THE EPIDEMIOLOGICAL TRANSITION AND ITS INTERPRETATIONS

ANATOLY VISHNEVSKY

A critical analysis of A. Omran's theory of epidemiological transition (ET) and its various interpretations. The periodization of ET proposed by Omran is questioned, and the differentiation of the two "epidemiological revolutions" by M. Terris is compared with it. The great world historical significance of ET as a trigger and an integral part of the demographic transition as a whole is noted, and disagreement with the interpretation of ET as an integral part of the "sanitary transition" is substantiated. The concept of the "cardiovascular revolution" is contested. A method of graphical representation of ET is proposed and criteria for its completion are discussed. Grounds are given for disagreement with ideas about the "first", Neolithic, and coming "third" ET, as well as about a "reverse" ET. The problems of "catching-up" ET in developing countries are considered.

***Key words**: epidemiological transition, epidemiological revolution, demographic transition, sanitary transition, stages of epidemiological transition, cardiovascular revolution, probability of death, average age of death.*

The term "epidemiological transition" (ET) was first introduced into scientific circulation by Abdel Omran in an article published in 1971 (Omran 1971; Omran 1977), and since then has been inextricably linked with his name. Omran's article has become one of the most cited, which even causes some irritation among a part of the demographic audience, and publications appear whose main purpose is to prove that too frequent mention of Omran's name is not justified and that his merits are exaggerated. The authors of one of these publications see the reasons for over-citation not in the true merits of Omran, but in the fact that "critics looking for new models or conceptual schemes have found in Omran a convenient starting point, target or whipping boy, to highlight their own conceptual innovations and give them weight" (Weisz, Olszynko-Gryn 2009: 323). This is good advice to everyone who also wants to become famous like Omran and to become a "whipping boy": you just need to put forward an idea that no researcher working in the relevant field of knowledge can ignore.

In fairness, it should be noted that Omran's concept is often highly praised as "a potentially powerful framework for the study of disease and mortality in populations, especially for the study of historical and international variations." (Mackenbach 1994: 330). Apparently, it is no coincidence that Omran's scheme is used as a starting point for new theoretical constructions, although at times these retain a rather tenuous link to the original concept, at which point the question arises whether the appeal to this concept is just a way to give such constructions additional weight.

ANATOLY G. VISHNEVSKY (avishnevsky@hse.ru), NATIONAL RESEARCH UNIVERSITY HIGHER SCHOOL OF ECONOMICS, RUSSIA.

THE ARTICLE WAS PREPARED WITHIN THE FRAMEWORK OF THE PROJECT "DEMOGRAPHIC AND MIGRATION PROCESSES IN RUSSIA IN THE HISTORICAL AND INTERNATIONAL CONTEXT IN THE LIGHT OF NEW METHODOLOGICAL APPROACHES" OF THE HSE PROGRAM OF FUNDAMENTAL RESEARCH, 2019.

THE ORIGINAL ARTICLE IN RUSSIAN WAS PUBLISHED IN DEMOGRAPHIC REVIEW IN 2020, 7(3), 6-50.
DOI: 10.17323/DEMREVIEW.V7I3.11635

And it is no coincidence that when one gets acquainted with such constructions, questions arise for their creators, and sometimes for Omran himself, as to the soundness of the foundation he has laid and the fruitfulness of the directions for the development of his ideas proposed by different authors.

"TRANSITION" OR "REVOLUTION"?

Omran used the term "transition", apparently following a tradition begun in the 1940s by Princeton demographers who coined the term "demographic transition" (Notestein 1945: 40; Davis 1945). In turn, this term has established itself in competition with the term “demographic revolution”, which appeared much earlier (in 1934) (Landry 2019). As early as 1944, K. Davis wrote about a “demographic revolution inseparable from the industrial revolution” (Davis 1944: 57). Even later, American demographers sometimes used the term "vital revolution" in the same sense (Freedman 1964).

Some authors, relying on French tradition, continued to use the term "demographic revolution" thereafter (see, for example, (Pavlik 1964: 234-247; 1982; Pavlik 1979; Vishnevsky 1973; 1976). Nevertheless, in world literature the term “demographic transition” prevailed, although, according to van de Kaa, this weakened the historical depth and meaning of the term (Van de Kaa 2010). The new term was adopted in Landry's homeland, albeit with some reservations. C. Chesnais, the author of a fundamental study of the demographic transition, which is clearly reflected in the title of his book (Chesnais 1986), nevertheless notes that insofar as we are talking about an extremely special, radically new stage of demographic development, “the term “demographic revolution”, somewhat forgotten, seems to be more successful" (Chesnais 1986: 18).

Concluding our brief terminological excursion, we note that the expression "epidemiological revolution" is sometimes used by authors who may not be familiar with the concept of demographic or epidemiological transitions at all. As an example, let us cite an article titled "The Epidemiological Revolution of the 20th Century". This article, published in 2005, states that “The 20th century has been characterized by a fantastic advance in life expectancy and by a shift from infectious to chronic degenerative diseases as prevailing causes of death” and the “roots and rationale for these epidemiological changes” are discussed (De Flora et al. 2005: 892). There are no references to Omran in this article; his name is never mentioned.

An even more interesting example is the use of the term "epidemiological revolution" by Milton Terris; we will look at it a little further on.

In general, the term "transition" prevails in the literature, although the reasons for this choice against the background of the widespread use of the term "revolution" ("industrial revolution", "scientific and technological revolution", etc.) are not entirely clear. As there is probably no point in arguing over the choice of the word, in this article both terms are used interchangeably. But some costs are still associated with this.

WHY "EPIDEMIOLOGICAL"?

In the phrase "epidemiological transition" questions are often raised not only by the word "transition", but also by the word "epidemiological".

In the demographic literature, there is a fairly widespread point of view that the concept of epidemiological transition is too narrow and does not cover all the changes taking place in our time with health and mortality.

In particular, it is argued that in Omran the concept of 'epidemiological transition' is "common to refer to the transition as a period rather than as a process of change" (Frenk et al. 1991: 23), which sounds rather vague. One of Omran's assumptions is that "during the transition, a long-term shift occurs in mortality and disease patterns whereby pandemics of infection are gradually displaced by degenerative and man-made diseases as the chief form of morbidity and primary cause of death" (Omran 1971: 516; Omran 1977: 64). Is there any clearer idea of what is the essence of the process denoted by the term "epidemiological transition"?

Another - central - reproach is that the concept of epidemiological transition does not go further than considering the "long-term process of change in the health conditions of a society, including changes in the patterns of disease, disability, and death", while it is necessary to consider also "the patterns of the organized social response to health condition", the healthcare transition (Frenk et al. 1991: 23). With this approach, the authors of the article believe, the seemingly narrow reduction of the ongoing changes to an epidemiological transition is overcome, and their broader interpretation becomes possible as a "health transition" (Ibid.) or "sanitary transition"[1].

This reproach is hardly justified either. When calling the transition "epidemiological", Omran had in mind its main implication - a change in the epidemiological picture, the epidemiological model of morbidity and mortality. This, in fact, was the essence of the transition. But this does not mean in any way that he ignored the "organized social response" expressed in the mobilization and transformation of the healthcare system.

Of course, the epidemiological transition has its own prerequisites, including changes in "the patterns of the organized social response to health condition." But, firstly, they are by no means the only ones. And secondly, there is no reason to consider the prerequisites of any process to be its essence or even an integral part.

Rather, it can be said that Omran's view of the whole panorama of change, united by the concept of "epidemiological transition," was not narrower, but broader than the view of his critics. He speaks of three main groups of determinants that led to the transition from the era of infectious to the era of chronic non-infectious diseases: 1) ecobiologic; 2) socioeconomic, political and cultural; 3) medical and public health. At the same time, he quite rightly notes that "the reduction of mortality in Europe and most western countries during the nineteenth century, as described by

[1] The term "sanitary transition" ("transition sanitaire") is used in French-language literature, since in French, just like in Russian, it is impossible to form an adjective from the word "health". For the same reason, we accept this very term, although some of the nuances contained in the English expression "health transition" are lost.

the classical model of epidemiologic transition, was determined primarily by ecobiologic and socioeconomic factors. The influence of medical factors was largely inadvertent until the twentieth century" (Omran 1971: 520; Omran 1977: 67). This is now a common idea. "In the past, a significant decrease in mortality in the 19th century has often been attributed to advances in medicine. Nowadays, the prevailing point of view is that immunization and effective treatment methods have borne fruit only in the 20th century (with the exception of smallpox, of course)" (Livi Bacci 2010: 211).

The supporters of the "renaming" of the epidemiological transition turned out to have many followers in the demographic world. In the English version of a multivolume demographic compendium, the title of the corresponding chapter uses the term "Health transition" (in the French version, "Transition sanitaire") (Meslé, Vallin 2002; 2006). The chapter authors saw fit to accept the semantic shift proposed by Julio Frenk et al. (1991) and "include within the wider concept of health transition an initial phase (that described by Omran) of life expectancy gains, attributed mainly to the decline in mortality due to infectious diseases, followed by a second phase dominated by the decline in cardiovascular diseases, leaving open the possibility of identifying later phases" (Meslé, Vallin 2002: 444; 2006: 250).

But Omran himself did not agree with the proposal to "rename" the epidemiological transition. Whatever the changes taking place - social, economic, demographic, medical, technological, environmental - they affect health not directly, but through a change in the epidemiological situation, that is, the prevalence of certain diseases and causes of death. It is this situation that predetermines a population's health, mortality rate and life expectancy, and it is within it that historically unprecedented shifts take place - that very transition, that very revolution which can be called nothing other than epidemiological. This is what Omran is talking about, arguing that "classifying all the changes in these variables under the "health transition" would, however, be confusing. Health is a dependent variable of epidemiology, not vice-versa" (Omran 1998: 99; Omran 2019: 178). The last phrase is the key one.

EPIDEMIOLOGICAL TRANSITION AND DEMOGRAPHIC TRANSITION

In the basic article of 1971, Omran pointed out that the impetus for the development of his theory was the realization of the shortcomings of the theory of demographic transition, and, apparently, he believed that the concept of the epidemiological transition, as a more comprehensive one, makes it possible to overcome these shortcomings, since this transition "triggered by economic and social development, encompasses the changing disease and health patterns (the health transition), the changing fertility and population age structure leading to ageing (parts of the demographic transition), the changing lifestyles (the lifestyle transition), the changing health care patterns (the health care transition), the medical and technological evolutions (the technologic transition), and the environmental and ecological changes (the ecological transition)" (Omran 1998: 99; Omran 2019: 178-179).

It seems to me that, in this case, Omran's ambitions are excessive. He - and this is his main merit - undoubtedly deepened the understanding of how, starting from about the 18th century, the mechanism for reducing mortality worked. We can say that Omran completed the theory of

demographic transition due to the fact that he conceptualized the process of reducing mortality, which was previously understood mainly at the level of describing its results.

Even more could be said. When Omran argues that “improved infant and childhood survival tends to undermine the complex social, economic and emotional rationale for high parity for individuals and hence high fertility for society as a whole” (Omran 1971: 530; Omran 1977: 74), he demonstrates a theoretical intuition that favorably distinguishes him from both A. Landry and F. Notestein, with his long list of social and economic changes as reasons for the decline in fertility, and from many other authors who are in solidarity with Landry or Notestein (see more about this: Vishnevsky 2017: 12-16). Omran's clear understanding of the mechanism of not only a decrease in mortality (here he is a pioneer), but also a decrease in fertility, gives reason to consider him one of the classics of the theory of demographic transition.

But when Omran infinitely expands the understanding of the epidemiological transition, including the most diverse, even distant consequences, such "expansion" turns out to be unproductive. It shifts the focus away from analyzing the demographic transition as a key, fundamental shift which, having already taken place in both mortality and fertility declines, is indeed generating countless and extremely important social outcomes. Attention is shifted to considering the entire spectrum of diverse economic, social and other changes, as a result of which their demographic primacy is overshadowed and once again underestimated.

The epidemiological transition has two hypostases, each of which is extremely important, despite the fact that they have completely different meanings.

First, the epidemiological transition is identical to a historically unprecedented decrease in mortality and prolongation of human life. This is indeed a huge revolution, the significance of which cannot be overestimated. It is enormous both for any individual and for those whose professional activities are related to the protection of the health and life of people, as well as for the whole society, which receives enormous benefits from the unexpected "profitability" of universal longevity. With an increase in the average life expectancy from 30-35 to 75-80 years, everything changes: the economy, culture, morality, people’s way of life. Realizing the new opportunities, society directs efforts and resources for their implementation, develops modern healthcare systems, achieves more or less success.

But secondly (in terms of order, but not significance), the epidemiological transition is equivalent to a disruption of the age-old demographic balance, and this is something completely different from the extension of human life. Society's response to the new situation is a decrease in fertility, which makes it possible to restore the balance; this is why the transition to a new type of demographic balance is called the “demographic transition”. It is primarily to this term that the term "epidemiological transition" refers. The epidemiological transition acts as a trigger of the demographic transition, as one of its components, but one can hardly agree with its broad interpretation, according to which the epidemiological transition “includes” a decrease in fertility, population aging and other manifestations of the demographic transition.

Unfortunately, as can be seen in the example of the tug-of-war towards the “sanitary transition”, the second hypostasis of the epidemiological transition and its fundamental significance are often overlooked or underestimated, and this transition itself is perceived as

something that takes place exclusively through the healthcare system[2], which leads to a devaluation of Omran's concept.

PERIODIZATION OF THE EPIDEMIOLOGICAL TRANSITION

Explaining his idea of the epidemiological transition as "shifts in mortality and disease patterns", Omran identifies three successive stages of such shifts (an era of pestilence and famine; an era of a receding pandemic; an era of degenerative and man-made[3] diseases) (Omran 1971: 516-517; Omran 1977: 64). The first of these stages is "the continuation of those health indicators that are characteristic of the pre-modern era" (Ibid.), "the preservation of epidemiological models of the past" (Omran 1998: 103; Omran 2019: 183-184). But what then is the difference between this stage and the rest of the "premodern era"? In essence, Omran includes in the composition of the *transition* both the previous (all human history) and subsequent states, that is, *from which* and *to which* the transition is made. It would seem that this strange logic should first of all provoke corrective criticism: we do not consider the tsarist autocracy and Soviet power to be stages of the revolution that led to the replacement of one by the other. But something completely different happened: Omran's followers and critics began, in competition with each other, feverishly adding new ones to the senseless stages of Omran.

