MORTALITY IN RUSSIA: THE SECOND EPIDEMIOLOGICAL REVOLUTION THAT NEVER WAS*

ANATOLY VISHNEVSKY

The article looks at different approaches to the conceptualization of the modern stage of mortality reduction (the "new stages" of the epidemiological transition, "the second epidemiological revolution", the "health transition"). During this stage, which has lasted for at least half a century, revolutionary changes have taken place in most developed countries. These changes manifest themselves in the drastic expansion of the degree of control over non-infectious causes of death—particularly over diseases of the circulatory system, neoplasms, and other non-communicable diseases, as well as over external causes of death. As a consequence of these changes, there has been a rapid shift of deaths from the abovementioned causes to older ages, an increase in the mean age of death from these causes, and, ultimately, a significant rise in life expectancy.

Russia, unfortunately, is watching this revolution from the outside, without taking any part in it. The age distribution of deaths from major classes of causes of death in Russia has not changed over the past half-century, life expectancy has stagnated, and Russia has increasingly lagged behind the majority of developed countries with respect to this indicator. Thus, the "second epidemiological revolution" has yet to occur in Russia.

Key words: *epidemiological transition, epidemiological revolution, second epidemiological revolution, health transition, causes of death, non-communicable diseases, injuries.*

1. THE EPIDEMIOLOGICAL TRANSITION, THE EPIDEMIOLOGICAL REVOLUTION, THE HEALTH TRANSITION

The concept of an epidemiological transition was formulated by the American demographer Abdel Omran in his 1971 article, "The epidemiological transition: a theory of the epidemiology of demographic change" [Omran 1971].

The term "epidemiology" generally refers to the science that studies the laws of the incidence and spread of diseases. This definition, which most likely goes back to Hippocrates and his teachings about epidemics, is especially relevant to the field of medicine. Within a medical framework, the meaning of epidemiology has changed, as the term is interpreted more broadly now than in the past. While epidemiology initially referred to the study of infectious diseases only, it has since been expanded to encompass the study of non-communicable diseases and injuries. The term is also used outside of medicine. For example, references are occasionally made to the epidemiology of crime. These newer uses of the word do not, however, contradict the original meaning of the Greek word *ἐπιδημία* (affecting a whole people), which is not directly related to medicine.

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

* THE ORIGINAL ARTICLE IN RUSSIAN WAS PUBLISHED IN DEMOGRAPHIC REVIEW, 2014, 1(4): 5-40.
URL: HTTPS://DEMREVIEW.HSE.RU/2014--4/150227447.HTML

THE STUDY CARRIED OUT WITHIN THE FRAMEWORK OF THE BASIC RESEARCH PROGRAMME AT THE NATIONAL RESEARCH UNIVERSITY HIGHER SCHOOL OF ECONOMICS (HSE) IN 2013-2014.

Omran also interpreted the term "epidemiology" in a broad sense, as referring to the essence of any mass event. He observed that “many epidemiologic techniques that have heretofore been limited to the examination of health and disease patterns can be profitably applied as well to the exploration of other mass phenomena”[Omran 1971: 509].

According to Omran, the epidemiological transition is a historic shift from an era when mortality was critically dependent on epidemics and famine and the average life expectancy ranged from 20 to 40 years; through an intermediate era during which the factors that contribute to crisis mortality—and especially to epidemics—became less important, mortality decreased, and life expectancy increased by about 50 years; to an era of diseases caused by the ageing of the body (degenerative diseases) or by human activities (man-made diseases) [Omran 1971: 516], when "life expectancy reaches an unprecedented high of 70+ “ [Omran 1971: Table 4].

At this last stage “morbidity comes to overshadow mortality as an index of health as degenerative and chronic disease problems prevail and mental illness, addictions, accidents, radiation hazards and other pollution problems become more prevalent”[Omran 1971: 516].

Thus, Omran’s concept points to which causes of death policy-makers should focus on after infectious diseases—the main source of high mortality in the past—have been largely brought under control. It appears that the direction of Omran’s thinking was prompted by the situation in developed countries in the 1960s, when the rise in life expectancy had slowed and the expert communities in these countries came to realise that the previous strategy for raising life expectancy—i.e., controlling infectious diseases—had been exhausted, and new approaches were called for.

Omran was not the only scholar who acknowledged the need to develop new strategies in the fight to further extend human life. Almost at the same time as Omran’s article appeared, the American Journal of Public Health published an editorial entitled, "The Epidemiological Revolution", which stated that “the new epidemiology … has extended the concept of public health control from the limited area of infectious diseases to encompass all causes of illness, disability and death” [Editorials 1972: 1440]. The focus of this editorial, which was written by the American hygienist Milton Terris, was on the revolution in epidemiological thinking. But in a later article in which Terris outlined his concept in more detail, he clearly pointed to objective changes that had occurred in the structure of morbidity in the previous century as societies gained control over infectious diseases, and which contributed to the first epidemiological revolution. He added that this development in turn led up to a “large and difficult task…, 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]. “During the first epidemiologic revolution, health departments achieved miracles of prevention of infectious diseases despite their separation from treatment services. The same can be true for the second epidemiologic revolution in the prevention of non-infectious diseases” [Terris 1976: 1156]. Although the discussion here is about diseases, from the general context it is clear that Terris is referring to all non-infectious causes of death. He noted at the outset that “epidemiologists have moved beyond a preoccupation with disease to include violence – accidents, homicide and suicide – among their concerns” [Editorials 1972: 1440].

Non-infectious causes of disease and death are of a different nature. As some of these causes are related to endogenous factors that cannot be separated from age-related changes of the human body, the ability of policy-makers to reduce death and disease from these causes is limited. The main opportunities to minimise mortality and morbidity from these causes appear to be related to the fact that the endogenous factors of human longevity are never separated by an impenetrable barrier from the exogenous factors – i.e. a person never lives in isolation from the natural and social environment. Thus, his natural longevity necessarily depends on conditions such as his work environment, his eating and sleeping habits, and his access to health care. Changes in these conditions could, to a certain extent, slow the ageing process, limit premature wear-and-tear on the body, and even help to "repair" the body. However, while death can be pushed to a later age, mortality from endogenous causes cannot, in principle, be eliminated.

By contrast, other non-infectious causes of death depend largely on exogenous, external factors, and can cut short the lives of otherwise healthy people long before their natural vitality has been depleted. Most exogenously caused and hence avoidable deaths now are deaths from external causes. As in the case of infectious diseases, these causes can be brought under control. Though the level of control cannot be absolute, mortality due to external factors is, in principle, avoidable and can be reduced to a minimum.

In part because many medical traditions developed during the successful fight against infectious diseases, the aims and successes of the second epidemiological revolution are often viewed primarily through the prism of disease control. When scholars note the undeniable progress made in recent decades in reducing mortality, their focus is usually on the fight against non-communicable diseases, especially cardiovascular diseases. Researchers tend to emphasise that the beginning of the decline in mortality from chronic degenerative diseases in the latter half of the 20th century was “a milestone in the history of medicine” [De Flora et al. 2005: 896]. Scholars frequently identify the cardiovascular revolution as the main epidemiological change [Meslé, Vallin 2002: 444], and point to the progress that has been made in the fight against cancer. By contrast, reductions in mortality from external causes of death are mentioned far less often.

It is however clear that the reduction in the risks associated with external causes of death is a very important component of the second epidemiological revolution. It is hardly surprising that Terris has placed external causes of death near the top of his list of the leading causes of death that must be brought under control first of all - after cardiovascular diseases and cancer.

“Accidents are a particularly tragic cause of mortality because they so often kill children and young people. Indeed, they are the leading cause of death up to the age of 35 years. For all ages, they are fourth in importance; if the attention paid to them were on a par with their significance to the nation's health, they could undoubtedly be driven out of the list of ten leading causes of death. Epidemiologic research has deepened our understanding of the host, agent, and environmental factors involved in various types of accidents and indicated the preventive measures that can and should be employed” [Terris 1976: 1156].

Curiously, Terris did not refer to Omran, and in the demographic literature that abundantly cited Omran there was no mention of Terris. However, both scholars—apparently independently of each other—clearly pointed out that the world has entered a new era, the era of non-

communicable causes of death, and both noted that these non-communicable causes include not just diseases, but also what in modern terms are called "external causes of death."

More recently, as scholars have come to understand better the special status and independent role of external causes of death in mortality trends, these causes have been assigned to a separate group. "Deaths were classified using a tree structure. The first level of disaggregation comprises three broad cause Groups: • Group I: Communicable, maternal, perinatal and nutritional conditions; • Group 11: Noncommunicable diseases; and • Group Ill: Injuries" [Murray, Lopez 1996: 14].

As Omran observed in his seminal article of 1971, the epidemiological transition ends with the era of degenerative and man-made diseases and causes of death. This proposed chain of events is consistent with the patterns observed today, at least in developed countries. This era was seen as the last stage of the epidemiological transition. Omran argued that the first steps towards this new era were taken mainly in the second half of the 19th century in the countries of western and northern Europe, with the first stage being the "pre-modern pattern of health and disease", and the last stage being the fall in childhood mortality: "In England, childhood mortality has obviously been dropping steadily since the late nineteenth century**"** [Omran 1971: 517, 524]). When we compare Omran's interpretation of these trends with that of Terris, we can see that Terris regarded the first epidemiological revolution as an early stage of this era, which ended in the developed countries by the middle of the 20th century. According to Terris, awareness of the new situation emerged in the 1940s. Writing in the 1970s, he argued that "the findings, the potentials, and the strategies and tactics required to implement the second epidemiologic revolution are not only not understood; they have hardly been discussed" [Terris 1976: 1155]. However, judging by subsequent trends, it is clear that a new strategy for reducing mortality was already being implemented around this time.

In later decades, a number of scholars – including Omran himself [Omran 1998] — proposed refining this periodisation by adding a few more stages, or even suggested that the approach to the classification of stages should change. They proposed, for example, adding a fourth stage of "delayed degenerative diseases", or a "stage that will propel life expectancy into and perhaps beyond eight decades" [Olshansky, Ault in 1986: 386]. But as Omran himself had initially talked about reaching a life expectancy of 70+ in the third stage of the transition [Omran 1971: Table 4], which does not exclude 80 +, this adjustment can hardly be considered a good basis for highlighting yet another stage. In Omran's conception what mattered was not the quantitative, but the qualitative characteristics of each stage: as the presence of degenerative and man-made diseases was the main determinant of the third stage, any additional stages might have been redundant.

Other authors who described the idea of simply adding another phase to Omran's periodisation as "unconvincing" suggested viewing the epidemiological transition as part of a more general "health transition" [Meslé, Vallin 2006: 249], and including "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 2006: 250].

Omran objected to "renaming" the concept, based on his broad interpretation of epidemiology, which "incorporates the scientific capacity to analyze social, economic, demographic, health care, technological and environmental changes as they relate to health outcomes. 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].

However the scholars who promoted the idea of the "health transition" stressed that the concept was intended to complement, not replace, the concept of the epidemiological transition. The health transition, they explain, consists of the epidemiological transition – i.e. the long-term process of change in the health conditions of a society, including changes in the patterns of disease, disability, and death, and of a *health care* transition which can be seen as the emergence of patterns of social response to these changes [Frenk et al. 1991: 23]. Such an approach can be useful in analysing the mortality situation in Russia.

A widely expressed view is that this situation is a manifestation of an incomplete epidemiological transition [Vishnevsky, Shkolnikov 1997: 12-15; Demographic modernization 2006: 257-259, 382-395; Vishnevsky 2009: 56-63] resulting from the catch-up nature of Soviet modernisation, or even a "reverse epidemiological transition" [Semenova 2005]. It may, however, be more accurate to describe these developments as indicative of an incomplete *health care* transition. The patterns of social response to the requirements of the time generated by the changing patterns of morbidity and mortality reflected, in particular, in the generalisations of Omran and Terris in the late 1960s and the early 1970s, led to the development in many countries of new strategies for preserving health and life in response to changing conditions. These strategies represent practical responses to the new challenges in further reducing mortality after the fight against infectious diseases had been decisively won. Although these diseases have not yet entirely disappeared, their incidence is far lower than in the past. These strategies have enabled countries to embark on the second epidemiological revolution predicted by Terris. Unfortunately, in Russia such adequate patterns of social response to the new challenges were not found.

2. HAVE THE CHALLENGES ASSOCIATED WITH THE SECOND EPIDEMIOLOGICAL REVOLUTION BEEN OVERCOME?

Several decades have passed since Omran and Terris first made their pioneering generalisations. It is now possible to judge whether the era they predicted has indeed begun, and how effective efforts to control non-communicable causes of death have been.

