with high and average levels of life expectancy, measures to improve the quality and accessibility of medical care are most relevant today. On the other hand, low life expectancy can be caused by both low income (Buryatia, Tuva) and social problems (for example, in regions with a high level of GDP, such as the Sakhalin Oblast and Kamchatka Krai).

In turn, the analysis of the main causes allows us to highlight the current problems of the regions from the standpoint of avoidable mortality. However, the development of specific recommendations aimed at reducing mortality in a particular territory requires a special in-depth study of the situation in this region.

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