Omran himself joined this game. Shortly before his death, he published an article entitled "The epidemiologic transition theory revisited thirty years later", in which he gave a brief overview of the evolution of the concept (Omran 1998; Omran 2019), where, in particular, he mentioned the authors (Olshansky, Ault 1986; Rogers, Hackenberg 1987), who proposed considering a fourth stage of the transition. In principle, he agrees with this proposal, although his complaisance in this case is not entirely clear. We have seen that he originally designated the third stage as the stage of degenerative and anthropogenic diseases, when life expectancy "reaches an unprecedented level of 70 years and beyond" (Omran 1971: table 4; Omran 1977: 83). Olshansky and Ault in 1986 proposed to supplement the Omran scheme with a fourth stage, which they called "the age of delayed degenerative diseases", when life expectancy will increase "to eight decades, and possibly more" (Olshansky, Ault 1986: 386). Even verbally, their fourth stage is no different from Omran's third stage: delayed degenerative diseases still remain degenerative, and life expectancy of 80 years or more fits well with Omran's wording "70 years and above".

But now Omran himself speaks of the fourth stage of the transition, which he characterizes as "an era of decreasing mortality from cardiovascular diseases , aging, lifestyle changes, the emergence of new diseases" (Omran 1998: 104; Omran 2019: 186). Moreover, he postulates a fifth stage, which will come in the middle of the 21st century and will be "one of the greatest

[2] Perhaps influenced by the fact that one of the ideologists of the "sanitary transition" was Julio Frank, a prominent health figure and the Minister of Health of Mexico in the first half of the 2000s. The "demographic" hypostasis of the epidemiological transition may have been of little interest to him.

[3] In the Russian translation, the expression "*man-made diseases*" is for some reason given as "occupational diseases", while Omran referred to them as "for example, radiation contamination, industrial injuries, exposure to chemical and biological weapons, polluting substances, road traffic accidents and plane crashes, sources of carcinogenic hazards in industry, in the environment or in food additives" (Omran 1998: 104; Omran 2019: 185-186).

achievements of mankind in the field of disease control, health promotion and further prolongation of healthy life" (Omran 1998: 115; Omran 2019: 207), and shares his assumption that "life expectancy will continue to rise, reaching or exceeding 90 years" (Ibid.).

When criticizing Omran's initial identification of three "eras", one cannot but give him his due for the fact that he, with large strokes, divided the entire history of human mortality into three fundamentally different segments and thus gave his periodization a historical scale, which, as we will see below, was noticed and appreciated. In response to his critics, he renounces such an enlarged vision of history, and his initially imprecise periodization takes on a completely bizarre look: there on equal footing are tens of thousands of years of the Paleolithic era, millennia of the Neolithic and several decades after 1970, when developed countries, apparently, just entered the final stage of the transition to a new epidemiological model of mortality. This is a completely natural development of events for a phenomenon understood as a "transition": it must have a beginning and an end.

MILTON TERRIS' TWO "EPIDEMIOLOGICAL REVOLUTIONS"

Almost simultaneously with the beginning of the triumphant march of Omran's idea of an epidemiological transition, and independently of Omran, similar ideas were expressed by another American researcher, a famous epidemiologist, one of the founders of the American National Association for Public Health Policy, Milton Terris. In 1972, in a journal published by the Association there appeared an editorial entitled The Epidemiologic Revolution, authored by Terris (1972). He developed his ideas in more detail in 1976 (Terris 1976), which was followed by many other publications where he invariably addressed this revolution and the new challenges it posed to healthcare. One can only wonder that in the abundant literature on the epidemiological transition, including the American one, Terris's name is usually not even mentioned. However, Terris never refers to Omran's article; perhaps he did not even know about its existence.

Unlike Omran, Terris did not try to fit modern epidemiological changes into a broad historical perspective. His work had more practical goals, was aimed at reorienting the modern healthcare system to meet new challenges. But maybe that is why he very clearly understood the 1960s and 1970s as a boundary separating new tasks from the previous ones, which gave him reason to talk about two different stages of modern epidemiological changes, which he called the first and second epidemiological revolutions. "We are at the beginning of an era ... We have a large and difficult task before us, nothing less than the implementation of the second epidemiologic revolution and the rescue of literally millions of men and women from preventable illness, disability and death" (Terris 1976: 1159).

Terris listed ten major causes of death that the main public health efforts now needed to tackle: heart disease (primarily coronary heart disease); cancer; vascular lesions of the brain; accidents; flu and pneumonia; bronchitis, emphysema and other chronic obstructive pulmonary diseases; diabetes; cirrhosis of the liver; atherosclerosis; obstetric injuries, difficult childbirth and other causes of infant mortality (Terris 1976: 1156).

This list is, of course, more specific than Omran's general indication of "degenerative and man-made diseases", but basically it fits into this generalized definition. If diseases such as the flu

do not fall under it, then this still does not contradict the general meaning of the tasks in the solution of which Terris saw the meaning of the "second epidemiological revolution." But what is important is that he considered it not as a sum of special "revolutions", but as an integral process.

It is precisely because of this integrity, which allows one to remain at a higher level of generalization, that Terris's two-part scheme for considering the epidemiological transition, if we understand by it the changes in the epidemiological model of morbidity and transition since the 19th century, seems to me more fruitful than the views of the supporters of a “multi-phase” transition.

THE MYTH OF THE CARDIOVASCULAR REVOLUTION

The rejection of a holistic view of the epidemiological transition and the associated costs was clearly manifested in the concept of the so-called "cardiovascular revolution". Of course, no one has a monopoly on the use of certain terms or on giving them one or another meaning. It is quite possible to speak of a "cardiovascular" revolution as well as, say, of a "bacteriological" or "sanitary-hygienic" revolution at the previous historical stage. The question lies in the level of generalization to which this or that term lays claim. A decrease in the level of generalization is a movement from conceptualization to descriptiveness, to empiricism, which of course is also needed, but as a starting point for research, not as a result with heuristic properties. And the loss of an overall perspective is fraught with serious costs.

Recognizing the existence of a “fourth stage” of the epidemiological transition, Omran wrote that “a most distinctive characteristic of this stage, which also marks its beginning, is the leveling off, then decline of cardiovascular mortality which occurred around 1970 in many developed countries” (Omran 1998: 104; Omran 2019: 186). Nevertheless, critics of Omran argue that his concept “ignores the fact that the new era of progress that opened up at the turn of the 1970s is based on a major epidemiological change, a cardiovascular revolution, which is different from that of the victory over infectious diseases that it follows” (Meslé, Vallin 2002: 444). In the English version it sounds even stronger: “is not linked in any way with the end of the era of infectious diseases, even though it did follow closely” (Meslé, Vallin 2006: 250).

From the point of view of historical logic, and logic in general, this is a very strange statement, although, unfortunately, it can often be heard from the lips of other eminent demographers. For example, as J. Caldwell wrote, “What happened in the mortality transition was the conquest of infectious disease, not a mysterious displacement of infection by degeneration as the cause of death” (Caldwell 2001: 159). No less strange is the criticism of “ the idea that some diseases are socially more acceptable than others. The displacement of infections by accidents and chronic diseases is often referred to as a sign of 'progress'. Some go to the extreme of designating the latter as the 'ills of civilization'. Actually, these health problems are a result of a defective process of industrialization that has given priority to economic growth over human welfare” (Frenk et al. 1989: 31).

In fact, there is nothing mysterious about replacing some causes of illness and death with others; some causes are indeed “more acceptable” than others, and the replacement of “less

acceptable" with "more acceptable" is the very essence of the epidemiological transition. There is no doubt that this transition is one of the brightest manifestations of human progress.

Since all people are mortal, the suppression of one cause of death inevitably leads to its replacement by some other; it cannot be otherwise. The rapid decline in mortality from infectious diseases led to an equally rapid expansion of mortality from other causes, among which cardiovascular diseases played the most important role. The assertion that "the cardiovascular revolution is different from the victory over infectious diseases" is, on the one hand, trite, and on the other, false. If the cardiovascular revolution is understood as a decrease in the likelihood of death from cardiovascular diseases, then their place should be taken by some other causes of death, as was the case at the previous stage, when these diseases as the cause of death themselves supplanted infectious diseases. In this sense, there is no difference. The question of at what stage of their "historical career" cardiovascular causes of death really played a revolutionary role is another matter.

At some point, cardiovascular diseases actually became the main "disease of civilization", and, contrary to the philistine journalistic discourse about these diseases as a terrible scourge, this was a tremendous progress and became the most important component of Terris's "first epidemiological revolution" or of Omran's "late stages" of the epidemiological transition. If desired, this could be called a cardiovascular revolution - and with even more reason than what is called such a revolution today.

The standard description of the situation on the eve of the so-called cardiovascular revolution is something like this: "While all European countries recorded a steady increase in life expectancy, mainly as a result of an accelerated decline in infant mortality and infectious diseases, this growth stopped in the 1960s, as new epidemiological threats emerged in the form of increased mortality from cardiovascular diseases, traffic injuries and other causes associated with risky behavior. According to the theory of epidemiological transition, these adverse events should have hindered further progress in life expectancy" (Fihel, Pechholdova 2017: 652).

This description has nothing to do with either reality or the theory of the epidemiological transition, at least in the part where it comes to cardiovascular diseases, which are completely meaninglessly placed next to traffic injuries. "Epidemiological threats in the form of an increase in mortality from cardiovascular diseases" appeared 100 years earlier, and they were not threats at all, because such an increase in mortality at the same time meant an increase in the average age of death - that is, something that should have been aimed at. Moreover, the gain in years of life in this case was the largest possible, because the average age of death from any other class of causes of death was lower than from cardiovascular diseases (Figure 1).

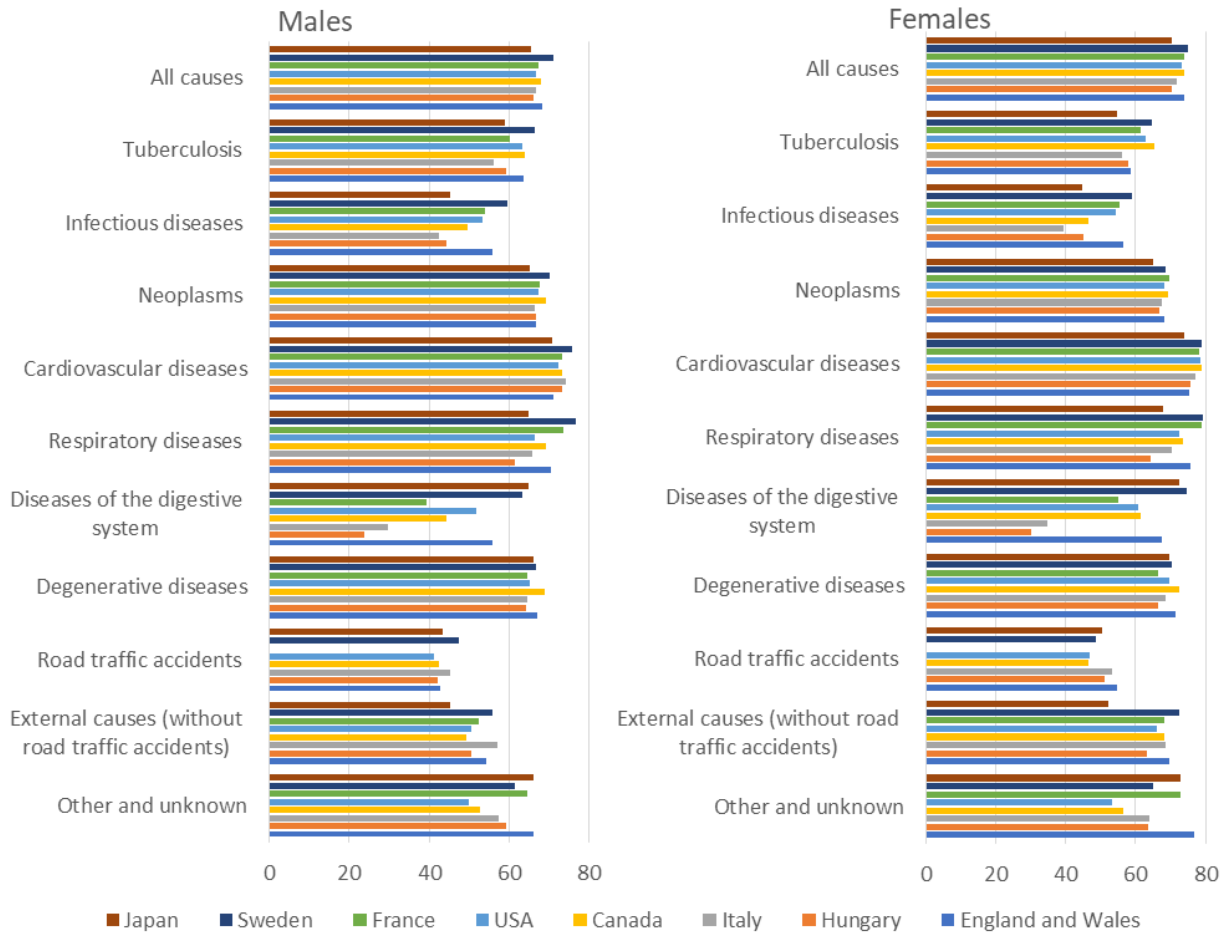

Figure 1. Average age of death from various causes in some countries in 1960, years

Source: (Preston, Keyfitz, Schoen 1972)

What actually happened can be clearly seen in the example of England and Wales, since in this case there are rather long data series. The rapid increase in the likelihood of dying from cardiovascular diseases (Figure 2), in combination with a rapid increase in the average age at death from these diseases (Figure 3) over 100 years, was the main driver of the increase in life expectancy. The average person who died from this cause could be considered to have drawn a lucky ticket, because any other cause would have brought him to the brink of the grave sooner.

What did the shift in the 1970s mean, when the chances of a newborn dying from causes belonging to the class of cardiovascular diseases began to decline? It is this decline that is called the "cardiovascular revolution." What is its meaning? When the chances of dying from these causes increased in the previous stage, the chances of dying at a later age also increased. What is happening now?

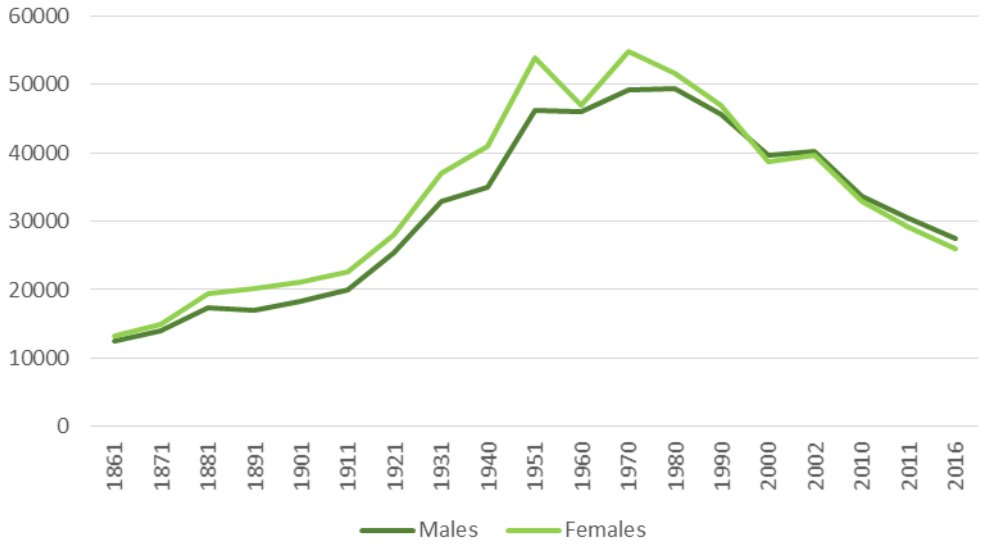

Figure 2. Probability of a newborn dying from cardiovascular diseases, England and Wales, 1861-2016, per 100 thousand births

Sources: (Preston, Keyfitz, Schoen 1972; Human Cause-of-Death Database; WHO Mortality Database).