In the 1960s, mortality in western European countries and in the then not so far behind them Russia was (and still is) mainly determined by the "big four" causes of death: cardiovascular diseases, neoplasms, respiratory diseases, and external causes. In 1970, the total contribution of the four classes of causes to the standardised mortality rate from all causes was close to 80% in the countries of Western Europe and continued to rise in the following years, whereas in Russia the total contribution had already reached 90% (Figure 1).

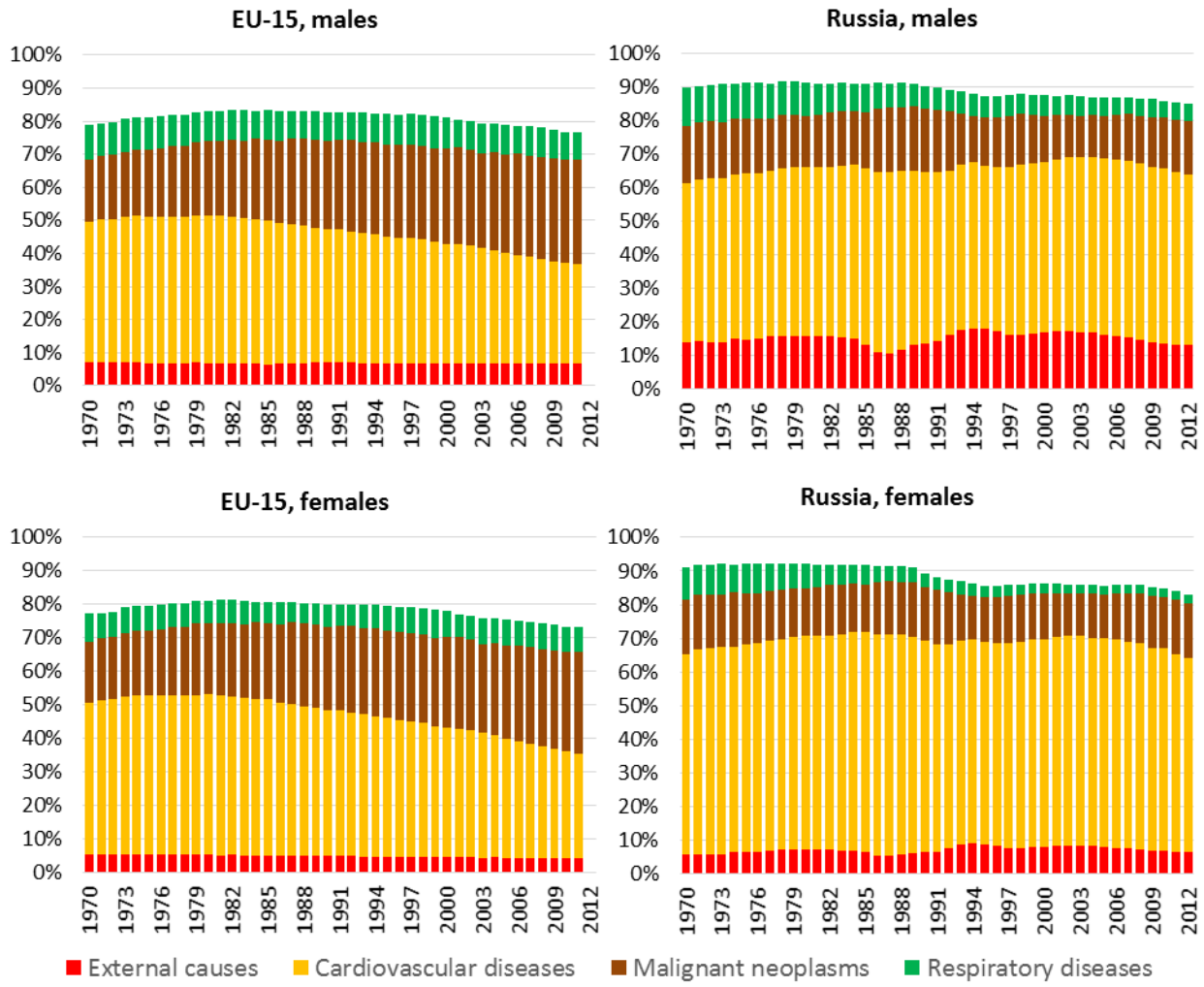

Figure 1. The total contribution of diseases of the circulatory system, neoplasms, respiratory diseases, and external causes to the standardised mortality rate from all causes in 15 countries belonging to the EU before May 2004, and in Russia[1]

Sources: [WHO HFA-DB 2014]; Rosstat.

Accordingly, the main challenges associated with reducing overall mortality levels were—and still are—reducing mortality from these four classes of causes. Judging by the dynamics of the standardised mortality rate, these problems have been largely solved in western European countries. The standardised mortality rates from three of the four main classes of causes of death have displayed nearly synchronous and rapid declines that can indeed be seen as representing a new epidemiological revolution. The exception to these general trends is mortality from cancer. Although cancer mortality has declined in the past two decades, it has not yet deviated substantially from early 1970s levels. (Figure 2).

[1] Austria, Belgium, the UK, Germany, Greece, Denmark, Italy, Ireland, Spain, Luxembourg, the Netherlands, Portugal, Finland, France, Switzerland

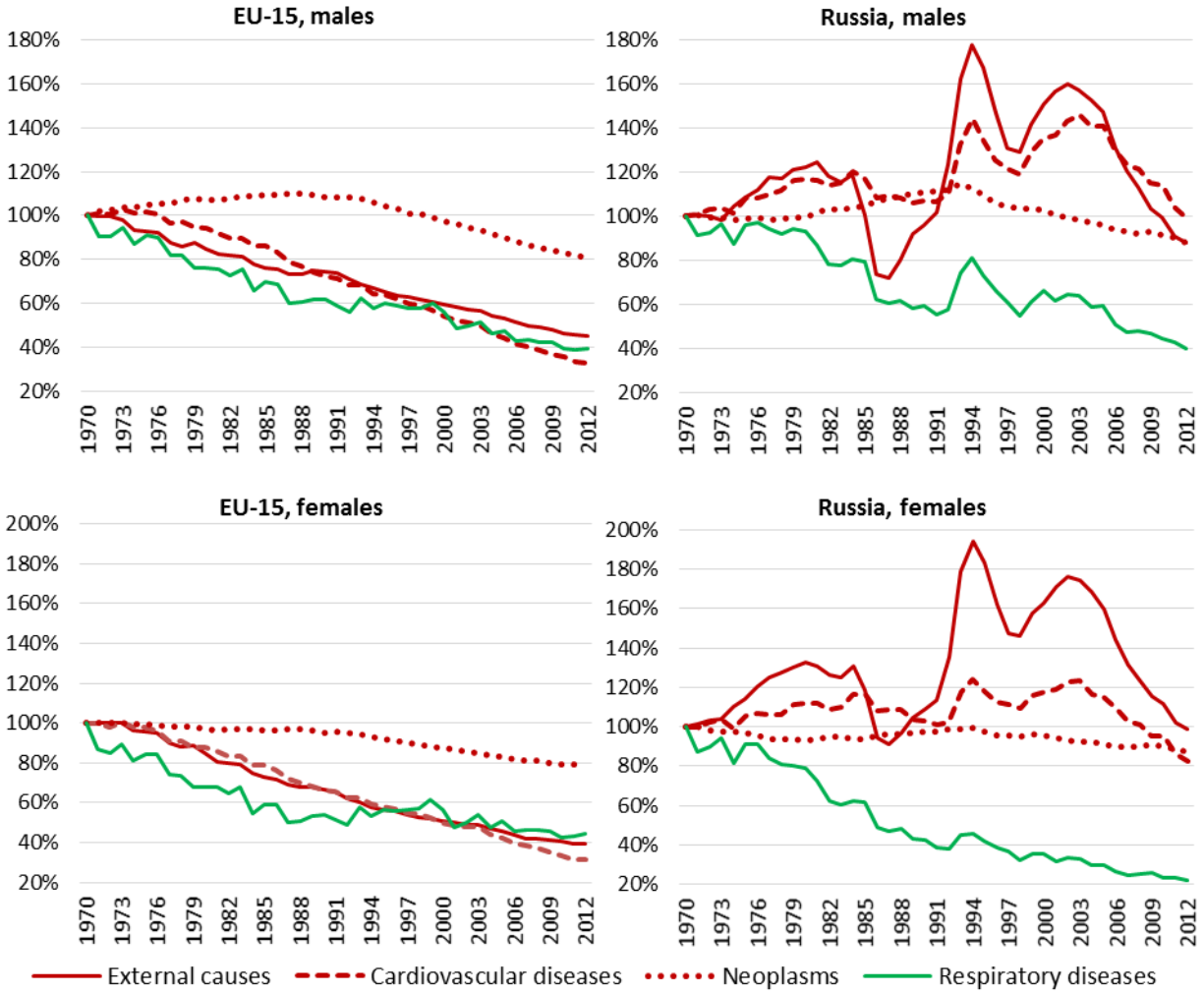

Figure 2. Dynamics of standardised death rates from diseases of the circulatory system, neoplasms, respiratory diseases, and external causes in Russia and 15 countries belonging to the EU before May 2004, 1970 = 100%

Sources: [WHO HFA-DB 2014]; Rosstat.

In Russia, these trends unfolded differently. Although there are significant structural similarities between western European countries and Russia, death rates in Russia from these four causes differed from those in Western Europe in 1970, and further diverged in subsequent years.

Although the total contribution to the standardised mortality rate of the causes of death included in the "big four" in the EU-15 has not changed very much (see Figure 1)—and these changes are not of a fundamental nature—the internal structure of this total contribution has undergone a major transformation. The main elements of this transformation are a drastic reduction in the contribution of circulatory diseases (from 45% in 1980 to 30% in 2011 among men and from 48% to 31% among women) and simultaneous growth in the contribution of cancer (from 19% in 1970 to 32% in 2012 among men and from 18% to 30% among women). Notably, the total contributions of these two classes of causes have become equal, albeit with cancer among men representing the largest share. The contributions of the other two classes of causes have not changed considerably.

In Russia, by contrast, no significant changes in the structure of the causes of death have occurred since 1970. The only change that can be seen in the Russian part of the graph is a certain decrease in the contribution of respiratory diseases. The establishing of control over the causes of death in this class can be attributed rather to the tasks of the first epidemiological revolution, of which it was a continuation and was therefore in Russia relatively more successful.

At the same time, what draws attention is the monstrous gap between Russia and the EU-15 in the dynamics of mortality from external causes of death (Figure 2). If in the EU-15 over the four decades from 1970 to 2010 the standardised mortality rate from causes of this class decreased by more than half (by 55% among men and by 60% among women), in Russia, after passing through several sharp fluctuations, the rate has returned to its 1970 level.

In Western Europe, external causes of death have been persistently in fourth place in the list of the big four causes. In Russia, external causes of death in the 1980s came in third place among women, but never dropped below third place among men, and often climbed up to second place (Figure 1). And yet the overall standardised mortality rate from the these four causes of death among both men and women in Russia in 1970 was much higher than in Europe, and later the gap only grew (Figure 1).

Enough has been said to argue that the second epidemiological revolution has been very successful in Western Europe, but has not yet taken place in Russia.

However, our analysis should be continued.