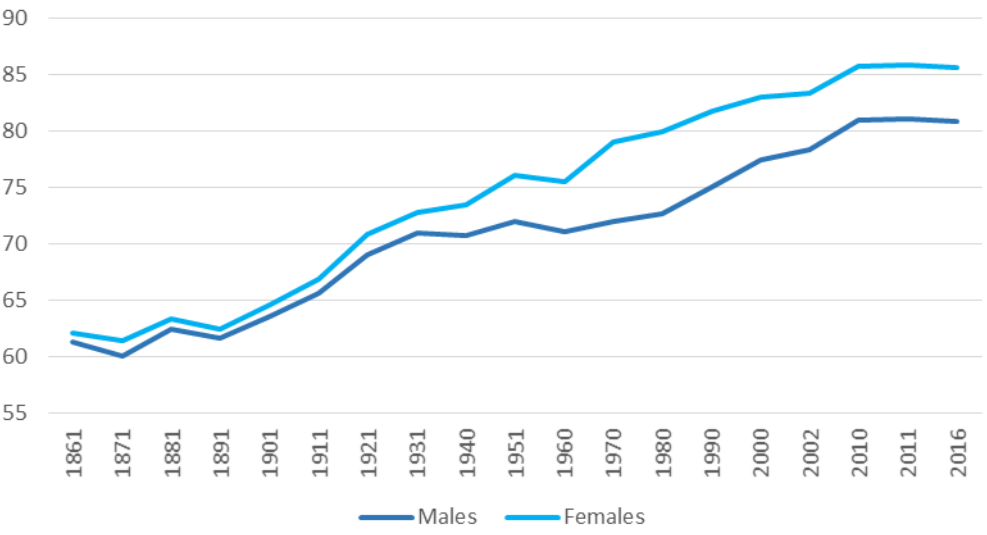

Figure 3. Average age at death from cardiovascular diseases , England and Wales, 1861-2016, years

Sources: (Preston, Keyfitz, Schoen 1972; Human Cause-of-Death Database;WHO Mortality Database).

Does not the decrease in the role of cardiovascular diseases as a cause of death mean that they have more successful competitors, with an even higher average age of death, and that the situation of a century ago is being repeated, when cardiovascular diseases demonstrated their competitive advantages over infectious diseases that often interrupted a person's life at the very beginning?

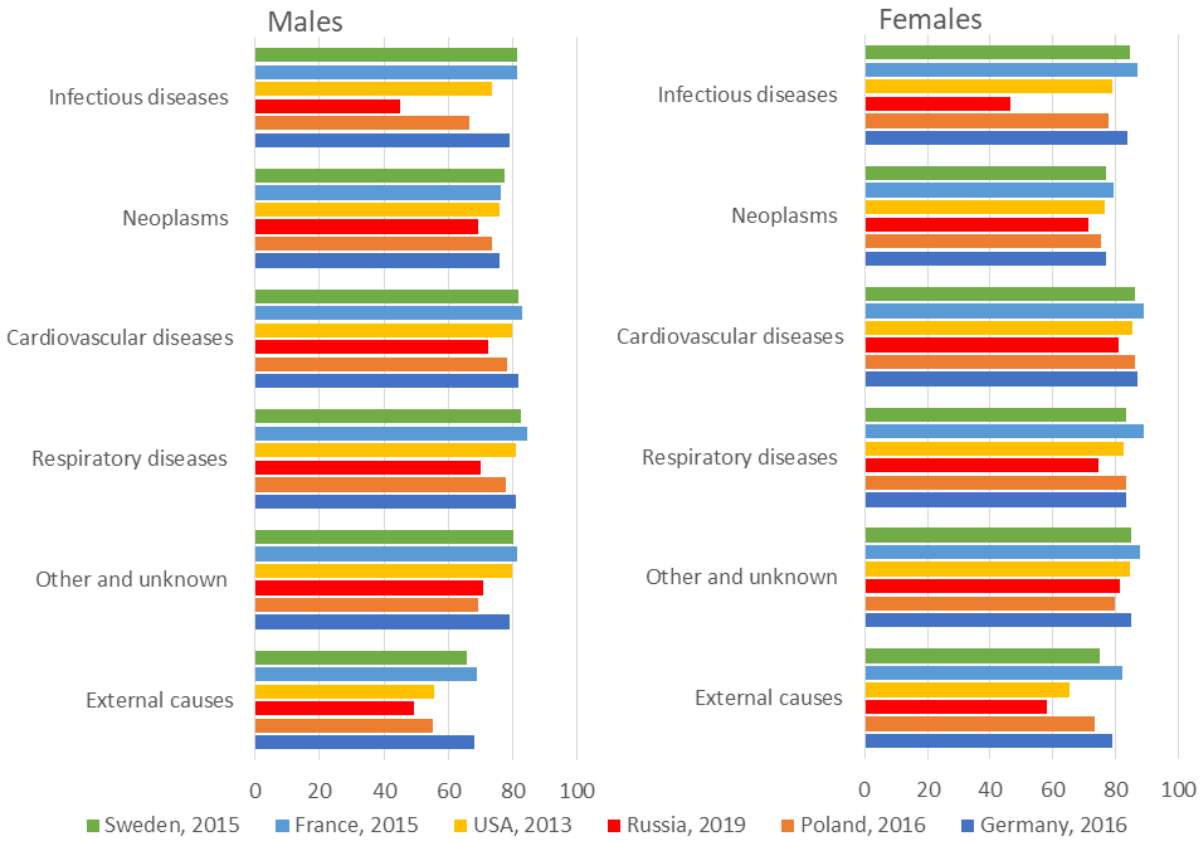

Figure 4. Average age at death from various causes in some countries, years. Latest available data

Sources: (Preston, Keyfitz, Schoen 1972; Human Cause-of-Death Database; WHO Mortality Database).

Comparison of Figure 1 with Figure 4 shows that there have been no fundamental changes in the ratio of the average ages of death from various causes over the past half century. True, cardiovascular diseases have a competitor with a slightly higher average age of death - respiratory diseases. This, apparently, is a consequence of the fact that, having already reached a very old age, people become more vulnerable to colds and pneumonia, from which, on the contrary, children have stopped dying - hence the increase in the average age of death from these causes. Otherwise, cardiovascular diseases are still the most "profitable" cause of death, and in this sense their advantage continues to increase: the average age at death from them has continued to grow, at least until recently (Figure 3). In this sense, no revolution has taken place; the tendencies that developed back in the middle of the 19th century persist. The decrease in the likelihood of death from cardiovascular diseases , hailed as a revolution, is actually a rather negative fact, although apparently inevitable.

The real picture of changes in the process of the ongoing epidemiological transition is determined by the complex interaction of the causes of death among themselves, and not directly, but through their relationship with age. As a person goes through life he resembles a fairy-tale Gingerbread Man: He escaped from grandfather, he escaped from grandmother ... but you can't outwit the old fox.

If someone lives to old age with a healthy heart, but dies of pneumonia, this can be regretted: if not for pneumonia, he could have lived for some more time. Nevertheless, based on

the above current figures for England and Wales, he is, in the average sense, in a better position than most people in his cohort, who died of cardiovascular disease younger than before their pneumonia.

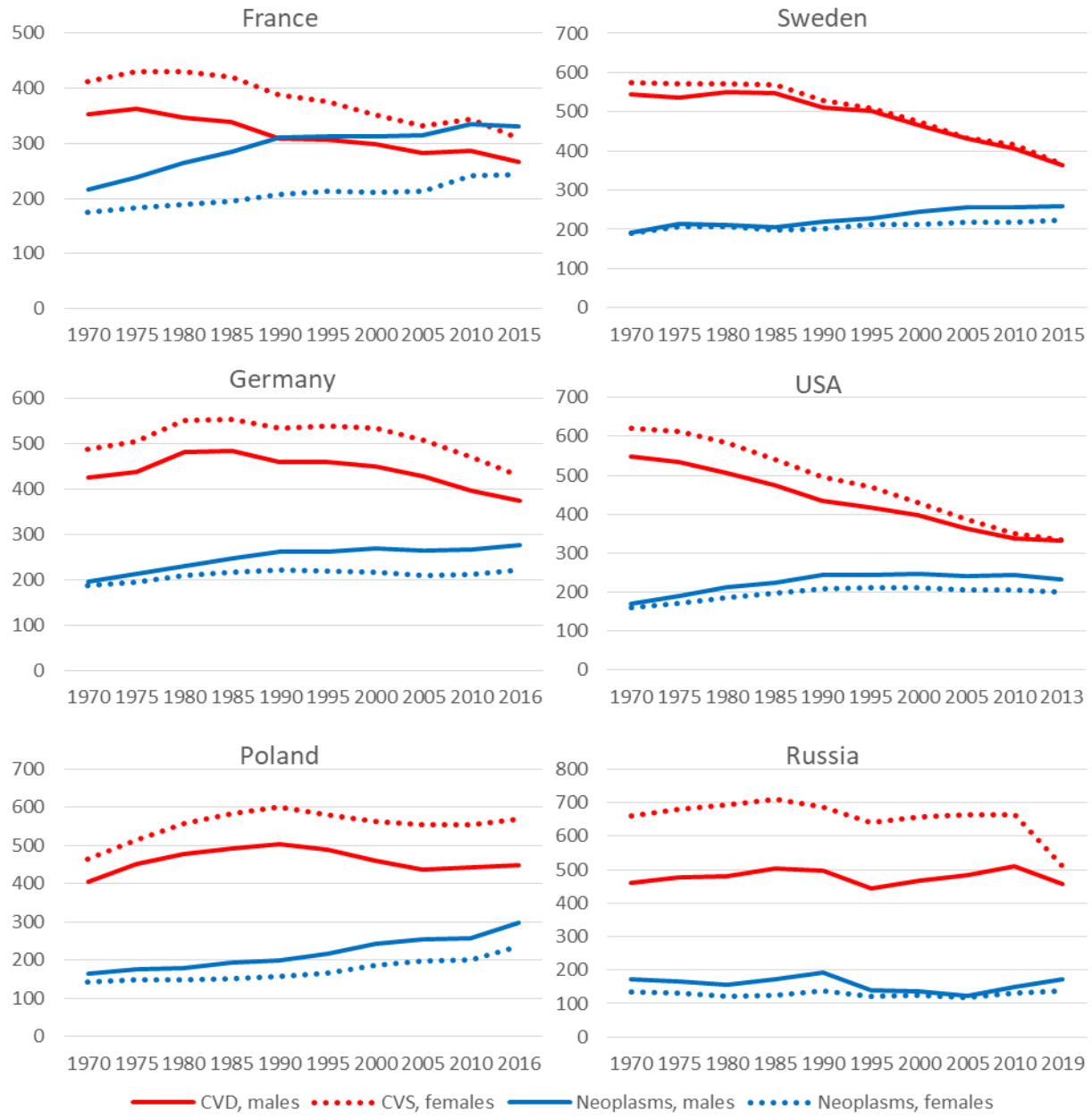

Figure 5. Probability of a newborn dying from cardiovascular diseases and from cancer since 1970 in some countries, per 1,000

Sources: (Human Cause-of-Death Database; WHO Mortality Database).

But if we replace pneumonia with cancer in our reasoning, the conclusion will be different. A person who lived to see his cancer and died from it loses in comparison with the part of his cohort that dies from cardiovascular diseases . But this happens to him precisely because he did not die from such diseases earlier. An increase in the average age at death from cardiovascular diseases preserves a part of the cohort for cancer, and this is exactly what is happening to one degree or another in all developed countries: the probability of a newborn dying from

cardiovascular diseases is decreasing, while the probability of dying from neoplasms is increasing (Figure five).

But at the same time, the average age of death is increasing for both groups of causes of death (unfortunately, this is only partially true for Russia) - see the table.

Table. Increase in the average age of death from cardiovascular disease (CVD) and neoplasms since 1970 in 6 countries, years

	Men		Women	
	Neoplasms	CVD	Neoplasms	CVD
France, 1970-2015	8.3	8.9	7.7	9.1
Sweden, 1970-2015	5.7	5.7	5.2	5.1
Germany, 1970-2016	7.6	8.9	7.4	8.5
USA, 1970-2013	8.2	7.3	7.0	5.2
Poland, 1970-2016	3.5	2.9	4.3	5.5
Russia, 1970-2019	5.3	0.0	5.4	2.4

Sources: (Human Cause-of-Death Database; WHO Mortality Database).

Considering that cardiovascular diseases and neoplasms account for 50-70% of all deaths, their interaction determines primarily the evolution of the epidemiological model of mortality at the current stage of the epidemiological transition. And this interaction develops in such a way that cardiovascular diseases, as a cause of death, lose to cancer: more and more people from each conditional cohort have a chance of dying from cancer earlier, while the chances of dying from heart or vascular disease, but later, decrease. Can this be called a revolution?

GRAPHICAL REPRESENTATION OF THE EPIDEMIOLOGICAL TRANSITION

In order to better understand the interrelated dynamics of mortality from different causes of death during the epidemiological transition, it is necessary to consider the associated changes in the prevalence of certain causes, on the one hand, and the age of death from each of them, on the other, and not individual causes, but all of them together. As a convenient tool for such analysis, back in the 1980s we proposed a graphical representation of such associated changes which gives a clear picture of the simultaneous shifts in the values of both these parameters: the probability of death from each of the causes and the average age of death from it.

Each graph is a set of rectangles, the number of which corresponds to the number of consolidated causes under consideration, with the width corresponding to the values of the probabilities for a newborn to die from the cause $i(P_i)$, $(i = 1,2,3 \ldots n; \sum P_i = 1)$, and the height to the values of $\overline{x}_i$. Accordingly, the area of such a rectangle is the expected number of person-years that people from the considered initial population of births who die from a given cause of death will live. The sum of the areas of all rectangles corresponds to the number of person-years that people who died from all causes will live, or, which is the same, the totality of all those born. This value is equivalent to the *T(0)* value of the life table. Divided by the root of the table, it gives *e(0)*, the life expectancy for the entire population of births. Since in this case we are considering the distribution not of absolute numbers, but of probabilities, which add up to one $(\sum P_i = 1)$, then we must divide by 1.

Accordingly

$$e(0) = \sum P_i \bar{x}_i$$

The larger the combined area of all rectangles, the greater the lifespan.

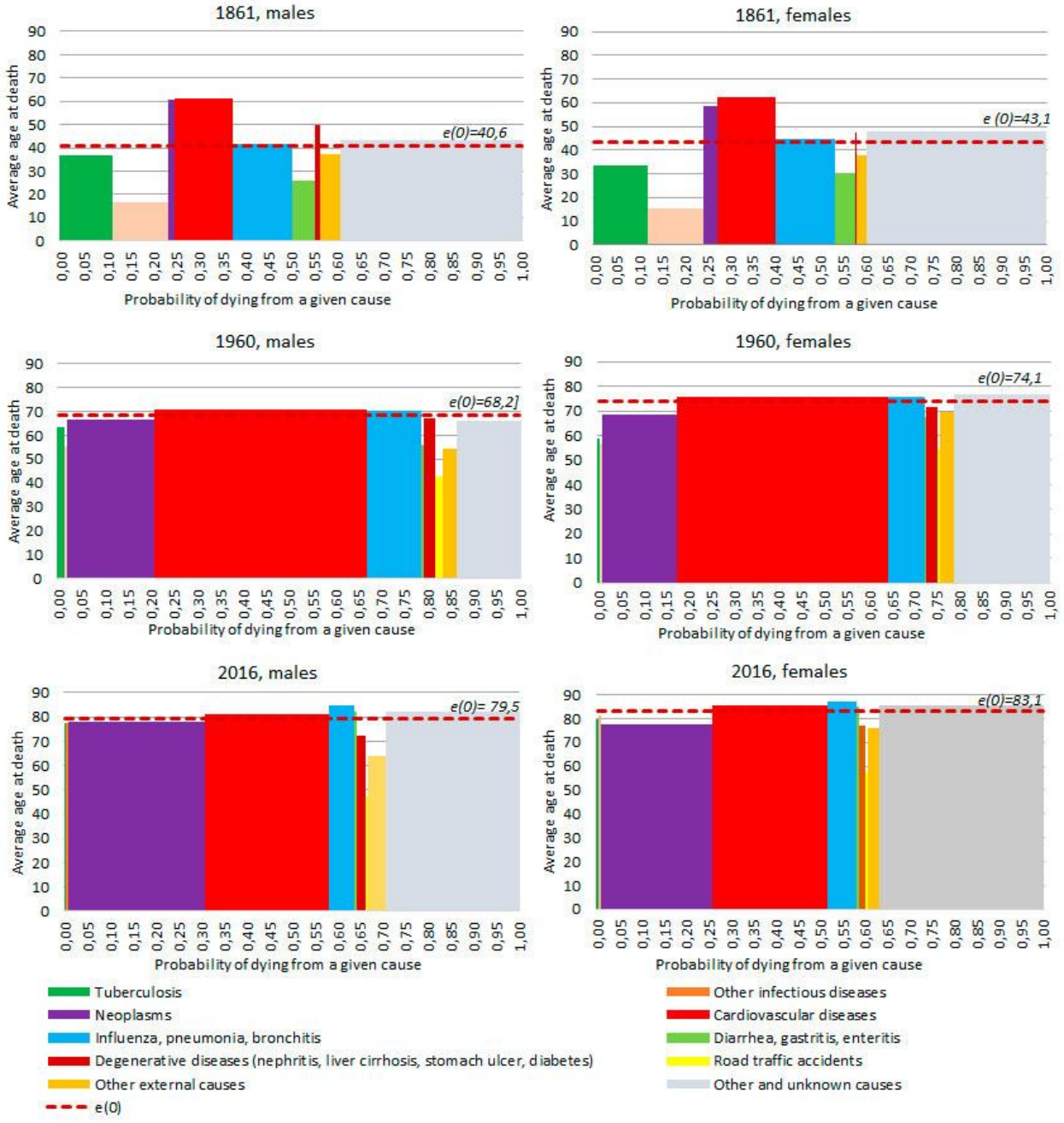

Figure 6. Lifespan of generations of men and women and its distribution by the number of years lived depending on the cause of death in terms of mortality in England and Wales in 1861, 1960 and 2016, person-years (areas of rectangles)

Sources: (Preston, Keyfitz, Schoen 1972; Human Cause-of-Death Database).

Each individual graph can be viewed as a current epidemiological model of mortality for a particular country or a particular region, but a comparative analysis showing changes over time or spatial differences indicates the existence of typical models and the evolution from one type to

another. Sharp and similar differences between the types arising in the course of such evolution at its present stage give grounds to speak of the formation of a new type of epidemiological model of mortality, which is the essence of the epidemiological transition.

Figure 6 shows the distribution of the lifespans of generations of men and women under mortality conditions in England and Wales in 1861, 1960 and 2016.

A huge increase in the life expectancy of generations over little more than a century and a half from 1861 to 2016 is obvious. Life expectancy for men and women increased by 38.9 and 40 years – a factor of 2 and 1.9, respectively. 71% of the increase in life expectancy for men and 77.5% for women was achieved in the first 100 years from 1861 to 1960; these are the fruits of Terris's "first epidemiological revolution". The contribution of the last 50 years of the "second epidemiological revolution" is more modest, however, and the period is twice as short.

But what matters is how the epidemiological picture of mortality has changed. During the transition from the 1861 mortality model to the 1960 model, mortality from tuberculosis, other infectious and gastric diseases, i.e., causes associated with the lowest age of death, sharply decreased. Their place was taken by completely different causes, and in the transition from one model to another, on average, those who were lucky to die from cardiovascular diseases and, for women, also those who died from flu, pneumonia or bronchitis, gained the most - all of these people, again on average, lived longer than all their conditional peers. However, women who died from other and unknown causes even gained a little more.

By 1960, causes with a pronounced low age of death had largely lost their importance. The main reserve for growth in life expectancy now became an increase in the average age of death from the remaining causes. This is happening now in all countries as a result of more or less coordinated actions of health systems and other state and public structures responsible for the preservation of the health and life of citizens. The relatively low average age of death from its key causes in Russia (Figure 4) is an undoubted sign of its lagging behind.

COMPLETION OF THE EPIDEMIOLOGICAL TRANSITION

Graphs similar to those shown in Figure 6, but referring to England and Wales in 1861, 1911 and 1964, were first used in a 1986 article (Andreev, Vishnevsky, Shaburov 1986). The concept of the epidemiological transition was absent in this article, although it spoke of a "new historical type of mortality" in developed countries, which was associated with "an abrupt increase in society's control over exogenous factors of mortality as a result of the transition from an agrarian to an industrial economy" (Andreev, Vishnevsky, Shaburov 1986: 114). But a few years later, two-dimensional graphs of the structure of mortality by causes of death were already considered precisely as a tool for analyzing the epidemiological transition (Vishnevsky, Shkolnikov, Vasin 1991; Vishnevsky, Shkolnikov, Vassin 1991). The authors preferred the term "epidemiological transition" to the more neutral "transition to a new type of mortality", because Omran's term pointed to the differentia specifica of this transition, to the essence of the changes.

Based on an analysis of the structure of causes of death in 31 developed countries in 1974-1976, the authors of the above publication in 1986 came to the conclusion that "the period of

radical restructuring of the structure of causes of death is basically now behind us" and, in contrast to the previous period, there is no longer a clear connection between the average life expectancy and the probability of dying from various causes (Andreev, Vishnevsky, Shaburov 1986: 122). It was also noted there that biologists who studied the problems of life expectancy had come to a similar conclusion, formulating - albeit in the form of a hypothesis and on other grounds – the position that "the elimination of individual causes of death cannot change the magnitude of the age increment in the intensity of mortality" (Gavrilov 1984: 908-909). Developing this idea and claiming universality, the assertion that "causes of death are an unnecessary entity which can be completely dispensed with when predicting human mortality" (Gavrilov, Gavrilova 1986: 82) was clearly untenable in relation to the period of the epidemiological transition. But the fact of the growing independence of life expectancy from changes in the ratio of causes of death, which coincides with the conclusion of the Gavrilovs, can be interpreted as evidence of the end of the epidemiological transition.

Usually - and this is one of the most surprising features of the scientific discourse about the epidemiological transition – in the constant expectation of the next stages which will bring new successes in the fight against disease and death and increase life expectancy (however, sometimes there is also talk of new threats), the question of completing the transition is not even put. Meanwhile, since we are talking initially about a transition, that is, about a process that, by its very essence, must be localized in time and have a beginning and an end, it certainly cannot be infinite, just as there cannot be an infinite bridge connecting one riverbank with another.

What will the completion of the epidemiological transition look like? To some extent, the answer to this question is suggested by Figure 6, which shows the disappearance of fundamental differences in the age of death from various causes. As soon as this happens, the change in the epidemiological picture, while continuing to be very important from the point of view of an epidemiologist, doctor or healthcare organizer, ceases to interest the demographer, because it ceases to be part of the *demographic* transition. A decrease in mortality and an increase in life expectancy can continue after that, but already in an "evolutionary", not a "revolutionary" mode, as during the transition. They will already occur "on the other side of the river". The successes will be much more modest, the decrease in mortality will shift to older ages and will practically not affect the demographic balance.

"THE FIRST EPIDEMIOLOGICAL TRANSITION"?

Before moving on, let us note that the mixing of generalization levels is characteristic of the interpretation not only of the epidemiological transition, as discussed above, but also of the demographic transition as a whole, which includes the epidemiological transition as one of the main components.

The huge, unprecedented shift in the balance of mortality and fertility caused by the epidemiological transition, which irreversibly changed the conditions for the reproduction of human populations, and the consequent decrease in fertility necessary to restore demographic equilibrium constitute the essence of a single historical process called the "demographic transition" ("demographic revolution").

The demographic transition meant unprecedented changes in the very foundation of the most important, fundamental socio-biological process, and they could not but lead to radical changes on all floors of the building standing on this foundation. Such changes have really taken place and continue to occur. They are very important for the life of the society they affect. However, we are not talking about independent changes, but only about the consequences of the main, fundamental shift - the transition to a new demographic balance. After this transition began and was grasped, all its consequences were predictable - unlike the very shift of balance which human history had never known and people even in the 18th century could not imagine.

Meanwhile, a tradition has already developed of considering these consequences as adjacent, equivalent to the main shift, of splitting it into separate "revolutions" or "transitions" - "first", "second", "third", etc. (Van de Kaa 1987; Coleman 2004; Eggleston, Fuchs 2012). It seems that every self-respecting demographer strives to acquire his own transition, but in the end we see only an increasing shift towards descriptiveness to the detriment of conceptualization.

If, as is usually done, the pedigree of the theory of the demographic transition (demographic revolution) is traced to A. Landry, one cannot fail to see that although Landry, unlike Omran, focused on changes not in mortality, but in fertility, he also, like Omran, identified three stages of these changes, which he called “demographic regimes” (Landry 2019: 95). In the historical past, there existed a pervasive “primitive” regime with no conscious restriction of fertility. This was then replaced by an "intermediate" regime which in France lasted until the end of the 18th century and in other European countries until the end of the 19th century, after which it gave way to the "modern" demographic regime. All of demographic history is thus reduced to two main stages, separated by a third which is both intermediate and short.

In essence, the American demographers who developed the theory of demographic transition in the 1940s held the same view. All of demographic history seemed to them like “a long, thin powder fuse that burns slowly and haltingly until it finally reaches the charge and then explodes... The first real burst of world population growth came with the latest stage in cultural progress - the Industrial Revolution.” (Davis 1945: 1).

Omran was thinking along the same lines when he characterized all past history as a “premodern era”, during which “the major determinants of death are the Malthusian "positive checks," namely, epidemics, famines and war” (Omran 1971: 517; Omran 1977: 64). But by the time his article appeared in 1971, such ideas about the demographic uniformity of the "premodern era" and, accordingly, about the steady growth of the Earth's population in the past were questioned.

In 1960 Scientific American published a well-known article by Edward Deevey, The Human Population (Deevey 1960). This article argued that throughout human history the number of people on Earth did not increase uniformly, but in leaps, each of which was a response to a revolution in culture. According to Deevey, there have been three such revolutions (and, accordingly, such leaps) in all of history. The first occurred in the early Paleolithic, when man learned to create and use tools; the second occurred in the Neolithic era, the so-called "Neolithic revolution", which marked the transition from foraging to a productive, agrarian economy; and the third is a product of the modern scientific and industrial revolution. Each such revolution expanded the ecological niche available to man; once it was filled, demographic growth stopped and a

relative equilibrium was established, which did not exclude constant fluctuations in the population size. This was, in any event, the case with the first two revolutions. Now, the idea of three demographic revolutions formulated by Deevey - the Upper Paleolithic (as opposed to Deevey, who attributed it to the Lower Paleolithic), Neolithic and Modern - has become quite widespread (see, for example, (Birabin 2006: 16)). However, understanding the similarities and differences between these world historical demographic upheavals will apparently still require a considerable amount of time, including for those who reflect on the epidemiological transition.

In 1998, the American annual Review of Anthropology published an article by a group of authors entitled "The Emergence and Re-emergence of Infectious Diseases: The Third Epidemiological Transition" (Barrett et al. 1998). The authors of the article drew from the concept of Omran and referred to it, but developed the idea that the epidemiological transition highlighted by Omran is not the only one in human history. At the same time they, at least in part, followed the pattern that had developed by that time in the analysis of the history of demographic transitions.

The first epidemiological transition was attributed by Barrett et al. to the era of the Neolithic demographic revolution (the "second" in the Deevey frame of reference), the very fact of which was not immediately recognized, despite, it would seem, its almost complete obviousness. As the Hungarian researchers Acsádi and Nemeskéri wrote confidently in 1970, the new economic system not only served as a basis for the reproduction of mankind, it accelerated a process that, due to its striking similarity to the demographic revolution of our time, can be called the "demographic revolution of the Neolithic era" (Acsádi, Nemeskéri 1970: 196). However, this thesis was long in doubt[4]. Thus, recognizing significant changes in the demographic situation in many regions of the world and the undoubted acceleration of population growth in the Neolithic, Soviet specialists in the history of primitive societies did not agree that "some authors interpret these changes as the "first demographic revolution" and associate them with the transition to a productive economy, which, strictly speaking, is inaccurate", while "the mechanisms and scale of this "demographic revolution" remain very uncertain" (Shnirel'man 1986: 444).

Now the very fact of the demographic revolution of the Neolithic era seems to be beyond doubt, but disputes over its mechanisms have been going on for many years. And perhaps the main reason for the endlessness of these disputes is that they are dominated by the desire to see the meaning of the changes then taking place through the prism of the experience of the modern demographic transition.