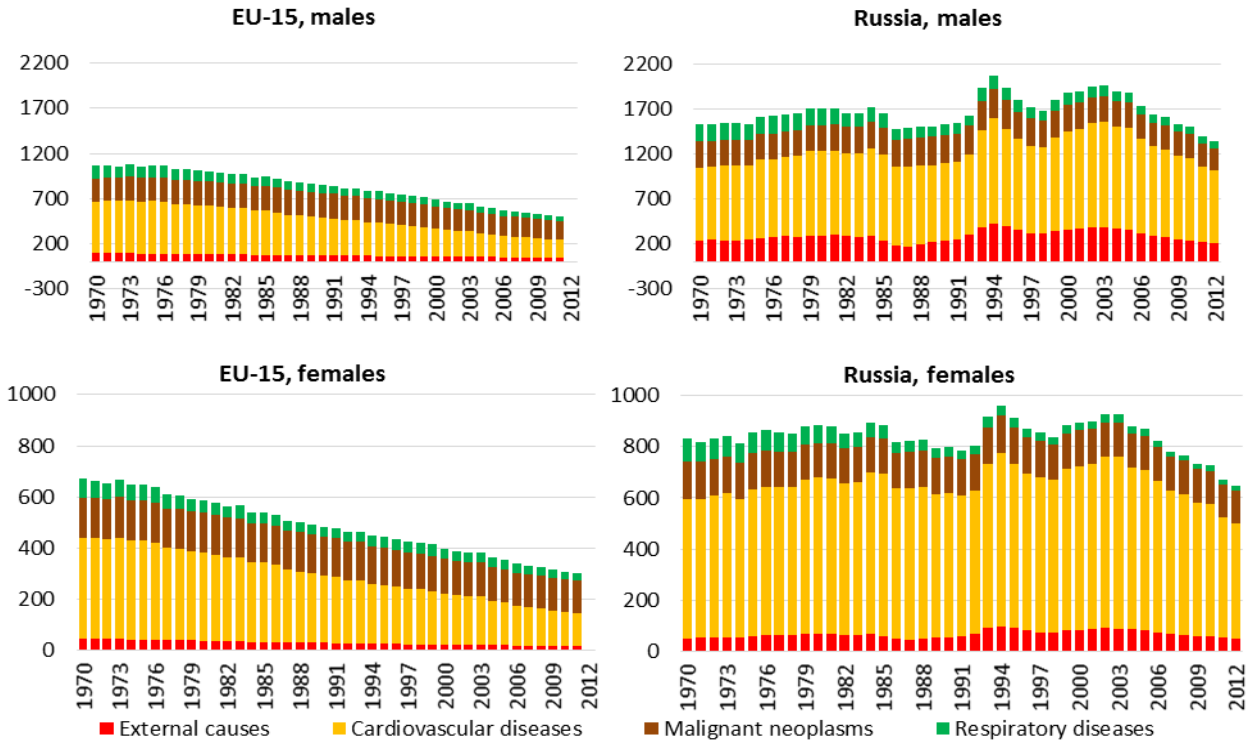

Figure 3. Standardised mortality rate from cardiovascular diseases, malignant neoplasms, respiratory diseases, and external causes in the 15 countries belonging to the EU before May 2004, and in Russia, per 100,000

Sources: [WHO HFA-DB 2014; Rosstat.

3. IS THE REVOLUTION REALLY ONLY CARDIOVASCULAR?

While recent demographic studies do not use the term "second epidemiological revolution", they frequently refer to the "cardiovascular revolution" in discussing the changes in mortality that have been taking place over the last half-century.

It would seem that the above graphs leave no doubt that this is what happened, that it was precisely the reduction in mortality from circulatory diseases which determined the whole picture of changes in mortality over the past "revolutionary" decades. When we look at the EU-15 countries, we can see that the sharp reduction in the standardised mortality rate from diseases of this class and its share in the big four causes of mortality led to an overall reduction in mortality from the four causes combined. Since the proportions of the big four causes in total mortality changed little over these decades, it makes sense to assume that the reduction in mortality from diseases of the circulatory system had a decisive influence on the decrease in the standardised mortality rate from all causes.

We should, however, recall the limited analytical capabilities of the standardised mortality rate. This indicator, though a convenient tool for the comparison of different countries or different periods in the same country, is nevertheless not perfect, especially because it does not allow us to take into account the age profile of the changes – a drawback that is easily illustrated by the example of mortality from respiratory diseases.

We have seen that the standardised mortality rate from this class of causes of death was the only class among the big four causes that declined steadily in Russia. Indeed, the rate decreased even faster in Russia than in the EU-15 countries: in 2011, for example, the standardised mortality rate from respiratory diseases was 33% lower among Russian women than among women in the EU-15. While this trend appears to represent a positive achievement for Russia, should it really be described as such?

The reduction in mortality from respiratory disease over the past 50 years in all developed countries was due to the exclusion of more and more minors, especially children, from this class of causes. Respiratory diseases largely retained their role as a dangerous threat to life only for the very elderly, whose vitality was already essentially exhausted. As a result of this, the mean age of death from causes of this class from 1960 to 2010 increased for women in the US by 10.2 years, in France by 10.3, in Italy by 17.4, and in Japan by 21.4 years, while in Russia growth was only 5.1 years. Women in Russia in 2010 died from this cause, on average, at the age of 68.6 years, while in the US it was 82.2 years, in Italy 87.5, in France 87.7, and in Japan 89.8. From a demographic point of view, dying from this cause in these countries was "profitable". We should therefore consider how positive a reduction in mortality from this cause really is, and in general reflect on what should be understood in this case by "decline in mortality." To do so, we need to move away from the standardised mortality rate and take advantage of some other analytical tools.

At least one such tool has been well known to demographers for several centuries: mortality tables by causes of death. These tables allow us to consider both the changes in the age profile of mortality of each individual cause or group of causes of death, and the probability of a newborn in each birth cohort - fictive or real (in practice, of course, we are more likely to have to deal with

fictive cohorts) - dying from this cause. In other words, the indicators of such tables enable us to examine changes in causes of death in two dimensions.[2]

The familiar expression "mortality reduction" is highly misleading, as the probability of death for all people is the same and is always equal to 100%. When we speak of "mortality reduction", we simply mean the delaying of deaths to older ages. But when we are talking about reducing mortality from selected causes, the argument changes. An individual may avoid death from this cause, but he will die from some other cause, and it is important to understand which causes of death are considered preferable. Different people may have different answers to this question, but from the perspective of demography, which investigates the impact of changes in mortality on the growth of life expectancy, there can be only one answer: the outcome that is preferable is an increase in the number of deaths from those causes from which, on average, people die later in life.

Since causes of death compete with each other, real changes can go in two directions: the mean age of death from each cause (groups of causes) of death can change, or the probability of dying from each of these causes can change.

In the first case, an increase always contributes to a "mortality reduction", while a decrease always contributes to a "rise in mortality". In the second case, the effects are less clear. The only unconditionally beneficial case is a fall in the probability of death from causes with a lower mean age of death. A decline in the probability of death from causes with a higher mean age of death is beneficial only in two cases: first, when such reductions are compensated for by an increase in the mean age of death from this cause, so that the total time lived by a person dying from the cause increases at least a little; or, second, when this cause is replaced by others with a higher or increasing mean age of death. As a rule, both happen, but complex interactions whose results cannot always be easily evaluated can arise.

Let us take for example the changes in French male mortality in the 50 years between 1960 and 2010, and try to understand these changes in terms of causes of death.

The total time lived by a generation consists of the total time lived by those who have died from each of the causes (or groups of causes) of death. Accordingly, the changes that occurred over the 50-year period can be clearly illustrated by a diagram [Andreev, Vishnevsky, Shaburov 1986; Vishnevsky, Shkolnikov, Vassin 1991: 82-91] that represents the distribution of the entire time lived by a generation according to the time lived by those who died of the large classes of causes of death. Along the horizontal axis in this chart are the probabilities of a newborn dying at some point in his life of one of the causes ($\boldsymbol{P_i}$). Along the vertical axis is the mean age of death from this cause, or the life expectancy of the people who will die from it ($\boldsymbol{\bar{x}_i}$). The area of each selected coloured rectangle is the total time lived by those who died of the *i*-th cause, and the sum of these areas is the total time lived by some hypothetical generation. Clearly, if $\sum P_i = \boldsymbol{1}$, then

$$\sum P_i \bar{x}_i = e_0. \qquad (1)$$

[2] The present article uses mortality tables by cause of death for Russia and other countries drawn up and provided by E.M. Andreev.

Figure 4 shows two such diagrams related to the male population of France at the beginning and the end of the period.

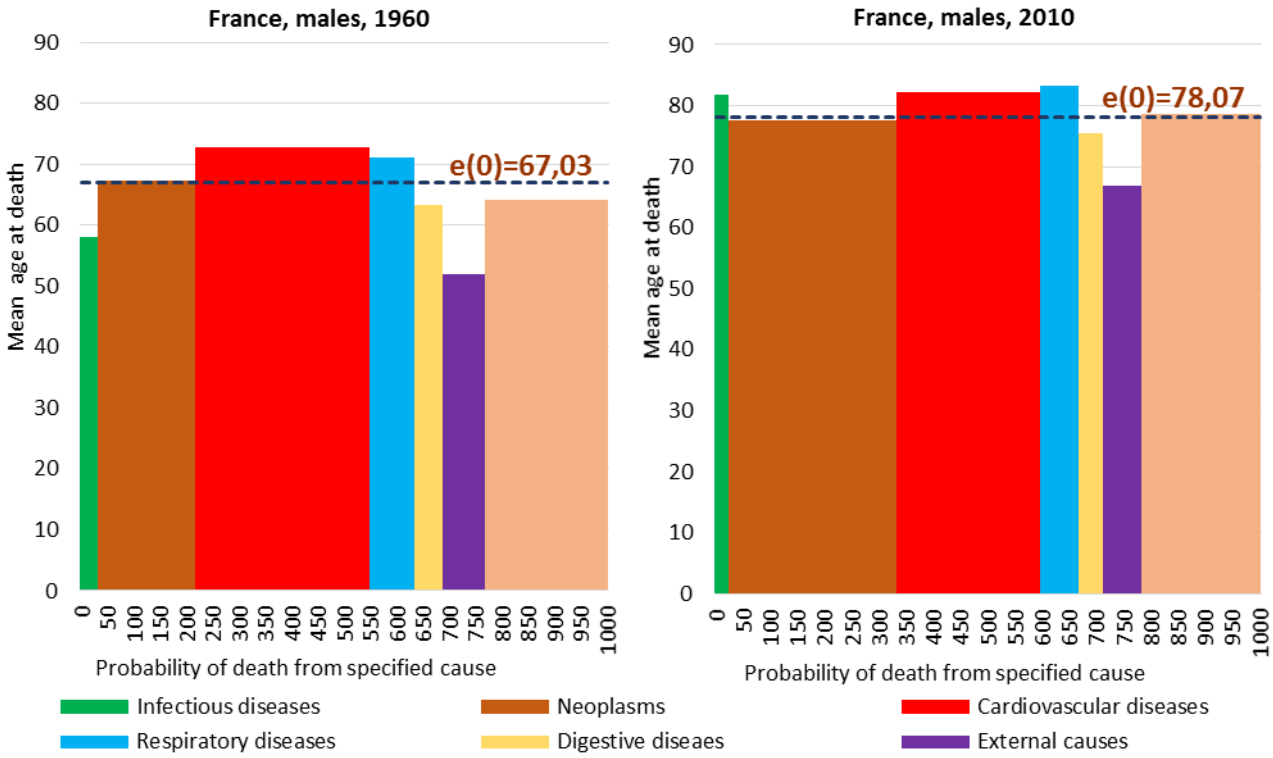

Figure 4. Distribution of the total time lived by a hypothetical cohort by the time lived by those who died from the large classes of causes of death. France, males, 1960 and 2010.

Note: The dotted line corresponds to the life expectancy at birth - e(0)

A comparison of the two graphs in Figure 4 shows that the proportion of deaths from circulatory diseases in the total hypothetical cohort declined from 33.1% to 26.4%, and that the individuals who nonetheless died from these diseases died later, with the mean age at death from these causes increasing by 9.4 years. While the rectangle corresponding to this cause of death became narrower and higher, its overall area actually decreased slightly—meaning that its share of the total shaded area decreased, as the area itself increased. The most important achievement was that the increase in the mean age of death from cardiovascular disease was strongly supported by the increase in the mean age of death from the pathologies that replaced these diseases as the cause of death. Not including cancer, the mean age of death from all major causes increased more than the mean age of death from cardiovascular diseases. The mean age of death from diseases of the respiratory and digestive system increased by more than 12 years, and the mean age of death from external causes rose by almost 15 years. Diseases of the circulatory system lost their primacy in the mean age of death, giving way to respiratory diseases. When we look at cancer mortality among men in 2010, we see that the risk of dying from cancer was higher than the risk of dying from diseases of the circulatory system. The mean age of death from cancer increased less than the mean age of death from cardiovascular disease between 1960 and 2010; nevertheless, the increase in the mean age of death from cancer over the period was very significant (8.4 years). In 2010, the mean age of death from cancer was much higher than the mean age of death from any other class of causes in 1960, including cardiovascular diseases. Thus, over the study period the

area of the cancer rectangle on the graph almost doubled, and exceeded the area of the cardiovascular disease rectangle. Paradoxically, it was precisely the growth in life expectancy of those who died from cancer that made the decisive contribution to the overall increase in life expectancy of the hypothetical cohort over the study period: in total, the cohort's life expectancy grew by 11 years.

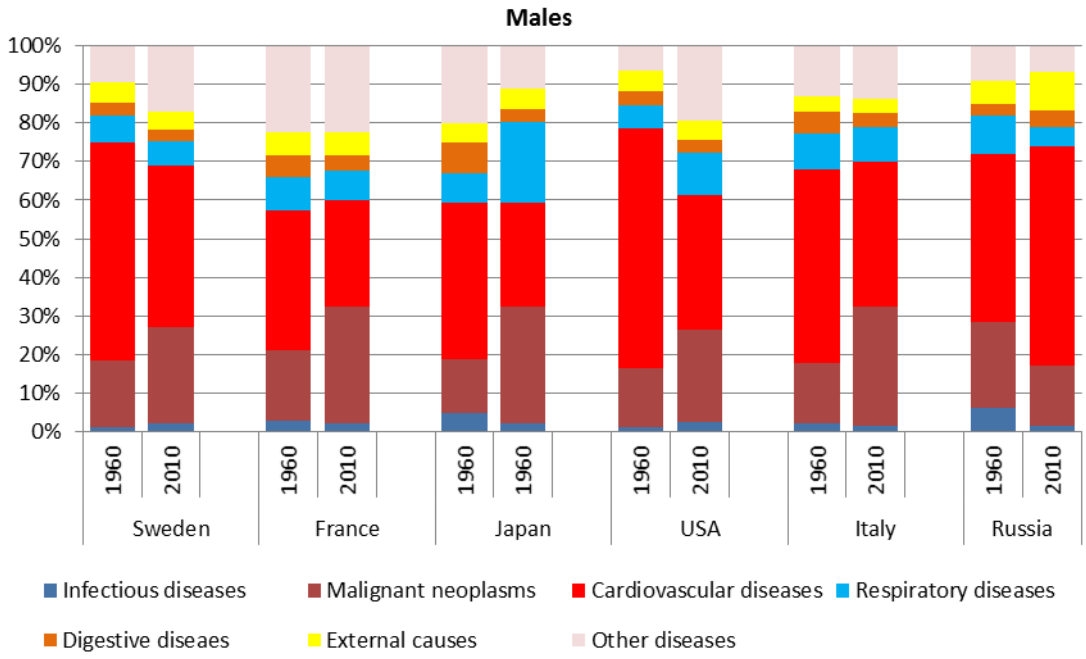

Figure 5. Distribution of the total time lived by a hypothetical generation by the time lived by those who died from large groups of causes of death in 1960 and 2010 in selected countries, males

The male population of France is not an exception among developed countries. In all these countries, both for men and women, the changes went in the same direction (Figures 5 and 6). While there are substantial differences between the countries shown in these figures (three European countries, the US, and Japan), they are more similar than different. We can see that the share of the total time lived by those who died from cardiovascular disease decreased, while the share of time lived by those who died from cancer and from "other diseases" increased – or as in the case of Japan, those who died from respiratory diseases increased, and in the case of the US, those who died both from "other diseases" and respiratory diseases increased. On the contrary, when we look at Russia, we see that these changes run in the opposite direction, and moreover that there is a conspicuous increase among men in the proportion of total time lived by those who died from external causes that is absent in other countries.

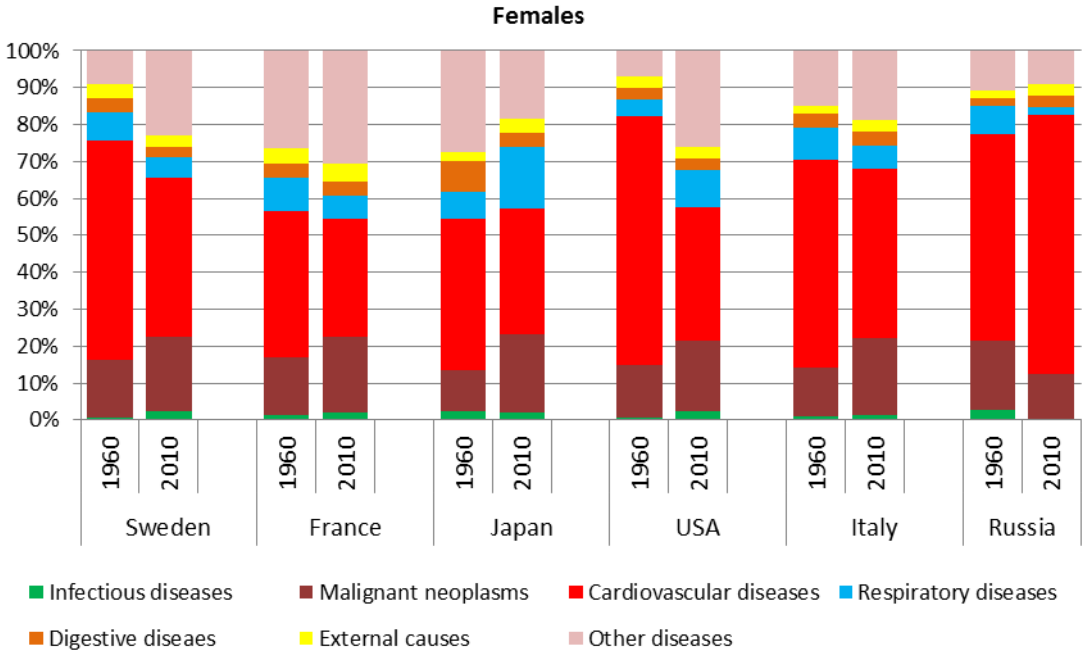

Figure 6. Distribution of the total time lived by a hypothetical generation by the time lived by those who died from large groups of causes of death in 1960 and 2010 in selected countries, females

The typical trend observed in the most developed countries (but not in Russia) led to a new cohorts' total lifetime distribution by lifetime of groups of those who die from different causes of death. It was the consequence of a significant increase in the mean age of death from all major classes of causes (Table 1). It is interesting that the rise in the mean age of death among those who died of cardiovascular diseases was, as a rule, not the largest of the improvements that occurred.

Table 1. Increase in the mean age of death in selected countries over 50 years (1960-2010), years

Cause of death	France	Italy	Sweden	USA	Japan	Russia
	Males					
Infectious and parasitic diseases	21.31	24.20	17.97	13.60	23.75	-8.39
Neoplasms	8.43	10.58	7.58	8.61	12.86	-2.47
Diseases of the circulatory system	9.39	8.82	6.78	7.38	10.46	-2.51
Respiratory diseases	12.15	18.70	6.14	14.53	19.89	4.66
Diseases of the digestive system	12.06	18.81	7.59	8.92	11.81	3.66
Other diseases	14.49	21.54	17.75	29.67	14.60	-2.10
External causes	14.86	16.69	12.48	7.35	20.35	2.62
All causes	**11.04**	**12.92**	**8.28**	**9.74**	**14.24**	**-0.59**
	Females					
Infectious and parasitic diseases	26.26	35.45	22.28	20.52	33.46	-6.33
Neoplasms	8.95	10.59	8.17	7.84	15.87	-4.55
Diseases of the circulatory system	10.35	10.83	8.01	6.27	14.83	0.85
Respiratory diseases	10.32	17.42	5.05	10.17	21.40	5.09
Diseases of the digestive system	16.76	24.39	8.68	10.53	16.10	5.75
Other diseases	14.05	20.91	20.01	28.32	15.79	5.76
External causes	12.75	16.75	6.82	2.90	23.81	1.42
All causes	**11.10**	**13.18**	**8.60**	**7.90**	**16.15**	**2.56**

If we leave out Russia, which will be discussed below, then such a significant increase in the mean age of death from each of the major groups of causes, and consequently from all causes taken together, signifies the realization of the "second epidemiological revolution" predicted by M. Terris, even though not as large-scale as the first.

But the "second" revolution can hardly be reduced to the "cardiovascular revolution" that is now so frequently cited as the main reason why mortality has continued to decline in recent years. Truly revolutionary changes can be observed when we look at all of the big four causes, and at most of the other causes of death. Thus, reductions in mortality from cardiovascular disease are not exceptional.

4. CHANGES IN MORTALITY OVER HALF A CENTURY IN RUSSIA AND IN FRANCE

We now turn to Russia, where, as we have already pointed out, the second epidemiological revolution has not yet taken place. What form does Russia's stagnation take, and in what areas are the missed opportunities the greatest?

First, let us consider the distinguishing features of changes in mortality in Russia over the past half-century.

We have seen that in France tremendous changes occurred between 1960 and 2010 in the distribution of the lifetime of the male generations according to time lived by those dying from different major causes of death. Some changes also took place in Russia. However, if in France these changes give reason to talk about a second epidemiological revolution, in Russia, on the contrary, they are more likely evidence of its absence.

To begin with, we compare the situations in the two countries with the help of the graphs in Figures 4 (France) and 7 (Russia).

The differences are immediately apparent. In Russia there is virtually no growth in height of the main columns which in France show significant growth; an expansion of the base of the rectangle corresponding to diseases of the circulatory system along with a narrowing of the base of the rectangle of neoplasms (in France it is the reverse); a significant expansion of the low column of external causes, which in France became somewhat narrower but much higher; and a narrowing and shortening of the column "other causes" - the exact opposite of what was observed in France. As a result, the sum of shaded areas (i.e., the total time lived by a fictive generation) on the Russian chart did not change, indicating total stagnation, while on the French chart it significantly increased, indicating a growth of life expectancy of 11 years.

The current (2010) picture for Russia is much worse than that for France fifty years ago (the upper part of figure 8), and its comparison with the picture for modern France (the lower part of the same figure) clearly speaks of a lost 50 years: whereas a second epidemiological revolution occurred in France, it did not occur in Russia.

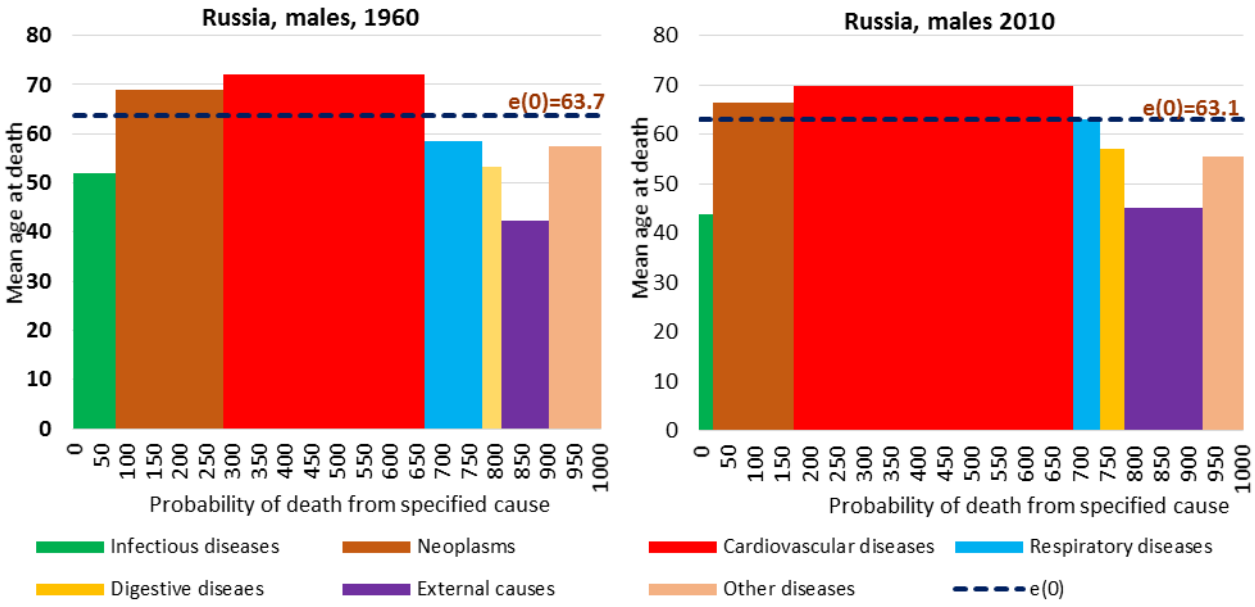

Figure 7. Distribution of the total time lived by a fictive generation according to the time lived by those who died from major classes of causes. Russia, males, 1960 and 2010

Note: The dotted line corresponds to the life expectancy at birth - e (0)