Its trigger was indeed an epidemiological transition, a rapid change in the epidemiological model of mortality which ultimately led to a radical change in the conditions of demographic equilibrium, a decrease in mortality, a resulting decline in fertility and everything that followed. But nothing suggests that the mechanisms of previous demographic revolutions (transitions) were the same.

[4] I still have a letter from my Czech colleague and friend Zdenek Pavlik, at that time the main "promoter" of the theory of the demographic revolution in the "socialist camp", which he sent after the publication of my article in the journal Voprosy Filosofii, which, in particular, spoke about the Neolithic demographic revolution [Vishnevsky 1973]. He praised the article, but with the proviso: "I do not think," he wrote, "that there really are two demographic revolutions that have the same meaning, but otherwise our views are not different."

I have written before, with reference to (McEvedy, Jones 1978: 14-15), that the Upper Paleolithic (the “first”, according to Deevey) demographic revolution did not occur because mortality decreased (Vishnevsky 2018). No matter how great were the achievements of Paleolithic gatherers and hunters, the dynamics of the Paleolithic populations of Homo sapiens, like their predecessors in the wild, still depended on their density. The number of primitive communities did not increase, and the mortality rate of Australian aborigines at the time of the first contacts with Europeans at the end of the 18th century differed little from the mortality rate of Cro-Magnons. The breakthrough was in something else: the technologies and forms of social organization developed by our ancient ancestors allowed them to infinitely expand the ecumene, which made possible the growth of the world population *without an increase in population density*. And it can be assumed that it was the development of more and more new spaces in different natural and climatic zones of the planet that was one of the main motivators of technological, cultural and social innovations that constituted the essence of the Upper Paleolithic revolution, so that “initially it was demographic factors that were the cause, and the change in technology — the consequence” (Vishnyatsky 2000: 265). In demographic terms, the acceleration of population growth in the Paleolithic was of a migratory nature.

The situation is different with the demographic revolution of the Neolithic era (“the second,” according to Deevey), associated with the transition from a foraging to a producing economy. A productive agrarian economy for the first time weakened the dependence of the dynamics of human populations on density and made possible not only a new acceleration in population growth, but also the emergence of huge clusters of people, such as that which arose, for example, several millennia ago in the Nile Valley. Of course, this could not have happened without changing the demographic balance, the ratio of fertility and mortality.

The demographic balance can change due either to an increase in fertility or a decrease in mortality, or to both. The question of what exactly happened in the era of the Neolithic revolution is endlessly controversial. For more than a decade there has been discussion, in particular, of the point of view according to which one of the consequences of this revolution was an increase (not a decrease) in mortality, the so-called "Neolithic mortality crisis" - see, for example, (Caldwell, Caldwell 2003). But even if we take the opposite point of view and recognize the predominance of positive changes in mortality over negative ones, does this give grounds to speak of a "Neolithic epidemiological transition"?

The emergence of a manufacturing economy has significantly expanded the economic limits of population growth, but they have not disappeared. Apparently, the ecological and biological barriers which limited the possibilities of concentration of people and of their economic activity have not been completely overcome. Accordingly, the natural mechanisms for controlling the dynamics of population numbers have not ceased to function either. They have only acquired new, crisis forms, embodied in the image of the biblical horseman of the Apocalypse: "a pale horse: and his name that sat on him was Death, and Hell followed with him. And power was given unto them over the fourth part of the earth, to kill with sword, and with hunger, and with death, and with the beasts of the earth." (Rev. 6: 7-8).

These were the "deterrents" listed by Omran - epidemics, famine and wars - which he, with reference to Malthus, ascribes to all "premodern" history (Omran 1971; Omran 1977: 64).

Yet, most likely, they did not always exist, but appeared as a result of the Neolithic breakthrough and made themselves felt as the possibilities of an expanded ecological niche were exhausted and the population was approaching a new dangerous line. In the Paleolithic, the longest segment of human history, when mortality was of course quite high but the population density was low, these factors hardly played an equally important *demographic* role.

With the advent of a productive economy and a settled way of life, the epidemiological picture probably changed and became more complex, and for the epidemiologist these changes are important - for him they can really mean a revolution. But this is a revolution not on the scale that is inherent in the modern epidemiological revolution of Omran (who preferred the word "transition"): its meaning lies *in the transition from an uncontrolled to a controlled epidemiological picture of human existence*. There has never been such a transition in the history of mankind. Accordingly, history has not known such radical shifts in mortality rates. Even if the life expectancy of a medieval European or a Russian peasant at the end of the 19th century was slightly higher than the life expectancy of a primitive man, it was not by much; the differences were not fundamental. A significant break from the level of all past eras was first seen in some European countries no earlier than the first half of the 18th century, when they entered Omran's "period of a declining pandemic", i.e. when the epidemiological transition itself began there and the red dotted line in Figure 7, though referring already to the middle of the 19th century, irrevocably separated the modern era from all previous ones.

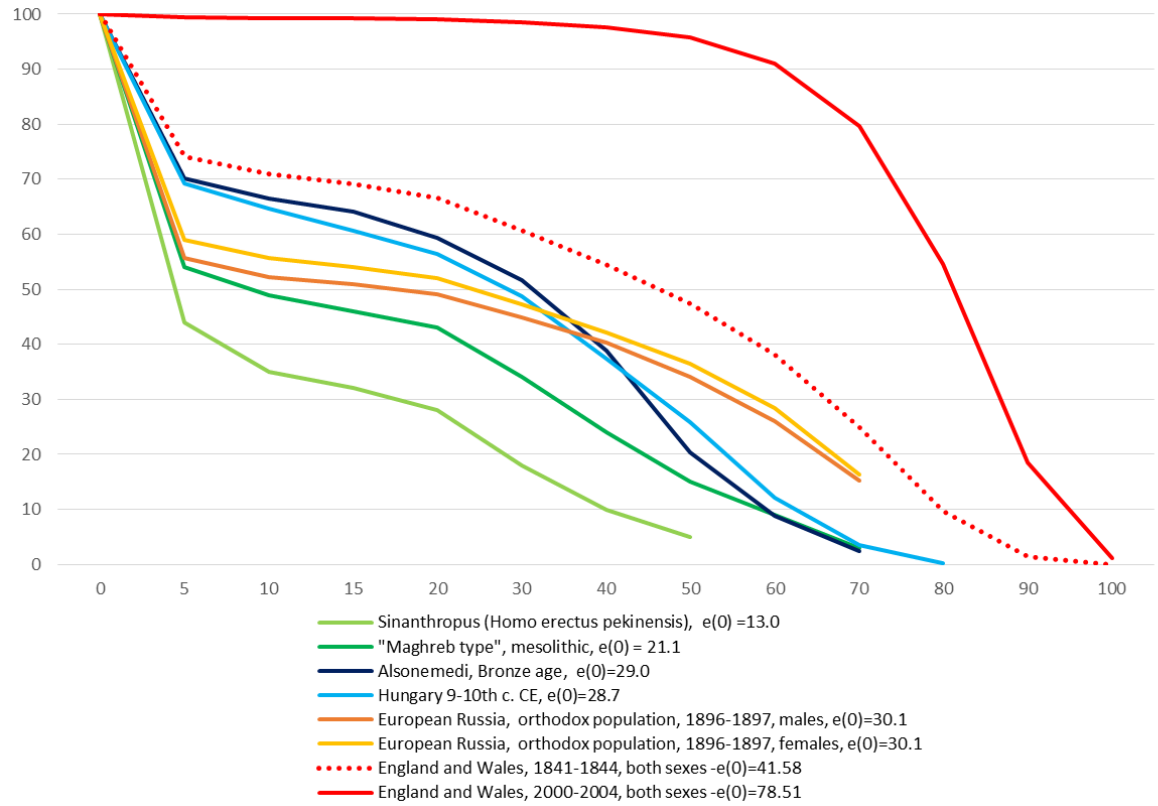

Figure 7. Life table number of survivors l_x in different historical epochs

Sources: (Acsádi, Nemeskéri 1970: 172, 266-267,282-283, 130-309; Paevsky 1970: 290; Preston, Keyfitz, Schoen 1972).

Therefore, if there is reason to talk about a *demographic* transition of the Neolithic era, which was of an *economic* nature, there are no grounds for statements about the Neolithic *epidemiological* transition. Most likely, the modern epidemiological transition is the first and, so far, the only one that the history of mankind has known.

"A THIRD EPIDEMIOLOGICAL TRANSITION"?

In the aforementioned article by Barrett et al. (1998), recourse to the authors' concept of a supposed first epidemiological transition is linked to building a historical chain in which the current epidemiological transition has not only an antecedent, but also a subsequent link. It is this last link that is named the "third epidemiological transition."

If I deny the existence of epidemiological revolutions in the past, does this mean that I deny the possibility of their occurrence in the future? Of course not; I have no reliable grounds for this. Nevertheless, since the idea of the possibility of a new epidemiological transition has been expressed and has received some support in the literature, I would like to more accurately understand what, in fact, is at stake.

The article by Barrett et al. is titled "Emerging and re-emerging infectious diseases: the third epidemiologic transition," and this title already contains the thought developed in the article. It notes three new trends: 1) the emergence of previously unknown infectious diseases that cause death in the adult population; 2) an increase in the incidence of pre-existing infectious diseases that were considered to be under control; 3) the ability of many emerging pathogens to generate antimicrobial resistant strains faster than safe new drugs can be developed (Barrett et al. 1998: 256).

The authors of the article are not the first to point out all these trends and the danger of the return of infectious threats that would seem to be in the past. However, earlier authors, who also wrote in sufficient detail about these new trends, were still not sure that they gave grounds to speak of a separate stage in epidemiological history; rather, they tended to believe that this was not the case (Olshansky et.al., 1997 , Box 1). Barrett et al. unambiguously interpret the resurgence of infectious threats as the onset of a new stage which they call the "third epidemiological transition" (Barrett et al. 1998: 248).

One cannot but agree that the tendencies noted indicate new threats and, accordingly, new challenges for modern societies. But do they also represent a challenge to the epidemiological model of mortality resulting from the transition conceptualized by Omran?

Grounds to talk about a transition appeared when the role of infectious diseases fell sharply for the first time, "and they were not replaced by others, so that the overall mortality rate at a given age remained at the same level. The age of death itself has risen, and life expectancy has increased. The term epidemiological transition is used to denote the transition not only from one dominant structure of pathology to another, but also a radical transformation in the age of death" (Meslé, Vallin 2002: 440).

This idea (which, as we have seen when considering the question of the "cardiovascular revolution," was greatly underestimated by Meslé and Vallin themselves) can be expressed even

more concretely. Although during the epidemiological transition changes in mortality affect the entire age scale, reducing infant and child mortality is of fundamental importance, especially in the early stages of transition. Can those quite real threats, about which many authors anxiously write, once they have occurred, shake the current epidemiological model of mortality? Is there any reason to believe that infectious and parasitic diseases will regain their former role as the main source of infant and child mortality, due to which, in the past, the long-term balance of high fertility and high mortality was mainly maintained? Is it possible for the survival curve to drift to its previous shape?

One should probably not underestimate the epidemic nature of infectious diseases, their ability to spread quickly as a result of contacts between people and the associated risks. But if we ignore this feature of infectious diseases for a moment, then, as causes of death, they are no different from any other cause. In competition with other causes, as we saw with the example of cardiovascular diseases and cancer, they can win or lose only depending on what is the average age at death from each of them. If the average age of death from infectious and parasitic diseases becomes approximately the same as from most other causes of death, these diseases "fit" into the new epidemiological model of mortality, do not contradict it, do not speak of a step backwards or a transition to some other model. If the epidemiological transition is completed - in the sense mentioned above - then even an increase in mortality from infectious diseases in this case does not give grounds to speak of any new transition.

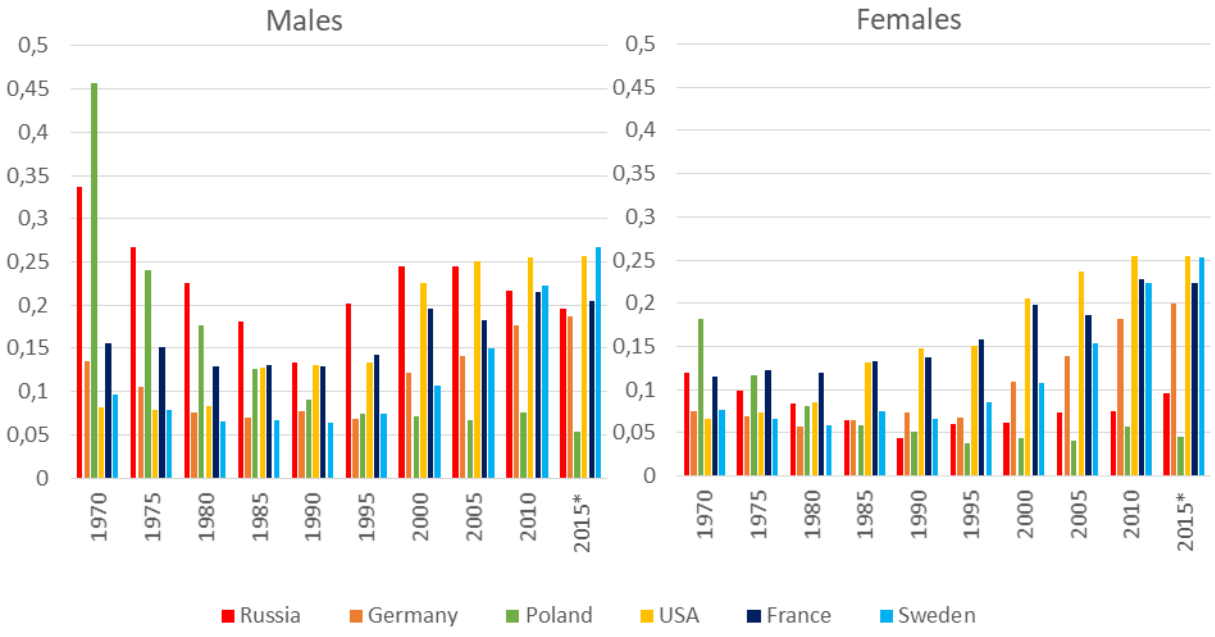

Figure 8. Probability of a newborn dying over a lifetime from an infectious or parasitic disease in selected countries, 1970-2015*

** Russia - 2019, Germany and Poland - 2016, USA - 2013, France and Sweden — 2015.*

Sources: (Preston, Keyfitz, Schoen 1972; Human Cause-of-Death Database; WHO Mortality Database).