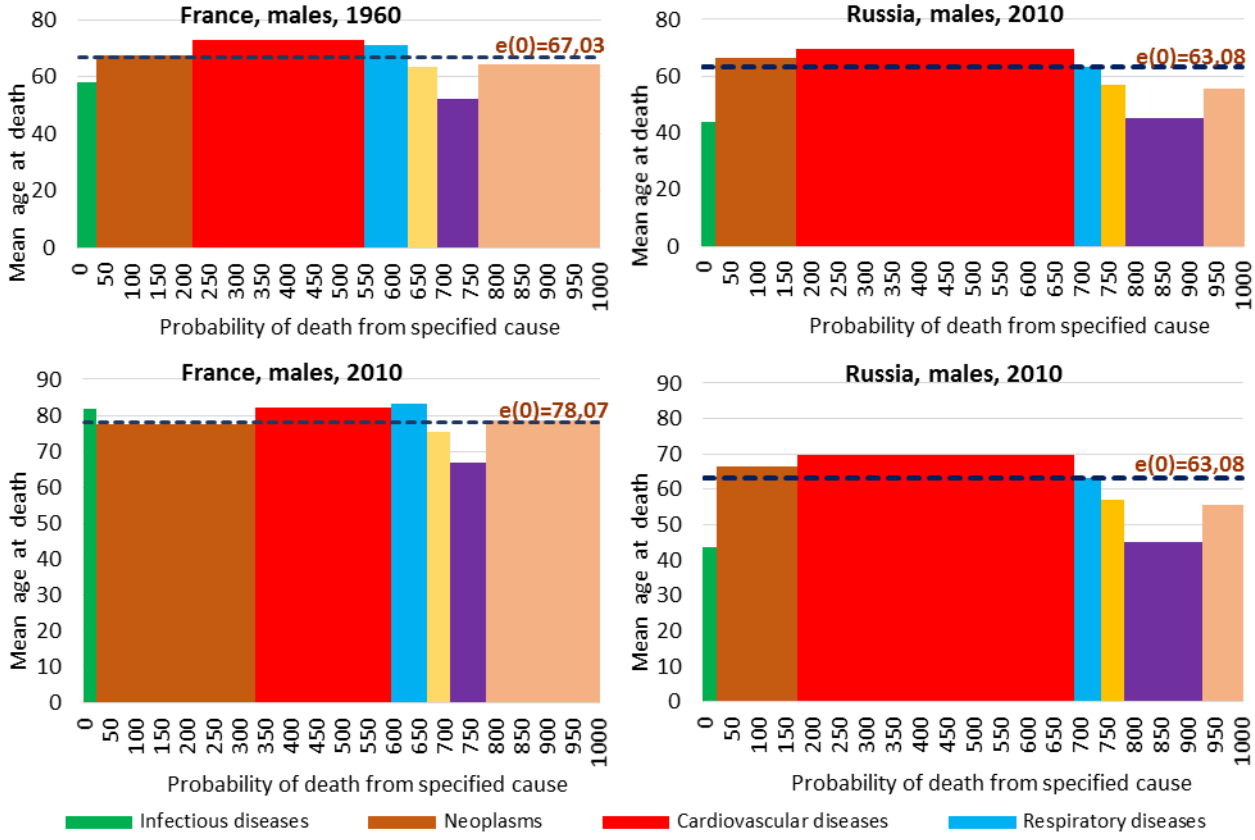

Figure 8. Distribution of the total time lived by a fictive generation according to the time lived by those who died from major classes of causes. France, males (1960 and 2010) and Russia (2010)

Note: The dotted line corresponds to the life expectancy at birth - e (0)

Let us try to examine the changes that have occurred in the two countries in more detail. For this we will also make use of the opportunities provided by the mortality tables by causes of death, which contain, in particular, data on the distribution of numbers of deaths by age and cause of death - the numbers d_{xi} (where *x* is age and *i* is the cause of death). These are so-called 'table numbers', independent of the actual age structure.

Let us compare the matrices of changes in d_{xi} in the two countries $({}_{2010}d_{xi} - {}_{1960}d_{xi})$ (Table 2-5).

The negative values in the table signify a reduction in the number of deaths between 1960 and 2010, while the positive values signify an increase.

Let us consider first the changes that interest us from the point of view of age.

Table 2. Changes in the numbers of deaths by age groups and causes of death between 1960 and 2010 $({}_{2010}d_{xi} - {}_{1960}d_{xi})$. The male population of France, per 100,000 deaths

Age	Infectious and parasitic diseases	Neoplasms	Diseases of the circulatory system	Respiratory diseases	Digestive diseases	External causes	Other diseases	All causes
0	-73	-6	-20	-291	-72	-54	-2165	**-2681**
1-4	-38	-43	-13	-69	-15	-96	-159	**-434**
5-9	-11	-35	-6	-9	-9	-68	-31	**-169**
10-14	-4	-25	-7	-9	-8	-58	-33	**-144**
15-19	-7	-31	-17	-11	-3	-149	-29	**-247**
20-24	-16	-29	-19	-10	-7	-138	-33	**-251**
25-29	-32	-37	-36	-8	-23	-212	-29	**-377**
30-34	-79	-44	-61	-19	-41	-197	-75	**-516**
35-39	-107	-54	-104	-40	-69	-158	-68	**-600**
40-44	-145	-60	-171	-48	-106	-186	-85	**-802**
45-49	-201	-116	-380	-95	-200	-220	-166	**-1378**
50-54	-273	-65	-689	-187	-327	-283	-272	**-2096**
55-59	-317	-41	-1259	-261	-439	-335	-405	**-3057**
60-64	-351	-99	-2005	-408	-514	-324	-696	**-4397**
65-69	-296	353	-2956	-535	-526	-217	-1006	**-5184**
70-74	-218	852	-3754	-692	-399	-118	-1276	**-5605**
75-79	-40	2034	-3362	-671	-76	96	-1108	**-3127**
80-84	198	3278	-727	-136	248	396	-31	**3226**
85+	805	6929	8903	2115	1100	1686	6301	**27839**
Total	**-1205**	**12760**	**-6683**	**-1385**	**-1486**	**-634**	**-1367**	**0**

On the right, in the summary column of the French table for males, all of the figures except the last two (aged 80 years and older) are negative. This means that at all ages up to 80 years, the total number of deaths decreased: out of every 100,000 deaths, more than 31,000 shifted to the oldest age groups.[3]

[3] Note that the current estimates of the numbers d_{xi} for older ages may not be entirely accurate, due to the traditional calculation of indices for the "open" interval of 85 years and older, which was justified when this interval had a relatively small number of deaths. When it began to grow, a more detailed elaboration was required of the data within this interval. Now some developed countries (not yet all) are shifting to the elaboration of mortality indices by cause of death using separate groups for ages 85-89, 90-94, 95+, which will perhaps in the future lead to a refinement of estimates existing today.

Table 3. Changes in the numbers of deaths by age groups and causes of death between 1960 and 2010 ($_{2010}d_{xi}$ - $_{1960}d_{xi}$). The male population of Russia, per 100,000 deaths

Age	Infectious and parasitic diseases	Neoplasms	Diseases of the circulatory system	Respiratory diseases	Digestive diseases	External causes	Other diseases	All causes
0	-416	-2	12	-1506	-541	-17	-674	**-3144**
1-4	-297	-10	0	-287	-46	-92	-77	**-808**
5-9	-83	-20	-16	-35	-13	-182	-35	**-384**
10-14	-47	-11	-14	-20	-10	-99	-22	**-223**
15-19	-41	-17	-35	-9	-11	-52	-33	**-197**
20-24	-74	-19	4	-5	3	136	-6	**40**
25-29	-15	-23	122	37	75	375	83	**653**
30-34	27	-70	290	91	181	662	167	**1349**
35-39	-107	-56	520	106	240	439	190	**1331**
40-44	-164	-302	651	52	277	811	218	**1541**
45-49	-330	-217	1193	60	301	596	207	**1810**
50-54	-376	-452	1460	-105	318	895	234	**1974**
55-59	-685	-459	1935	-228	283	498	151	**1495**
60-64	-271	296	1014	-434	354	742	-325	**1375**
65-69	-385	139	1103	-562	181	396	-569	**303**
70-74	-480	-297	1456	-668	90	204	-788	**-483**
75-79	-489	-846	1668	-654	-28	25	-721	**-1046**
80-84	-452	-1315	872	-750	-87	-93	-205	**-2030**
85+	-511	-2006	498	-959	-174	-186	-219	**-3557**
Total	**-5197**	**-5687**	**12734**	**-5876**	**1391**	**5058**	**-2424**	**0**

Table 4. Changes in the numbers of deaths by age groups and causes of death between 1960 and 2010 ($_{2010}d_{xi}$ - $_{1960}d_{xi}$). The female population of France, per 100,000 deaths

Age	Infectious and parasitic diseases	Neoplasms	Diseases of the circulatory system	Respiratory diseases	Digestive diseases	External causes	Other diseases	All causes
0	-62	-6	-17	-212	-46	-45	-1635	**-2024**
1-4	-35	-32	-6	-59	-13	-64	-139	**-349**
5-9	-11	-25	-6	-9	-6	-33	-36	**-127**
10-14	-8	-20	-11	-8	-5	-15	-20	**-87**
15-19	-8	-22	-12	-9	-6	-50	-35	**-141**
20-24	-22	-36	-25	-10	-6	-55	-62	**-216**
25-29	-37	-25	-32	-15	-20	-51	-78	**-259**
30-34	-56	-52	-45	-15	-39	-44	-100	**-352**
35-39	-65	-122	-67	-21	-69	-39	-113	**-496**
40-44	-58	-148	-111	-28	-108	-11	-122	**-586**
45-49	-59	-236	-230	-38	-136	-26	-135	**-860**
50-54	-64	-220	-448	-51	-200	-23	-181	**-1187**
55-59	-69	-213	-752	-76	-239	-65	-306	**-1719**
60-64	-78	-332	-1378	-181	-283	-88	-508	**-2848**
65-69	-94	-342	-2612	-377	-319	-125	-959	**-4827**
70-74	-86	-296	-4192	-689	-303	-176	-1495	**-7237**
75-79	-16	108	-5548	-1085	-166	-216	-1893	**-8818**
80-84	155	1199	-4113	-1177	92	-102	-1333	**-5279**
85+	1154	6214	12978	1222	1815	1905	12125	**37412**
Total	**478**	**5393**	**-6626**	**-2838**	**-59**	**677**	**2975**	**0**

Table 5. Changes in the numbers of deaths by age groups and causes of death between 1960 and 2010 ($_{2010}d_{xi}$ - $_{1960}d_{xi}$). The female population of Russia, per 100,000 deaths

Age	Infectious and parasitic diseases	Neoplasms	Diseases of the circulatory system	Respiratory diseases	Digestive diseases	External causes	Other diseases	All causes
0	-379	-1	10	-1195	-466	-14	-511	**-2557**
1-4	-291	-13	0	-285	-38	-63	-83	**-773**
5-9	-77	-9	-19	-33	-10	-66	-33	**-247**
10-14	-47	-9	-21	-18	-7	-24	-23	**-149**
15-19	-56	-12	-35	-8	-8	-6	-35	**-161**
20-24	-78	-14	-36	-4	3	27	-70	**-171**
25-29	-46	-11	-17	10	38	129	-77	**26**
30-34	-27	-49	14	27	81	182	-37	**190**
35-39	-97	-19	59	20	117	164	-67	**177**
40-44	-63	-191	87	10	141	213	17	**215**
45-49	-116	-175	196	6	158	177	0	**246**
50-54	-106	-210	178	-40	201	233	50	**306**
55-59	-172	-301	596	-58	304	205	62	**636**
60-64	-73	566	-451	-290	274	249	-220	**55**
65-69	-124	422	74	-414	194	195	-441	**-94**
70-74	-214	1	604	-689	132	125	-856	**-897**
75-79	-275	-624	3004	-834	111	83	-885	**580**
80-84	-327	-1457	4087	-1008	38	11	-15	**1328**
85+	-521	-3394	6283	-1652	-149	-100	821	**1288**
Total	**-3090**	**-5501**	**14612**	**-6454**	**1115**	**1719**	**-2402**	**0**

In the Russian table, there were fewer changes. The negative numbers refer to ages up to 20 and over 70. Among these groups the number of deaths decreased, although these declines tended to be small. But the number of deaths increased quite significantly among people between ages 20 and 70. Nearly 12,000 out of every 100,000 deaths shifted into these age groups.

In the French Table for females, in the right column all the values up to age 85 are marked with a "minus" sign. Here the shift of deaths to an older age is more noticeable than in males, with more than 37,000 out of every 100,000 deaths shifting to the group beyond age 85. The Russian table for females, even more than the one for males, is characterized by a long-term stagnation of the mortality situation. Changes are hardly noticeable, but where they are, they are not always favourable. Negative values, indicating a reduction in the number of deaths, can be found in the right column only up to the age of 25 years and between 65-74 years. In the older age groups (75 years and older) there was a shift of only (in rounded figures) 3,200 deaths per 100,000, of which fewer than 1,300 per 100,000 were to the age group of 85 and older. At the same time, there was an increase of 1,850 for every 100,000 deaths in middle age (from 25 to 65 years). The whole picture is clearly reflected in Figure 9.