Infectious and parasitic diseases have not disappeared completely anywhere; even in the most prosperous countries, there are both tuberculosis and AIDS, as well as outbreaks of measles or other infectious diseases. Everyone knows about seasonal flu epidemics. Among the groups of

causes of death named by Terris, the establishment of control over which he saw as the task of the "second epidemiological revolution", the main place, like Omran's, was occupied by chronic diseases and "man-made" external causes. But in fifth place on his list - after heart disease, cerebrovascular disease, cancer and external causes - were influenza and pneumonia, whose role, he expected, would be diminished thanks to flu vaccination of at-risk populations and improved antibiotic therapy.

It is now clear that such expectations were overly optimistic. This is indicated by both the already mentioned return of old infectious diseases and the emergence of new ones, as well as the growth of their resistance to drugs. This is also evidenced by the mortality statistics in economically developed countries: the probability of dying from infectious diseases, which had been decreasing for a long time, has begun to increase (Figure 8).

But the same mortality statistics also indicate that, simultaneously with an increase in the likelihood of dying from infectious diseases, the average age of death from infectious diseases is also increasing (Figure 9), that is, infectious diseases are increasingly becoming the cause of death of elderly people, competing in this sense with cardiovascular or oncological diseases, and not, say, with diphtheria or measles. Only Russia is showing its usual lag. Turning again to the data for England and Wales, in 1861 the average age of death from cardiovascular diseases in men was 44.8 years higher than from infectious diseases, in 1960 it was 15.4 years higher, and in 2016 - only 2.5 years higher. Corresponding gaps for women were 47.0, 19.1, and 3.6 years. As seen in Figure 4, in countries with low mortality the average age at death from infectious diseases is often higher than from cancer.

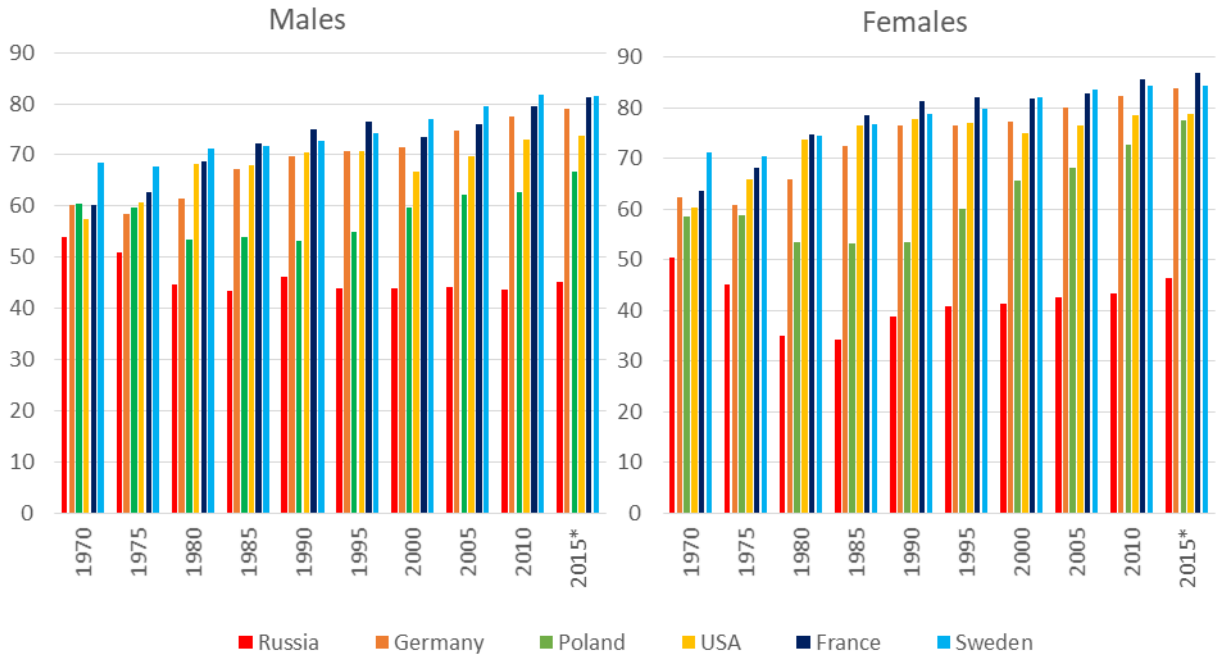

Figure 9. Average age at death from infectious or parasitic diseases in some countries, 1970-2015*, years

** Russia - 2019, Germany and Poland - 2016, USA - 2013, France and Sweden — 2015.*

Sources: (Preston, Keyfitz, Schoen 1972; Human Cause-of-Death Database; WHO Mortality Database).

But this speaks of the continuation and final stages of the current epidemiological transition, and in no way of the beginning of a new one. There is, in this case, no “radical transformation at the age of death” (Meslé, Vallin 2002: 440) - the above-mentioned fundamentally important feature of the epidemiological transition of Omran.

Even COVID-19, an undeniable confirmation of the accuracy of all the alarming warnings about a possible revanche of infectious diseases, fits well into the current epidemiological model of mortality in the sense that it turned out to be almost harmless for children, and especially dangerous for older and very old adults.

"The third epidemiological transition" sounds impressive, but is there any reason to multiply entities unnecessarily? This does not bring one closer to understanding the actual tasks of the struggle for human longevity, but rather moves one farther from it. Now these tasks are associated with the implementation of the current - and, I repeat once again, the *only* - epidemiological transition.

"REVERSE EPIDEMIOLOGICAL TRANSITION"?

“The reverse epidemiological transition in Russia” is the title of the book which, as stated in its annotation, “established general and specific patterns of development of the epidemiological transition in Russia up to the last third of the 20th century, which created the preconditions for the possibility of reverse epidemiological development … the epidemiological transition which is taking place in modern Russia” (Semenova 2005).

The fact that Russia, like other European republics of the USSR, for decades has been an amazing example of marking time and even going backwards in everything related to mortality and life expectancy is a well-known fact. But how can this example be interpreted in the context of the concept of epidemiological transition? Is there really a fundamental possibility of a "reverse transition"?

There are authors who are convinced that such a possibility exists: “The evolutionary changes in the patterns of morbidity and mortality are reversible, giving place to what could be called a counter-transition” (Frenk et al. 1989 : 31). Omran also believed that “reversal or stagnation of the transition is possible during economic, political, environmental, morbidity or other crises” (Omran 1998: 100; Omran 2019: 179).

It is hard to dispute the possibility of a temporary "regress" during crises. Much harder to accept is a backward evolutionary movement. What might be considered an indicator of such a backward movement, how might it manifest itself? Attempts known to us to find an answer to this question can hardly be considered successful.

When V. Semenova, who has devoted a whole book to the “reverse transition” in Russia, in conclusion stresses that its indicator cannot be “the increase in mortality from one cause or another” (Semenova 2005: 266), it is rather an evasion from an answer than an answer. An opportunistic, relatively short-term increase in mortality is always possible, but this may have nothing to do with the epidemiological transition. If, however, a complete or at least partial return to the previous epidemiological model does occur - only in this case is it possible to speak of a

reverse transition - then this should be signaled above all by an increase in mortality, and it should be significant and stable. If there is no such increase, then there is no reason to speak of a "reverse transition". But - here we can agree with V. Semenova - there are no such grounds even if the mortality rate increases in a time of no social crisis. The coronavirus pandemic may lead to an increase in mortality, but it can hardly fundamentally change the already established epidemiological model of mortality.

It is obvious that the epidemiological transition is a historical process that has its own determinants and is extended over time. It cannot be absolutely independent of other processes - economic, political, etc. - taking place in society, which can accelerate and slow it down. If a country goes through a period of political crisis or economic and social stagnation, this cannot but slow down the epidemiological transition, and then the indicators of this transition simultaneously become indicators of the general situation in the country. As applied to Russia, this is clearly seen in the example of the dynamics of infant mortality - not the only, but one of the main, possibly the most important, indicator of the epidemiological transition.

In the second half of the 19th century, in Western Europe it was the decline in infant mortality that became the most noticeable sign of the new demographic order. In 1900, there were only two countries in Europe (Norway and Sweden) where the infant mortality rate dropped just below 100 per 1000 births - a very low rate for the time. In Russia at that time it was 250 per 1000, making it hardly possible to speak even of the beginning of a transition. By 1950, this coefficient had dropped to 28.2 in Norway and to 21.0 in Sweden, but in Russia too it had dropped, to 88.4, meaning that the epidemiological transition had also come to Russia. Russia was still far from Sweden, but it was close to Portugal, also a Western European country, although backward for that time.

Until about the mid-60s, infant mortality in Russia decreased much faster than in Portugal, and the gap between them - in favor of Russia - increased. But then Russia entered a period of stagnation, and in 1982 was overtaken by Portugal, after which the gap began to grow now in favor of Portugal (Figure 10). The seemingly innocent infant mortality rate has proven to be a reliable marker of the general situation in the country. Stagnation and even growth of this indicator in the 1970s gave grounds for E. Todd's prophetic prediction about the entire Soviet political system[5]. But even then, there was no reverse epidemiological transition. The transition only slowed down, and the convergence of the Russian indicator with the now low Portuguese or Swedish indicator was only postponed to a later date.

[5] "In Brezhnev's USSR, the growing frequency of violent deaths is accompanied by a new phenomenon, an increase in infant mortality ... The state is no longer capable of positive action ... It is impossible to foresee in what form the Soviet crisis will express itself and whether or not the decay characteristic of this system now will result in a general spasm - reformist, revolutionary or military. But we can already observe the first manifestation of the crisis - sanitary regression and an increase in violent mortality ... The disintegration of the first of the communist systems has already begun" (Todd 1990: 333). (The 1990 edition reproduces the text of a 1978 speech published in 1980 in Economie et humanisme, no. 252).

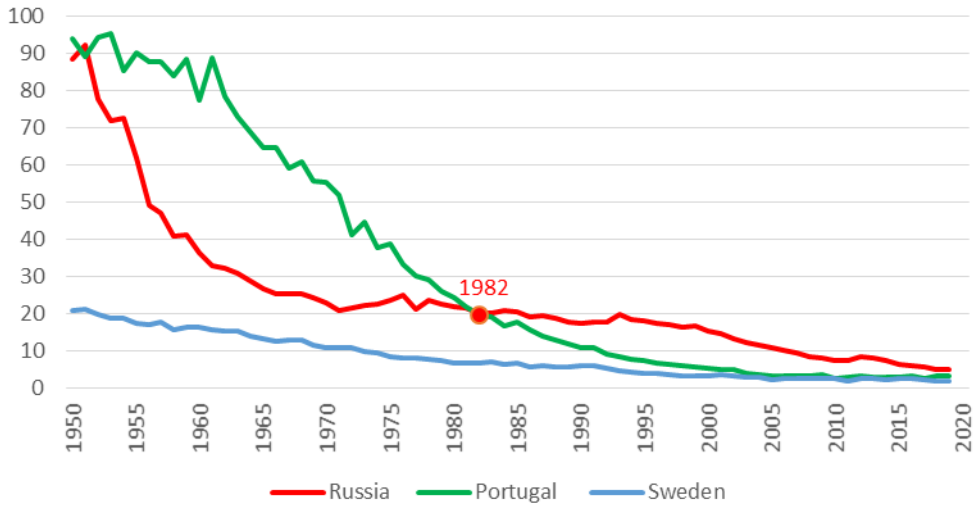

Figure 10. Infant mortality in Russia, Portugal and Sweden, 1950-2019, per 1000 births

Source: (Demoscope Weekly).

Incompleteness of the epidemiological transition as a continuing and protracted process is a normal state. It can be overcome more quickly or more slowly, depending on the general pace of modernization of a society. Counter-modernization trends in the economy, public life, culture and politics can slow down the epidemiological transition. But if we rule out global catastrophes of irreparable proportions or some serious backward movement, there can be no return to the models that existed even at the beginning of the twentieth century. The epidemiological transition is irreversible.

THE EPIDEMIOLOGICAL TRANSITION IN DEVELOPING COUNTRIES

The concept of the epidemiological transition proposed by Omran reflected the experience accumulated in economically developed countries, not only in the European countries of the classical transition, but also in a country like Japan, where the transition began later, but proceeded at an accelerated pace.

For developing countries, Omran noted, there was "the relatively recent and yet-to-be completed transition" (Omran 1971: 535; Omran 1977: 88), which he characterized as "slow". At the same time, he noted that, despite the similarity of trends in the developing countries of Latin America, Asia and Africa, there are still significant differences between them (Omran 1971: 536; Omran 1977: 89). As the epidemiological transition gained momentum in the developing world, the real problems associated with these differences became more apparent, and in his 1998 paper Omran provided a more extensive and detailed outline of "non-Western" transition models (Omran 1998; Omran 2019).

It is not surprising that at this time interest in the problems of developing countries increased among other researchers, and inevitably they again and again turned to Omran's concept. But, in a strange way, the use of this concept was almost always accompanied by criticism of its

creator, often completely unfair and, most importantly, testifying to a refusal to use the cognitive possibilities that are inherent in it.

In 2014, a special issue of the journal Global Health Action was published under the general title Epidemiological Transitions - Beyond Omran's Theory, focusing on the pressing problems of developing countries.

The author of the introductory article for the issue concludes that the concept of epidemiological transition "was relevant as a way of describing and understanding to some extent the relation among disease and mortality patterns in the course of population change in Western societies until the 1950s, rather than as a universal description or prediction regarding population health patterns enlightening to the formulation of health policies in contemporary societies or in developing countries" (Defo 2014a: 13).

The conclusion about the "irrelevance" of Omran's theory in relation to developing countries is made, in particular, on the basis of testing seven hypotheses that supposedly follow from the theory of epidemiological transition but are not confirmed by the experience of Africa. Let's give, for example, one of these hypotheses and its verification.

Hypothesis 4: "According to Omran's epidemiological transition theory, mortality from infectious diseases in non-Western countries was projected to decline from 42.1% of all deaths in less developed regions in 1970 to 19.4% in 2015, as a result of which life expectancy at birth should increase from 57.5 to 68.5 years".

Test of hypothesis 4: "Africa is far from the rest of the world ... Infectious and parasitic diseases alone account for 41% of all deaths in Africa, compared with 15% in the world as a whole ... 64% of all deaths in the world are caused by noncommunicable diseases; this figure is 87% in developed regions and 28% in Africa. In most developing regions, the contribution of noncommunicable diseases (causes of death in group II) exceeded the contribution of causes of death in group I already in 1990, while in sub-Saharan Africa this ratio was only 0.4 ... Almost 20 years later, this ratio is still 0.4 for Africa versus 2.4 for the world as a whole, 12.4 for developed countries, 11.9 for East Asia, 4.9 for Latin America and the Caribbean, and 1.4 for South Asia."

Should a theory of epidemiological transition indicating a natural decrease in the proportion of deaths from infectious diseases as a global trend really predict this decrease with an accuracy of a tenth of one percent by a certain date for entire continents? Apparently, the author of the article believes that this is so, because this is how he formulates his "hypothesis 4" and, naturally, comes to the conclusion that "hypothesis 4 in Africa is not confirmed" (Defo 2014b).