Let us now look at how the life-table numbers of deaths varied in accordance with the major classes of causes of death.

In the last, summary line of the French table for males, all numbers except for the number of deaths from cancer are negative, and the whole increase in deaths from cancer occurred at ages over 65, and especially over 75, years. In the last line of the Russian table the number of deaths from cancer is negative, and, in contrast to France, their largest decline occurred precisely in the

oldest age groups. On the other hand, in France the number of deaths from cancer (12,760 per 100,000) increased by about as much as in Russia the number of deaths from diseases of the circulatory system (12,734 per 100,000). The only difference is that in Russia nearly 90% of this increase came from deaths before age of 80, including 62% between ages of 35 and 70 ears.

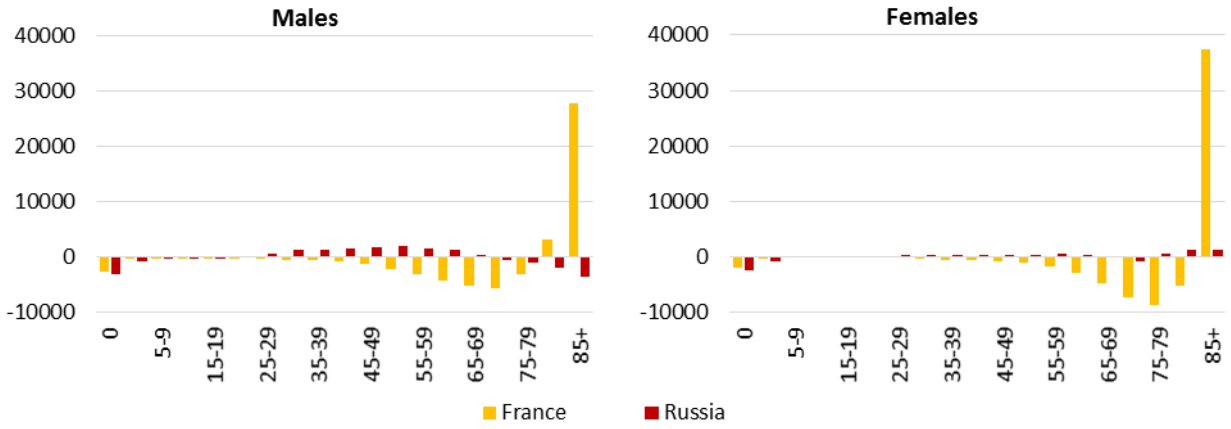

Figure 9. Changes in the table numbers of deaths (d_x) for 1960-2010, by age groups in France and Russia, per 100,000 deaths

We will now address the issue of external causes of death. Among the French male population, the numbers of deaths from external causes declined overall, increasing only at ages 75+, and especially at ages 85+. Among the Russian male population, the numbers of deaths from external causes significantly increased, with growth occurring in all age groups from 20 to 80. Among men between ages 20 and 45, the increase in deaths from these causes was greater than the increase in deaths from diseases of the circulatory system.

The nature of the differences in the last lines of the French and Russian tables for females is about the same as for men. The changes go somewhat more often not in the opposite, but in the same direction, although the scale of changes is different. For example, the number of deaths from external causes among women increased both in Russia and in France, but in France the increase was significantly lower (see also figure 10).

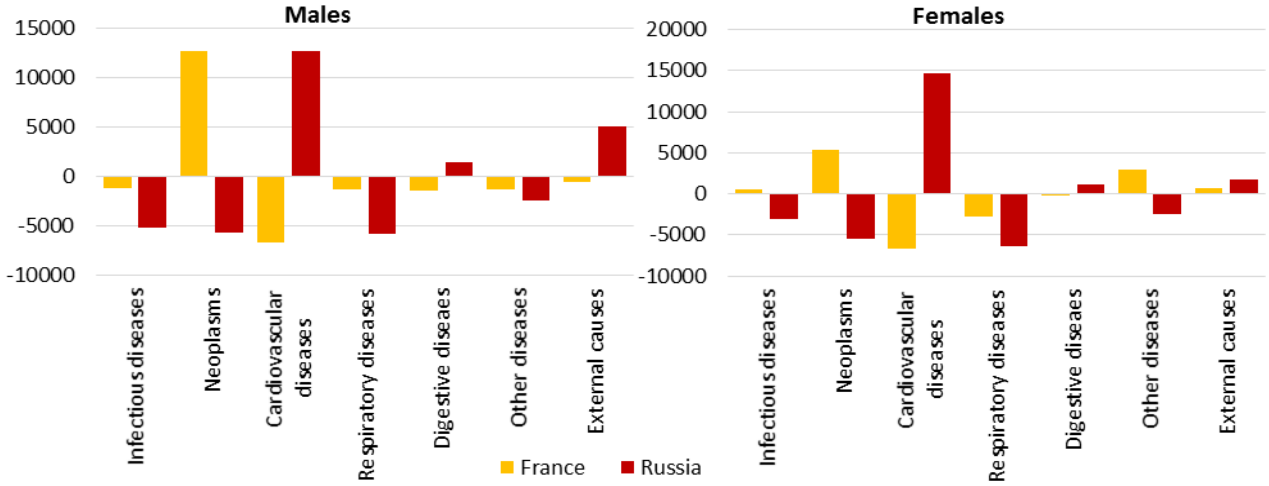

Figure 10. Changes in the table numbers of deaths (d_x) for 1960-2010, by major groups of causes of death in France and Russia, per 100,000 deaths

To briefly summarize the results of our comparative analysis of changes in mortality in the two countries, we find that while France, like most developed countries, has made significant progress in the shifting of death from all causes to old age, the situation in Russia seems to have been hopelessly stuck in place for half a century.

5. WHERE IS RUSSIA FALLING BEHIND?

Were there any changes for the better in the last two decades of the study period? A negative answer to this question has already been given in our previous comparison of standardized mortality rates in Russia and in the EU-15 countries. In order to get a more detailed understanding of the trends in the past decade, we will continue this comparison, analyzing the evolution of age mortality curves of major groups of non-communicable causes of death: cardiovascular diseases, neoplasms and external causes. It is in persisting and even increasing differences between the curves in the EU-15 countries and in Russia that lies the key to understanding why Russia is lagging behind.

Let us start with the leading cause of death in Russia and (at least until recently) in the EU-15: diseases of the circulatory system.

In Russia, the number of male deaths from this cause begins to increase rapidly after reaching the age of 25. The majority of deaths from these causes is concentrated at the age of 70-75 years, after which their share even goes down (Figure 11). In the countries of Western Europe the growth starts later (Russian indices, fixed at 25 years, there are not reached even by age 40) and the curves rise far less sharply, but this increase lasts until a very late age, so that the peak of deaths from circulatory diseases is not accounted for by those aged 70-75 years, as in Russia, but is closer to 90 years. Among females the age distribution of deaths from diseases of the circulatory system is more similar to Western Europe's, but is nonetheless shifted far toward younger ages.

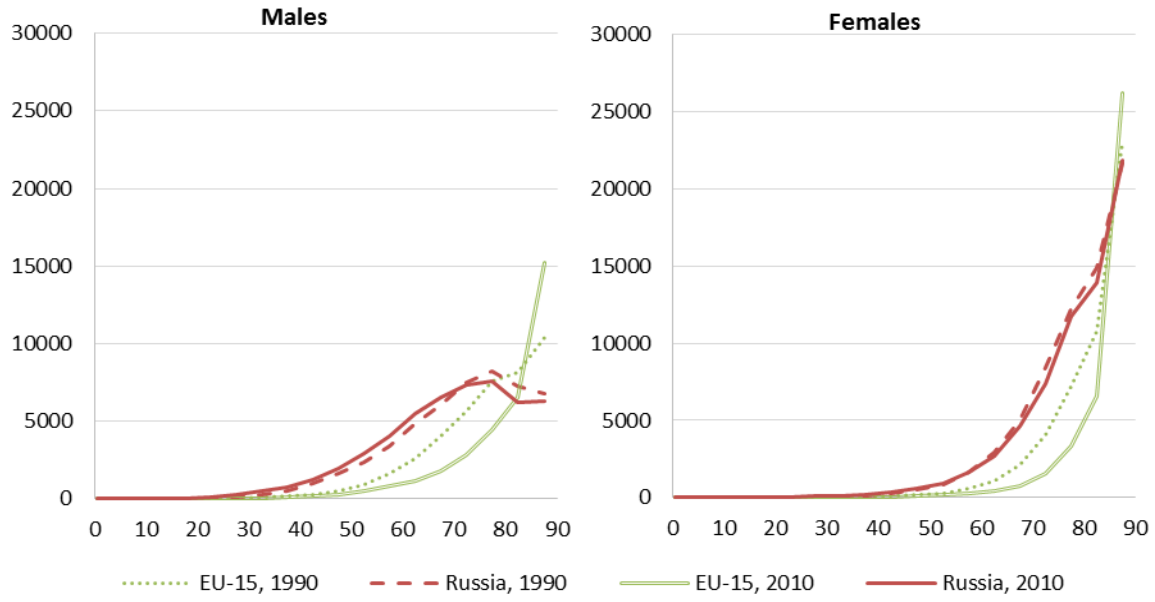

Figure 11. Age distribution of table numbers of deaths (d_x) from diseases of the circulatory system

The age distribution of deaths from cancer (Figure 12) looks somewhat different. In this case to the peak number of deaths is reached at younger ages in Russia than in the EU-15 countries, but the age of the onset of growth as well as the steepness of the curve until ages 60-65 are about the same in Russia and in the EU-15 countries. At older ages, the Russian and the western European curves diverge considerably, but the overall losses from cancer vary much less than the losses from cardiovascular diseases.

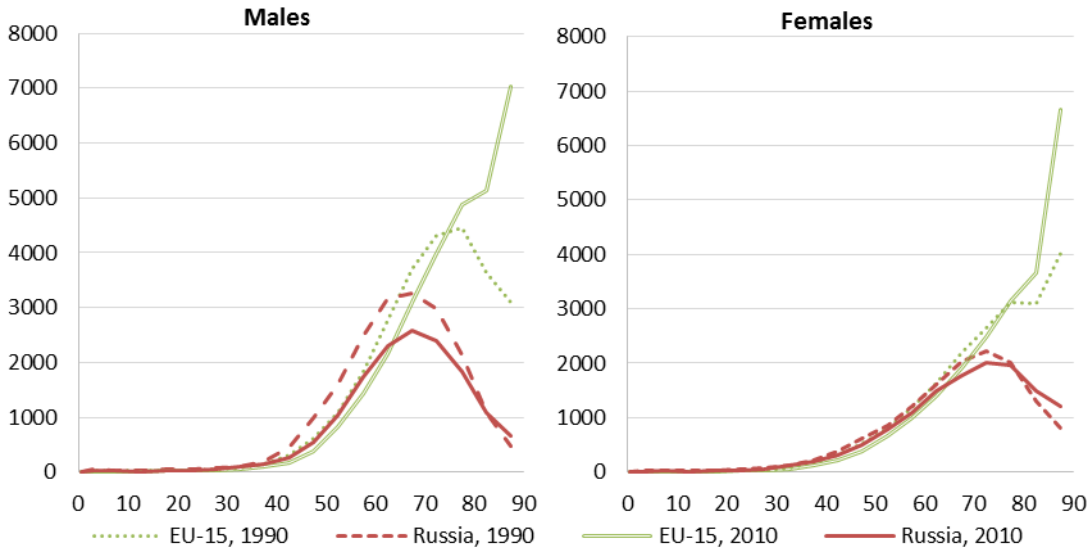

Figure 12. Age distribution of table numbers of deaths (d_x) from neoplasms

But the differences in the age distributions of deaths from external causes are particularly striking (Figure 13).