The sum of such conclusions leads to the general conclusion that modern theoretical approaches are unsuitable for analyzing the demographic situation in Africa and the demographic prospects of this continent. "By and large, the conjectured linkages between mortality, fertility, and population growth find little empirical support in much of Africa, calling into question the basic premise of the transition approach embodied in the demographic, epidemiological, and health transition models. Despite signs of an onset of fertility decline in a handful of African countries, the widening gap between fertility and mortality patterns within and across countries combined with the enduring prevalence of infectious diseases in the continent suggests that a new and

different perspective is needed for understanding health and disease trends in Africa." (Defo 2014b).

IS IT REALLY SO?

Africa, the homeland of Humanity, is now indeed the world's most underdeveloped continent. However, this does not mean that the law of universal gravitation does not work in Africa or that the periodic table is incorrect there. Demographic theory establishes patterns common to all, and this also applies to the theory of epidemiological transition. As noted above, its semantic dominant (admittedly, very poorly articulated by Omran) is not just that some diseases and causes of death are replaced by others, but that their new set sharply pushes up the age of death of the overwhelming majority of people, and as a result the entire demographic picture of the world changes. This prediction is universal: if an epidemiological transition takes place at all, it cannot happen differently in either developed countries or developing countries. Any differences in the path, that is, whether it is longer and more rugged or less long and rugged, depending on historical circumstances, can only lead to a similar result. And Omran constantly pointed out this difference in paths when talking about different models of transition.

Unfortunately, neither Omran himself nor his followers or critics, when discussing developing countries, explicitly use the concept of catch-up epidemiological transition, although, in fact, they constantly operate with facts that point to precisely this nature. This is especially clear in those cases when they write about the "overlapping" of some stages of the transition with others. Such an overlap arises precisely due to the fact that different stages of the transition are not implemented sequentially, as occurred (and could not have occurred otherwise) in the pioneering countries, but in parallel - through the borrowing and uneven development of ready-made medical technologies and social practices. The coexistence in time of different stages of the transition is evidence of its incompleteness.

This is what Omran had in mind when he wrote about the triple burden of health problems in non-Western societies at different stages of transition. "It entails at least three major health burdens superimposed upon one another: unfinished old health problems; rising new health problems; and ill-prepared health systems and medical training." (Omran 1998: 106; Omran 2019: 190).

This absolutely correct reasoning has been confirmed by the experience of many "catching up" countries, was indicated, for example, by an analysis of the incomplete epidemiological transition in the late USSR at the turn of the 1980s-1990s. "The incompleteness is explained by two reasons: 1) the main tasks of the early stages of the epidemiological transition have not been fully resolved and elements of the traditional structure of pathology and causes of death remain ... 2) as the epidemiological transition (the second epidemiological revolution) is completed, the fight against pathogenic factors dangerous at a new stage of development has not been sufficiently developed". Regional contrasts were superimposed on the general incompleteness of the epidemiological transition in the USSR - a consequence of the fact that different republics of the USSR were at different stages of the transition (Vishnevsky, Shkolnikov, Vasin 1991: 1014; Vishnevsky, Shkolnikov, Vassin 1991: 93). From this it was concluded that in some republics, in

which 75% of the population of the USSR lived, “the epidemiological transition had advanced the most, a “new” pathology clearly prevailed, and the main efforts should be directed towards combating it. This requires a new strategy to promote the health and lives of people. In the rest of the republics, the situation is far from so clear; there are still very strong, especially among the rural population, elements of the "old" pathology, and the old strategy still retains its significance" (Vishnevsky,Shkolnikov, Vasin 1991: 1020-1021; Vishnevsky, Shkolnikov, Vassin 1991: 95). The differences noted were explained by the "unevenness of the epidemiological transition of various groups of the population" (Vishnevsky, Shkolnikov, Vasin 1991: 1014; Vishnevsky, Shkolnikov, Vassin 1991: 82) and were perceived not as an indicator of the inconsistency or incompleteness of Omran's theory, but rather as confirmation of its explanatory power.

Meanwhile, in the literature, the fact of "overlapping" of some stages of the transition by others, discovered, for example, in Mexico, is considered as inconsistent with the theory, requiring its modification (Frenk et al. 1989: 31). This is yet another of many examples of how a general theory is required to be able to predict in detail any given situation and almost give instructions on how to “formulate health policies” for each country. Can such requirements be imposed on the theory? A theory may have no direct applied value at all, yet still have meaning as a worldview, thus contributing to a better understanding of objective processes, and this in itself is very important. It seems to me that Omran’s generalization has such a semantic meaning: it highlights the decrease in mortality, which is obvious to everyone, as a kind of integral and natural historical phenomenon. But this generalization is also important for practical activities; it provides guidelines for choosing priorities at different stages of the epidemiological transition and allows one to formulate its forecast.

On the other hand, for practical activity a single universal strategy based on a general, albeit correct theory, is not enough; in each case you need a certain tactic of action which takes into account many specific circumstances from which the theory is just abstracted in order to reach the highest level of generalization. In life, both strategy and tactics are needed, but strategy is more important. To use Clausewitz's words, “strategy is the doctrine of the use of combat for the purpose of war”, and tactics are “the doctrine of the use of armed forces in battle” (Clausewitz 2017). It is important to win the battle, but the main thing is to win the war.

The limitless variety of climatic, hygienic, economic, socio-political, socio-cultural and other conditions makes inevitable an equally limitless variety of tactics for implementing the epidemiological transition, its "models", in the words of Omran. In developing such tactics, his theory is a poor helper, but it does not pretend to be. The theory says only one thing, but it is an important one. If we ignore those developing countries that are generally incapable of making the epidemiological transition, then sooner or later, after overcoming enormous difficulties, they will arrive at exactly what Omran predicted: a new epidemiological model of morbidity and mortality, in which the indicators of general and healthy life expectancy will become approximately the same as in developed countries, and the main obstacles to further improvement of these indicators will be chronic diseases and anthropogenic environmental factors.

This has not yet happened, but life expectancy in the less developed, and especially in the least developed countries, is growing faster than in the developed countries, and the trend towards convergence is evident (Figure 11).

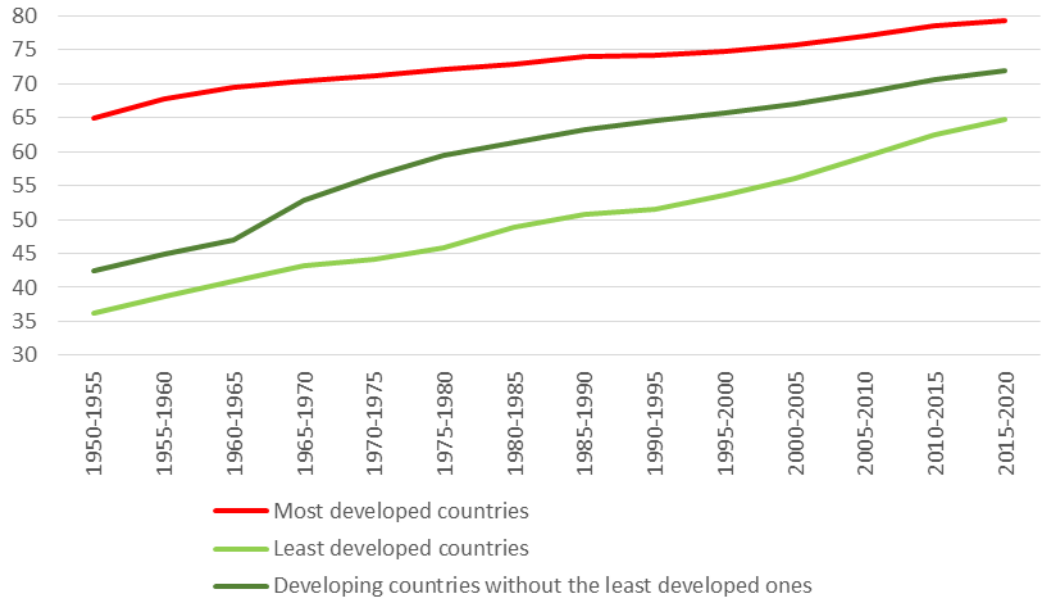

Figure 11. Life expectancy at birth in developed, less developed and least developed countries, years

Source: (World Mortality Report 2019).

Of the world's 48 least developed countries, 34 are in Africa, which, as already noted, is the least developed region of the world, including in terms of its position along the path of the epidemiological transition. Nevertheless, it would be a great exaggeration to say that in Africa nothing is changing in this sense, and that it is moving along a path completely different from that described by Omran.

According to UN estimates, infant mortality in sub-Saharan Africa in 2015-2020 (51 per 1000 births) was two times lower than in the most advanced European countries at the turn of the 20th century or in the USSR in 1950, and almost 5 times lower than in Russia at the end of the 19th century. In the region itself, it has decreased by a factor of almost 3.5 since the middle of the twentieth century (UN WPP-2019, file MORT / F01-1); such a decrease cannot but be attributed to significant changes in the epidemiological model of mortality. It is another matter that these changes are insufficient, that African countries are still in the early stages of an epidemiological transition, along the path of which other developing countries are significantly ahead of them (Figure 12). But this is no reason to deny the general direction of their movement, which is precisely characterized in a generalized form by the theory of epidemiological transition.

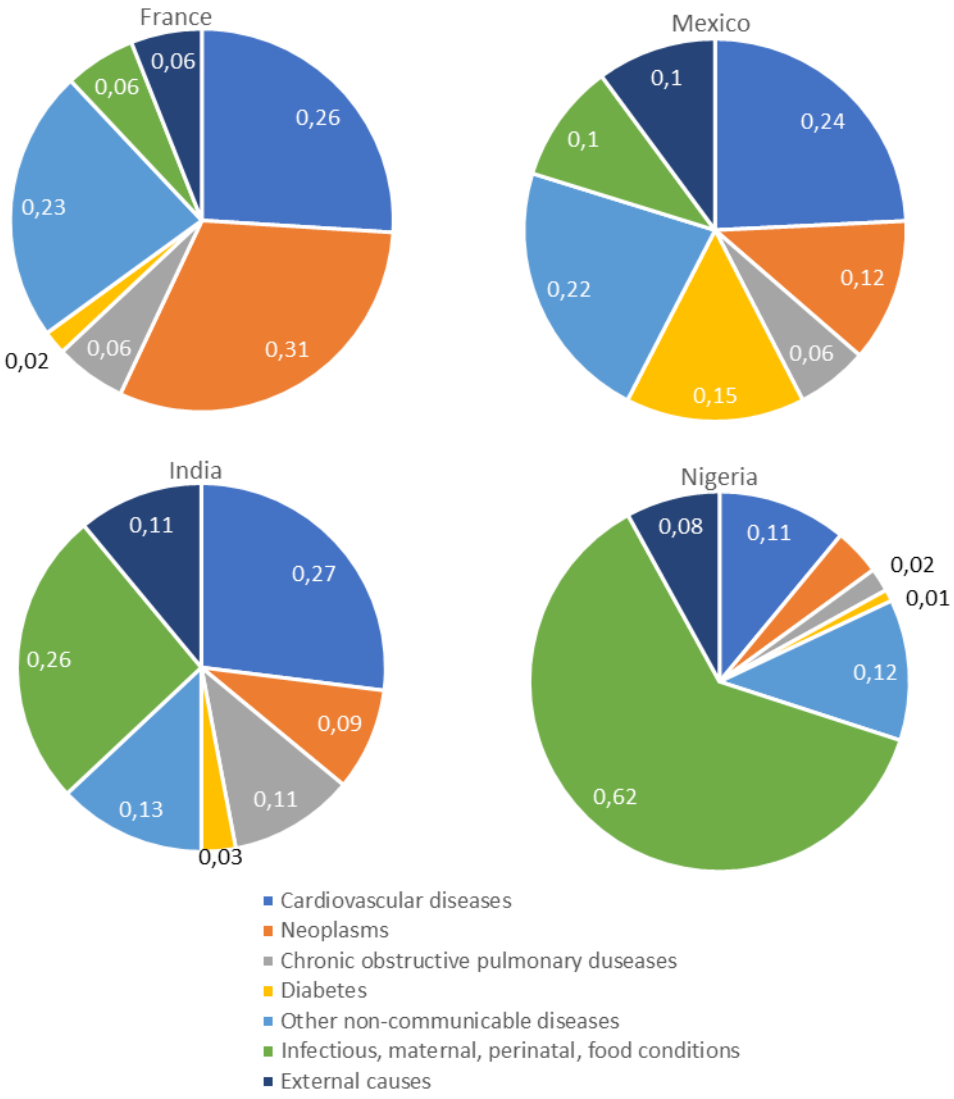

Figure 12. Structure of mortality by causes of death in France, Mexico, India and Nigeria, 2016

Source: (WHO 2018).

CONCLUSION

The emergence of the concept of epidemiological transition was an important stage in the development of scientific ideas about the demographic transition in general. Prior to that, for several decades the attention of researchers of the demographic transition was completely focused on the study of fertility and the search for explanations for its decline (a fact also, by the way, mentioned by Caldwell (2001: 159)).

Of course, the researchers also knew about the decrease in mortality, and to one degree or another took it into account when constructing their explanatory schemes - see, for example, (Davis 1963) - although, as it seems to me, with great incompleteness (Vishnevsky 2017). But from the point of view of the general logic of the theory of demographic transition, it was enough to point to the "mortality transition", the response to which was the "fertility transition".

The transition in mortality can be studied by analyzing its quantitative results, changes in mortality rates, which is being done quite successfully. An example of such an analysis is a study of mortality declines since the mid-18th century in Finland (Kannisto, Nieminen, Turpeinen 1999) or an analysis of the rectangularization of the survival curve in France in the 20th century (Robine 2001). The authors of these studies correlate their results with the stages of the epidemiological transition identified by Omran, but this is just a tribute to the prevailing discourse in the literature, which at that time could no longer do without references to the concept of Omran.

The reasons for the decrease in mortality did not raise any big questions; it seemed sufficient to point out economic, hygienic, and general cultural changes, at best to specify the reasons for the decrease in mortality, as, for example, McKeown et al. (McKeown, Brown, Record 1972) did. They concluded that the decline in mortality in Western Europe in the 19th century was mainly due to an increase in living standards and agricultural success, which led to improved nutrition and changes in hygiene conditions, thanks to which, in particular, mortality from intestinal infections decreased. Causes not depending on the action of people may have been important, too, for example, a decrease in the virulence of pathogenic bacteria.