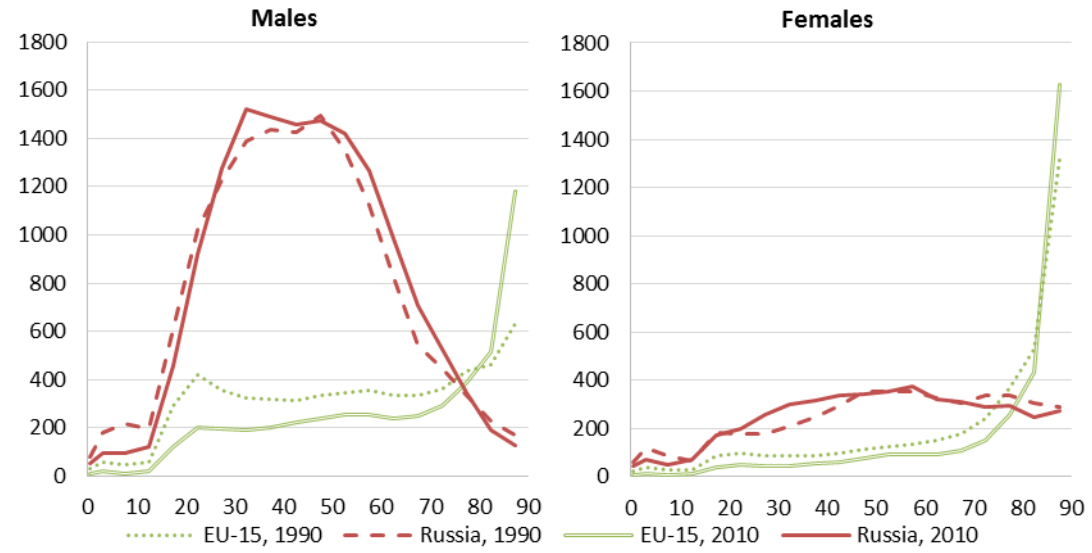

Figure 13. Age distribution of table numbers of deaths (d_x) from external causes

Here the differences between Russia and the EU-15 countries are exceptionally large, especially among males. Looking at these figures, it is possible to get the impression that Russia and western European countries belong to different civilizations. The mortality of adult males from

external causes of death in Russia is several times higher than in the countries being compared. Accordingly, the losses from this kind of mortality are extremely high.

Figures 11-13 also allow us to judge about the changes in the age distribution of the numbers of deaths over the two most recent decades (between 1990 and 2010). The curves for the EU-15 countries show a more or less pronounced tendency to shift down and to the right, "caving in" toward the lower right corner of the chart. When comparing the curves for 1990 and 2010, it is clear that the right end of the curves for 2010 move steadily upwards, indicating a shifting of an increasing number of deaths from each of the classes of causes considered to the very highest ages. These changes are most vividly apparent among males, especially in the age distribution of deaths from cancer, where there was a fundamental change in the direction of the curve in older age groups, although quite serious changes also occurred in the distribution of male deaths from cardiovascular diseases and external causes. Among females, the trend is the same, but less pronounced, possibly because such changes had occurred among them earlier, before 2010.

The Russian age curves of mortality, especially for males, generally show no shift towards the lower right corner of the graph that would indicate that a second epidemiological revolution had taken place.

6. "EXCESS MORTALITY" AND ITS DISTRIBUTION BY AGE AND CAUSES

As we did in comparing changes in mortality by cause of death in Russia and France over a 50-year period, we can take a closer look at the current differences in mortality rates between Russia and the EU-15 countries with the help of matrices of differences, or "diagnostic tables" (such tables were first presented in [Vishnevsky, Shkolnikov 1997: 78-81]). These tables allow us to compare the distributions of deaths by age and cause of death (the numbers d_{xi}), and to highlight the 'age-cause-specific risk groups' for the population of Russia, specifying for each group the excess number of deaths at age x from cause ***i*** (d_{xi}^{R} - d_{xi}^{EU-15}) compared to the corresponding figure for the EU-15.

We restrict ourselves to examining deaths that occurred before the age of 70 and consider as premature Russian losses only those deaths up to this age which are in excess in comparison with Western European countries (EU-15). Our analysis will consist of an evaluation of the contribution of each class of causes to the total number of such losses for the five-year age groups, and an identification of the major 'age-cause-specific groups' responsible for these losses.

Tables 6 and 7 show the excess number of deaths for all 'age-cause-specific groups' represented in these tables for males and females in 2010.

The number in the lower right corner of the table shows that in Russia in 2010 out of every 100,000 male deaths of all ages more than 46 000, and out of every 100,000 female deaths more than 21,000, could be considered in excess in comparison with the EU-15 countries; in the EU-15 these deaths would have come after the age of 70. The summary lines of the tables show that about 80% of the excess deaths (79.9% of males and 80.6% of females) were attributable to two classes of causes of death: circulatory system diseases and external causes. In general, of course, cardiovascular diseases are in first place, but before the age of 50 for men and 45 for women this

is not the case. Until these ages, the main source of our excess mortality is external causes of death. The contribution of all other causes of death is much smaller.

Table 6. Excess table numbers (d_{xi}^{R}-d_{xi}^{EU-15}) of male deaths up to 70 in Russia in comparison with the EU-15 per 100,000 males dying at all ages and from all causes, 2010

Age	Infectious and parasitic diseases	Neoplasms	Diseases of the circulatory system	Respiratory diseases	Diseases of the digestive system	Other diseases	External causes	All causes
0	99	6	6	176	6	936	97	**1326**
1-4	28	19	3	58	4	97	154	**362**
5-9	6	13	3	11	2	45	160	**240**
10-14	3	10	5	7	2	26	171	**225**
15-19	16	18	29	18	8	63	685	**837**
20-24	82	22	117	41	29	156	1603	**2049**
25-29	147	27	207	63	57	193	1744	**2437**
30-34	190	35	375	95	100	197	1752	**2742**
35-39	242	78	685	168	145	217	1845	**3380**
40-44	289	158	1225	248	179	258	1991	**4348**
45-49	298	317	1948	360	191	275	2013	**5402**
50-54	254	406	2762	442	176	243	1806	**6089**
55-59	196	483	3570	492	131	115	1474	**6462**
60-64	111	47	4403	507	59	-65	994	**6056**
65-70	2	-803	4649	386	-26	-353	534	**4390**
Total	**1964**	**836**	**19987**	**3068**	**1063**	**2402**	**17023**	**46344**

The number of excess deaths:	More than 1000	500-1000	300-500	100-300	50-100	Less than 50

Table 7. Excess table numbers (d_{xi}^{R}-d_{xi}^{EU-15}) of female deaths up to 70 in Russia in comparison with the EU-15 per 100,000 females dying at all ages and from all causes, 2010

Age	Infectious and parasitic diseases	Neoplasms	Diseases of the circulatory system	Respiratory diseases	Diseases of the digestive system	Other diseases	External causes	All causes
0	71	5	6	139	7	659	83	**970**
1-4	21	17	3	58	2	75	109	**284**
5-9	5	9	4	9	2	31	72	**133**
10-14	3	9	2	4	1	18	70	**106**
15-19	10	14	12	8	4	38	216	**302**
20-24	23	21	26	15	9	60	285	**440**
25-29	31	31	51	19	22	65	300	**518**
30-34	36	60	100	29	31	77	320	**653**
35-39	36	89	171	39	46	81	362	**825**
40-44	41	133	327	51	68	84	408	**1112**
45-49	35	191	613	73	83	107	466	**1568**
50-54	30	200	1117	73	109	119	504	**2152**
55-59	20	188	1981	71	162	124	506	**3051**
60-64	0	41	3065	43	122	44	380	**3696**
65-70	-28	-171	5182	30	102	-72	312	**5355**
Total	**333**	**837**	**12659**	**662**	**772**	**1510**	**4393**	**21165**

The number of excess deaths:	More than 1000	500-1000	300-500	100-300	50-100	Less than 50

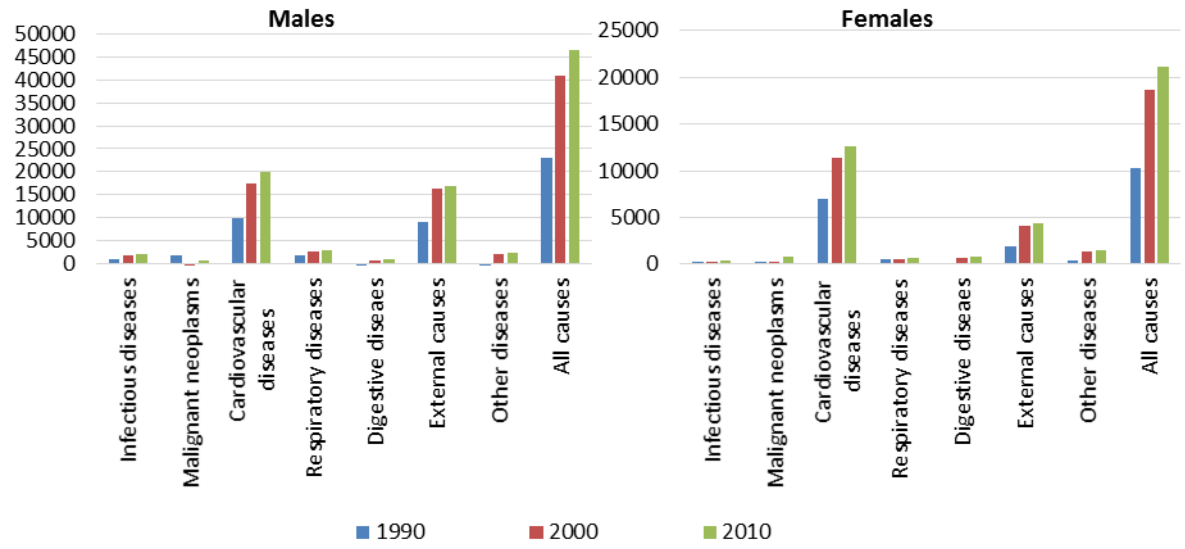

Figure 14. Excess table numbers of deaths from all causes (d_i) under the age of 70 years, per 100 deaths at all ages in Russia in comparison with the average values for the EU-15 countries, 1990, 2000 and 2010

Such "diagnostic tables" were also drawn up for the years 1990 and 2000 (see the appendix). A generalised picture of the extent to which Russia lagged behind the EU-15 countries due to differences in mortality from various causes of death on three dates (1990, 2000, and 2010) is shown in Figure 14. On the graph, the overall expansion of the lag is clearly visible, as well as the unacceptably high contribution to this lag of external causes of death, which almost compete with diseases of the circulatory system among males.

7. CAUSES OF DEATH AND LIFE EXPECTANCY

Excess mortality from some of the major causes of death at relatively young ages explains why life expectancy in Russia lags behind life expectancy in the EU-15 countries. In 2010, the difference was 15.4 years for males and 8.9 years for females. The decomposition of this difference by Andreev's method [Andreev 1982] gives an indication of the contribution of the major causes of death to this lag (Figures 15 and 16).

As expected, the main contribution to Russia's lag behind the EU-15 among both males and females comes from the same two classes of causes: cardiovascular diseases and external causes of death. Higher mortality from these two classes of causes accounts for 77% of Russia's lag in the life expectancy of males and even more (89%) for that of females. What's more, if we consider the differences in mortality throughout the age scale, the contribution of cardiovascular disease is substantially higher than of external causes. But if we limit ourselves only to the age of 70 years (Figure 16 and Table 8), the prevalence of diseases of the circulatory system becomes much less pronounced. This is especially true for males: the contribution of mortality from external causes to Russia's overall gap relative to the EU-15 is close to the contribution of diseases of the circulatory system (25.9% and 50.9% for all ages, but 31.2% and 38.6% for those under age 70).