For Notestein and other theorists of demographic transition, the very fact of the decline in mortality was important, but Omran went further, reflecting on the nature of this decline. "Notestein`s approach to mortality analysis is most fully elaborated in Omran`s epidemiology of the population change recognizing that mortality transition involves more than simple quantitative reductions in mortality levels and their short-term fluctuations... The main aspect that separates the epidemiological transition from the demographic transition is the addition of a new element, a shift in cause-of-death patterns and the stage-wise characterization of the transition stages by the configurations of the causes of death as well as the influences on them" (Defo 2014b). "The concept of the epidemiological transition helps to understand the "anatomy" of historical changes in mortality as an independent revolution that led to a radical change ... in the structure of <causes of death>" (Vishnevsky 2017: 10).

Omran just slightly shifted his angle of view and looked at the changes in mortality not from the side of their causes, but from the side of the result that he saw in a generalized form: not as the sum of the gains from reducing mortality from tuberculosis, childhood infections, stomach diseases, maternal mortality and others, but as a general qualitative shift, which in a short time fundamentally changed the entire epidemiological picture. This was the discovery whose meaning is precisely expressed in two words: epidemiological transition.

Perhaps Omran made this discovery by chance and it would have been more fair if such luck had fallen to the lot of the same McKeown or, say, Frank Notestein or Kingsley Davis. But it fell to Omran, and this fact cannot be changed.

As soon as this happened, Omran did not become a "citation classic" by accident. No researcher studying the historical or modern evolution of health and mortality in a broad sociobiological context can do without the fruitful, albeit not very simple, concept of the epidemiological transition, without attempting to use its analytical and prognostic potential.

But hence the possible costs. Omran formulated the concept in the most general form; many of the positions he expressed are not perfect, and the concept as a whole needs to be developed.

A deeper understanding is needed of the mechanisms of formation and evolution of the modern epidemiological model of morbidity and mortality, its "two-dimensionality", internal relationships, possible options and limitations and, apparently, of the ways of protecting it in the face of probable threats. The solution of these tasks can be successful only if we keep in sight the entire process of transformation of the two-dimensional epidemiological model of morbidity and mortality - the transformation that the concept of epidemiological transition implies.

And all attempts to alter, fragment or rename this concept or misuse it are not very effective attempts of Penelope's suitors to pull Odysseus's bow.

ACKNOWLEDGMENTS

The author thanks Evgeny Andreev and Alexey Shchur for their help in preparing data on mortality by causes of death.

REFERENCES

Acsadi G., Nemeskéri J. (1970). *History of human life span and mortality*. Budapest: Akadémiai kiadó.

Andreyev E.M., Vishnevsky A.G., Shaburov K.Yu. (1986). Prodolzhitel'nost' zhizni i prichiny smerti (Life expectancy and causes of death). In A.G. Volkov (Ed.), *Demograficheskiye protsessy i ikh zakonomernosti* (Demographic processes and their regularities) (pp. 110-130). Moscow: Mysl'. (In Russ.).

Barrett R., Kuzawa C.W., McDade T., Armelagos G.J. (1998). Emerging and re-emerging infectious diseases: the third epidemiologic transition. *Annual review of anthropology*, 27(1), 247-271.

Birabin J.-N. (2006). The History of the Human Population from the First beginnings to the Present Day. In G. Caselli, J. Vallin, G. Wunsh (Eds.), *Demography: Analysis and Synthesis. A Treatise in Population Studies* (Vol.3, Ch. 66). Academic Press.

Caldwell J.C. (2001). Population heath transition. *Bulletin of the World Health Organization*, 79, 159–160.

Caldwell J.C., Caldwell B.K. (2003). Was there a Neolithic mortality crisis? *Journal of Population Research*, 20(2), 153-168.

Chesnais J.-C. (1986). *La transition démograhique. Etapes, formes, implications écpnomiques*. PUF.

Clausewitz K. (2017). *O voyne. (Vom Krieg.)* Moscow: Izdatel'stvo AST. (In Russ.).

Coleman D. (2004). Migration in the 21st century: a third demographic transition in the making? *Plenary Address to the British Society for Population Studies Annual Conference*, Leicester, 13 September 2004.

Davis K. (1944). Demographic fact and policy in India. Demographic Studies of Selected Areas of Rapid Growth. *The Milbank Memorial Fund Quarterly*, 22(3), 256-278.

Davis K. (1945).The World Demographic Transition. *The Annals of the American Academy of Political and Social Science*, 237, 1-11.

Davis K. (1963). The theory of change and response in modern demographic history. *Population Index*, 29(4), 345–366.

De Flora S., Quaglia A., Bennicelli C., and Vercelli M. (2005). The epidemiological revolution of the 20th century. *The FASEB Journal*, 19, 892-897.

Deevey E.S. (1960). The human population. *Scientific American*, 203(3), 194-205.

Defo B.K. (2014a). Beyond the 'transition' frameworks: the crosscontinuum of health, disease and mortality framework. *Global Health Action,* 7(1), 24804. URL: https://doi.org/10.3402/gha.v7.24804

Defo B.K. (2014b). Demographic, epidemiological, and health transitions: Are they relevant to population health patterns in Africa? *Global Health Action*, 7(1), 24804. URL: https://doi.org/10.3402/gha.v7.22443

Demoscope Weekly. Prilozheniye. Tabl. Koeffitsiyent mladencheskoy smertnosti. URL: http://www.demoscope.ru/weekly/app/app4009.php

Eggleston K.N., FuchsV.R. (2012). The new demographic transition: Most gains in life expectancy now realized late in life. *Journal of Economic Perspectives*, 26(3), 137–156.

Fihel A., Pechholdova M. (2017). Between 'Pioneers' of the Cardiovascular Revolution and Its 'Late Followers': Mortality Changes in the Czech Republic and Poland Since 1968. *Eur J Population*, 33, 651–678. URL: https://doi.org/10.1007/s10680-017-9456-y

Freedman R. (Ed.) (1964). *Population: The Vital Revolution*. Garden City, New York: Doubleday & Co.

Frenk J., Bobadilla J.L., Sepulveda J., Cervantes M.L. (1989). Health transition in middle-income countries: New challenges for health care. *Health Policy and Planning*, 4(1): 29-39. DOI: 10.1093/heapol/4.1.29

Frenk J., Bobadilla J.L., Stern C., Frejka T., Lozano R. (1991). Elements for a theory of the health transition. *Health Transition Review*, 1(1), 21–38.

Gavrilov L.A. (1984). Sushchestvuyet li predel prodolzhitel'nosti zhizni organizmov? (Is there a limit to the lifespan of organisms?). *Biophysics*, 29(5), 908-909. (In Russ.).

Gavrilov L.A., Gavrilova N.S. (1986). *Biologiya prodolzhitel'nosti zhizni: kolichestvennyye aspekty* (Life span biology: quantitative aspects). Moscow: Nauka. (In Russ.).

Human Cause-of-Death Database. French Institute for Demographic Studies (France) and Max Planck Institute for Demographic Research (Germany). Available at www.causeofdeath.org

Kannisto V., Nieminen M., Turpeinen O. (1999). Finnish Life Tables since 1751. *Demographic Research*, 1. DOI: 10.4054/DemRes.1999.1.1.

Landry A. (2019). *La révolution démographique. Études et essais sur les problèmes de la population*. Paris: Ined Éditions.

Livi Bachchi M. (2010). *Demograficheskaya istoriya Evropy.* (The populaton of Europe). Saint Petersburg: Aleksandriya. (In Russ.).

Mackenbach J.P. (1994). The epidemiologic transition theory. *Journal of Epidemiology and Community Health*, 48, 329-332.

McKeown T., Brown R.G., Record R.G. (1972). An interpretation of the modern rise of population in Europe. *Population Studies*, 26(3), 345-382.

Meslé F., Vallin J. (2002). La transition sanitaire : tendances et perspectives. In G. Caselli, J. Vallin, G. Wunsch (Eds.), *Démographie : analyse et synthèse* (V. III. Ch. 57). INED.

Meslé F., Vallin J. (2006). The health transition: Trends and prospects. In G. Caselli, J. Vallin, G. Wunsh (Eds.), *Demography: Analysis and Synthesis. A Treatise in Population Studies* (V.2, Ch. 57). Academic Press.

Notestein F.W. (1945). Population – the long view. In Th.W Schults (Ed.), *Food for the world* (37-57). Chicago University Press.

Olshansky S.J., Ault A. (1986). The fourth stage of the epidemiologic transition: The age of delayed degenerative diseases. *The Milbank Quarterly*, 64(3), 355-391.

Olshansky S.J., Carnes B., Rogers R.G., Smith L. (1997). Infectious diseases - new and ancient threats to world health. *Population bulletin*, 52, 2.

Omran A.R. (1971). The epidemiologic transition: a theory of the epidemiology of population change. *The Milbank Memorial Fund Quarterly*, 49 (4, Pt. 1), 509-538

Omran A.R. (1977). Epidemiologicheskiy aspekt teorii estestvennogo dvizheniya naseleniya. (Epidemiological aspect of the theory of the natural growth of population. Original title: The epidemiologic transition: a theory of the epidemiology of population change). In D.I. Valentey, A.P. Sudoplatov (Eds.*), Problemy narodonaseleniya. O demograficheskikh problemakh stran Zapada* (pp. 57-91). Moscow: Progress. (In Russ.).

Omran A.R. (1998). The epidemiologic transition theory revisited thirty years later. *World Health Statistics Quarterly*, 51(2-4), 99-119

Omran A.R. (2019). Teoriya epidemiologicheskogo perekhoda: vzglyad 30 let spustya. (The epidemiologic transition theory revisited thirty years later). *Demograficheskoye obozreniye (*Demographic Review*)*, 6(1), 177-216. URL: https://doi.org/10.17323/demreview.v6i1.9117 (In Russ.).

Pavlik Z. (1964). *Nástin populačniho vývoje svéta*. (Outline of population development of the World). Praha: NCHAV.

Pavlik Z. (1979). Problemy demograficheskoy revolyutsii (Problems of demographic revolution). In A.G. Vishnevskiy, I.S. Kon (Eds.), *Brachnost', rozhdayemost', sem'ya za tri veka* (Nuptiality, fertility, family during three centuries) (pp. 158−168). Moscow: Statistika. (In Russ.).

Pavlik Z. (1982). *Rewolucja demograficzna jako olgólna praviwidlowość rozwoju ludności*. Warszawa.

Payevskiy V.V. (1970). Tablitsy smertnosti naseleniya SSSR (Mortality tables of the population of the USSR). In A.M. Merkov (Ed.), *Voprosy demograficheskoy i meditsinskoy statistiki (Izbrannyye proizvedeniya)* (Demographic and Health Statistics (Selected Works), (pp. 228-307).Moscow: Statistika.

Preston S.H., Keyfitz N., Schoen R. (1972*). Causes of Death: Life Tables for National Population*. New York: Seminar Press, Inc.

Robine J.-M. (2001). Redefining the stages of the epidemiological transition by a study of the dispersion of life spans: The case of France. *Population: An English Selection*, 13(1), 173-193.

Rogers R., Hackenberg R. (1987). Extending epidemiologic transition theory: A New Stage. *Social biology*, 34(3-4), 234-243.

Semenova V.G. (2005) *Obratnyy epidemiologicheskiy perekhod v Rossii* (Reversal epidemiological transition in Russia). Moscow: TSSP. (In Russ.).

Shnirel'man V.A. (1986). Demograficheskiye i etnokul'turnyye protsessy epokhi pervobytnoy rodovoy obshchiny (Demographic and ethnocultural processes of the era of the primitive tribal community). In Bromley YU.V. (Ed.), *Istoriya pervobytnogo obshchestva. Epokha pervobytnoy rodovoy obshchiny (The history of primitive society. The era of the primitive tribal community)* (pp. 427-489). Moscow: Nauka. (In Russ.).

[Terris M.] (1972). The epidemiologic revolution. Editorials. *American Journal of Public Health*, 62(11): 1439-1441.

Terris M. (1976). The epidemiologic revolution, national health insurance and the role of health departments. *American Journal of Public Health*, 66(12), 1155-1164.

Todd E. (1990). *La chute finale. Essai sur la décomposition de la sphère Soviétique. Nouvelle édition augmentée*. Paris: Robert Laffont.

UN WPP-2019 (2019). Population Division of the Department of Economic and Social Affairs of the UN Secretariat. *World Population Prospects 2019*, Online Edition. POP/DB/WPP/Rev.2019/MORT/F01-1.

Van de Kaa D.J. (1987). Europe's second demographic transition. *Population Bulletin*, 42, 1.

Van de Kaa D.J. (2010). Demographic transitions. In Zeng Yi. (Ed.), *Encyclopedia of life support systems (EOLSS). Demography* (Vol. 1, pp. 65-103). Eolss Publishers. Oxford, UK.

Vishnevsky A.G. (1973). Demograficheskaya revolyutsiya (Demographic revolution). *Voprosy filosofii* 2, 53-64. (In Russ.).

Vishnevsky A.G. (1976). *Demograficheskaya revolyutsiya (Demographic revolution)*. Moscow: Statistika. (In Russ.). 238 p.

Vishnevsky A.G. (2017). Nereshennyye voprosy teorii demograficheskoy revolyutsii (Unsolved problems in the theory of demographic revolution). *Naseleniye i ekonomika (Population and Ecnomics)*, 1(1), 3–21. (In Russ.).

Vishnevsky A.G. (2018). Demograficheskiy perekhod i gipoteza giperbolicheskogo rosta naseleniya (The demographic transition and the hypothesis of hyperbolic population growth). *Demograficheskoye obozreniye (Demographic Review)*, 5(1), 64-105. URL: https://doi.org/10.17323/demreview.v5i1.7710 (In Russ.).

Vishnevsky A.G., Shkol'nikov V.M., Vasin S.A. (1991). Epidemiologicheskiy perekhod i prichiny smerti v SSSR (Epidemiological transition in the USSR as mirrored by regional differences). *Ekonomika i matematicheskiye metody (Economics and Mathematical Methods)*, 27(6), 1013-1021. (In Russ.).

Vishnevsky A.G., Shkolnikov V.M., Vassin S.A. (1991). Epidemiological transition in the USSR as mirrored by regional differences. *Genus*, XLVII, 3-4, 79-100.

Vishnyatsky L.B. (2000). «Verkhnepaleoliticheskaya revolyutsiya»: geografiya, khronologiya, prichiny. («The Upper Paleolithic Revolution»: its Geography, Chronology, and Causes). *Stratum Plus, Arkheologiya i kul'turnaya antropologiya*, 245-271. (In Russ.).

Weisz G., Olszynko-Gryn J. (2009). The Theory of Epidemiologic Transition: the origins of a citation classic. *Journal of the History of Medicine and Allied Sciences*, 65(3), 287-326. DOI:10.1093/jhmas/jrp058

WHO (2018). *Noncommunicable diseases country profiles 2018*. Geneva: World Health Organization.

WHO Mortality Database.

World Mortality Report (2019). UN Department of Economic and Social Affairs, Population Division. CD-ROM. POP/DB/WMR/Rev.2019/1/FA1