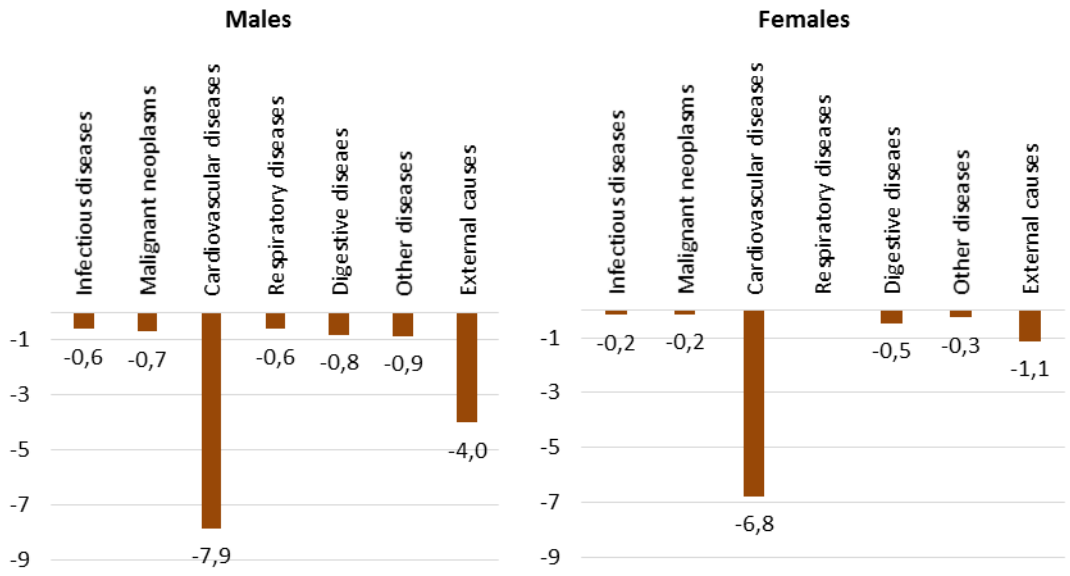

Figure 15. Total losses in life expectancy in Russia compared to the EU-15 as the result of differences in mortality from the major causes of death, 2010, years

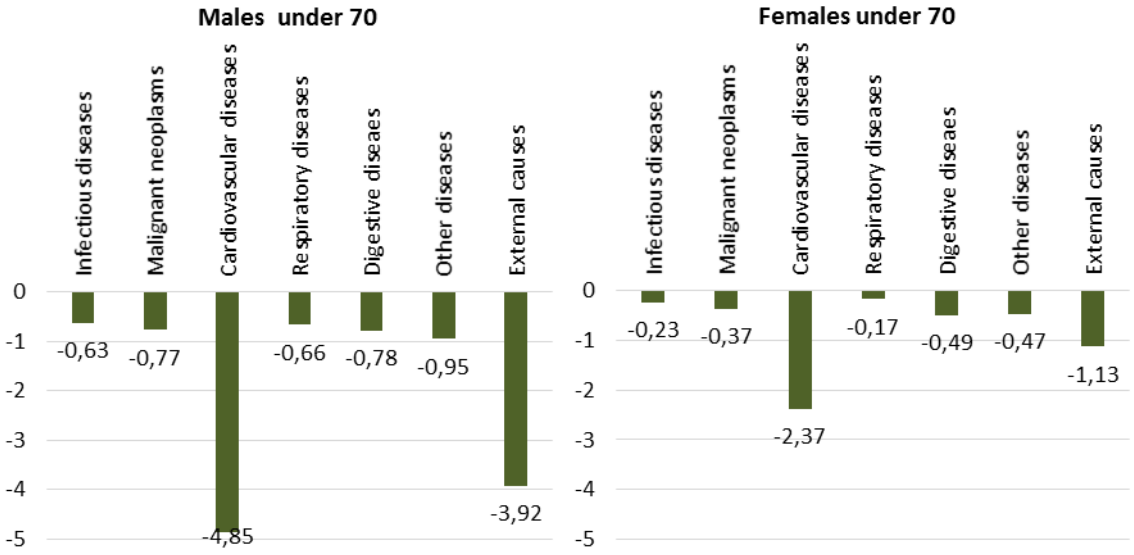

Figure 16. Losses in life expectancy in Russia under age 70 compared to the EU-15 countries as a result of differences in mortality from the major causes of death, 2010, years

Table 8. Contribution of higher mortality from cardiovascular diseases and external causes of death in Russia's overall life expectancy lag behind the EU-15, 2010, %

Cause of death	All ages		Under the age of 70 years	
	males	females	males	females
Diseases of the circulatory system	50.9	76.2	38.6	45.2
External causes of death	25.9	12.7	31.2	21.6
Total	76.8	88.9	69.8	66.8

CONCLUSION

In the first half of the 20th century, there was an unprecedented increase in life expectancy in developed countries. Despite the turmoil of two world wars, post-war devastation, and economic and social crises, life expectancy in the European countries for which data are available increased among both males and females by 20-25 years or more between 1900 and 1960 (Table 9). In Russia, life expectancy doubled over that period. After a thousand years of stagnation in life expectancy, such changes cannot be called anything other than revolutionary.

Table 9. Increase in life expectancy at birth in some countries, years

Country	Males		Females	
	1900-1960	1960-2010	1900-1960	1960-2010
Belgium	21.9	10.2	24.3	9.9
Denmark	20.2	5.6	20.5	6.5
Italy	25.1	11.9	29.9	12.3
Netherlands	24.4	7.1	25.5	7.5
Norway	19.6	7.5	20.7	7.5
Finland	25.1	11.3	29.2	11.2
France	23.8	10.5	26.8	10.7
Switzerland	22.5	10.7	25.3	10.0
Sweden	20.4	8.5	21.3	8.8
Russia	34.0	-0.3	40.3	2.9

After this dramatic surge in life expectancy, the more modest gains in life expectancy made in those same countries over the next half century (between 1960 and 2010) do not look particularly large: during this “second epidemiological revolution” life expectancy rose 10-12 years at most. But even if we use the word "revolution" only as a metaphor, and keep in mind that this trend is a continuation of the trends that began earlier, the achievements of the past 50 years look quite significant. They are all the more significant given that in the 1950s-1960s gains in life expectancy in many developed countries had slowed down, if not stopped altogether, leading many observers at the time to speculate that the options for further reducing mortality had been exhausted. These fears were not confirmed. While not of the same magnitude as the first, the second epidemiological revolution led to marked improvements in life expectancy in most industrialised, urbanised countries.

Russia, unfortunately, is watching this revolution from the outside, without taking any part in it. The question of why similar gains have not been realised in Russia is beyond the scope of this article. Our objective was to show which causes of death contribute the most to the gap in life expectancy between Russia and other developed countries. This knowledge is important, because otherwise it is impossible to identify the main weak points and to prioritise strategies for reducing mortality.

Our analysis shows that Russia still has roughly the same structure of causes of death as it did on the eve of the second epidemiological revolution. While the details of this structure—which we could not delve into given the scope of a single article—are not identical, the main features remain. It would not be an exaggeration to say that the gap between life expectancy in Russia and in other countries that are confidently following the path of the second epidemiological revolution is primarily attributable to our inability to solve two key challenges: to significantly shift mortality

from cardiovascular diseases to later ages and to drastically reduce the numbers of deaths from external causes.

ACKNOWLEDGMENTS

The author thanks E.M. Andreev, S.A. Vasin, and T.L. Kharkova for their valuable advice and assistance in carrying out the calculations.

ANNEX

Table A-1. Excess table numbers (d_{xi}^{R}-d_{xi}^{EU-15}) of male deaths up to 70 in Russia in comparison with the EU-15 per 100,000 males dying at all ages and from all causes, 1990

Age x	Infectious and parasitic diseases	Neoplasms	Diseases of the circulatory system	Respiratory diseases	Diseases of the digestive system	Other diseases	External causes	**All causes**
0	126	5	-2	244	7	672	48	**1100**
1-4	24	22	-4	56	3	34	124	**260**
5-9	4	18	-2	9	1	27	167	**224**
10-14	2	10	-2	1	2	8	143	**164**
15-19	5	18	14	9	6	5	316	**375**
20-24	13	14	21	8	10	-15	603	**654**
25-29	31	20	63	3	9	-67	876	**934**
30-34	56	30	165	14	8	-59	**1064**	**1277**
35-39	88	60	355	28	1	-32	**1118**	**1619**
40-44	101	145	665	60	6	2	**1116**	**2094**
45-49	127	375	**1107**	143	2	9	**1164**	**2928**
50-54	129	526	**1431**	212	-38	-49	**1005**	**3216**
55-59	108	657	**1781**	345	-90	-133	767	**3437**
60-64	75	398	**2234**	378	-92	-245	488	**3236**
65-70	28	-432	**2030**	226	-126	-466	209	**1468**
Total	**916**	**1866**	**9856**	**1737**	**-291**	**-307**	**9209**	**22985**

The number of excess deaths**:**	**More than 1000**	**500-1000**	**300-500**	**100-300**	**50-100**	**Less than 50**

Table A-2. Excess table numbers (d_{xi}^{R}-d_{xi}^{EU-15}) of female deaths up to 70 in Russia in comparison with the EU-15 per 100,000 females dying at all ages and from all causes, 1990

Age x	Infectious and parasitic diseases	Neoplasms	Diseases of the circulatory system	Respiratory diseases	Diseases of the digestive system	Other diseases	External causes	**All causes**
0	110	7	-1	189	3	419	41	**766**
1-4	21	17	-5	45	2	37	84	**202**
5-9	1	14	0	5	0	20	56	**96**
10-14	1	10	-3	3	2	10	35	**58**
15-19	2	13	6	4	4	28	96	**153**
20-24	8	19	11	5	7	28	80	**158**
25-29	8	25	14	3	2	8	92	**152**
30-34	8	34	27	4	0	20	125	**218**
35-39	12	37	55	8	-5	32	162	**300**
40-44	11	78	149	13	-6	34	193	**472**
45-49	10	100	322	27	-12	42	241	**730**
50-54	8	63	570	33	-8	28	230	**924**
55-59	6	29	**1095**	55	5	3	218	**1411**
60-64	0	-23	**1823**	48	6	-79	178	**1954**
65-70	-14	-176	**2897**	51	9	-262	127	**2632**
Total	**192**	**247**	**6961**	**492**	**10**	**367**	**1958**	**10227**

The number of excess deaths**:**	**More than 1000**	**500-1000**	**300-500**	**100-300**	**50-100**	**Less than 50**

Table A-3. Excess table numbers (d_{xi}^{R}-d_{xi}^{EU-15}) of male deaths up to 70 in Russia in comparison with the EU-15 per 100,000 males dying at all ages and from all causes, 2000

Age x	Infectious and parasitic diseases	Neoplasms	Diseases of the circulatory system	Respiratory diseases	Diseases of the digestive system	Other diseases	External causes	**All causes**
0	92	6	2	170	5	811	91	**1178**
1-4	24	14	1	56	3	87	143	**329**
5-9	6	9	1	10	2	40	147	**216**
10-14	2	8	4	5	2	22	153	**196**
15-19	15	12	26	15	8	50	586	**713**
20-24	80	16	112	38	29	133	**1471**	**1879**
25-29	142	20	201	61	55	163	**1644**	**2287**
30-34	178	28	366	92	93	165	**1682**	**2604**
35-39	222	57	659	162	128	183	**1784**	**3194**
40-44	284	73	**1148**	238	147	227	**1928**	**4044**
45-49	309	158	**1814**	346	153	265	**1967**	**5011**
50-54	265	235	**2571**	426	161	278	**1787**	**5722**
55-59	204	291	**3235**	464	118	174	**1459**	**5946**
60-64	115	-196	**3753**	427	9	-28	959	**5039**
65-70	2	-1191	**3493**	203	-113	-377	502	**2518**
Total	**1940**	**-460**	**17387**	**2712**	**800**	**2194**	**16303**	**40875**

The number of excess deaths**:**	**More than 1000**	**500-1000**	**300-500**	**100-300**	**50-100**	**Less than 50**

Table A-4. Excess table numbers (d_{xi}^{R}-d_{xi}^{EU-15}) of female deaths up to 70 in Russia in comparison with the EU-15 per 100,000 females dying at all ages and from all causes,2000

Age x	Infectious and parasitic diseases	Neoplasms	Diseases of the circulatory system	Respiratory diseases	Diseases of the digestive system	Other diseases	External causes	**All causes**
0	66	6	4	135	6	578	78	**873**
1-4	19	15	1	57	2	68	100	**263**
5-9	4	7	4	9	2	27	66	**118**
10-14	2	6	0	3	1	15	59	**87**
15-19	8	13	11	7	4	32	182	**256**
20-24	22	17	23	13	9	53	257	**394**
25-29	30	27	45	18	21	60	280	**482**
30-34	33	48	91	28	28	67	303	**597**
35-39	32	60	157	35	37	73	342	**737**
40-44	41	73	298	47	54	75	389	**975**
45-49	38	106	572	66	65	97	449	**1392**
50-54	34	125	**1057**	67	96	126	498	**2002**
55-59	22	92	**1863**	60	146	139	495	**2817**
60-64	-1	-47	**2767**	28	100	52	366	**3265**
65-70	-29	-245	4546	-38	61	-127	285	**4453**
Total	**320**	**301**	**11439**	**535**	**633**	**1335**	**4148**	**18711**

The number of excess deaths**:**	**More than 1000**	**500-1000**	**300-500**	**100-300**	**50-100**	**Less than 50**

REFERENCES

Andreev E.M. (1982). Metod komponent v analize prodolzhitel'nosti zhizni [Component method in the analysis of life expectancy] // Vestnik statistiki [Bulletin of statistics]. 9: 42-47.

Andreev E.M., A.G. Vishnevsky, K.Yu. Shaburov (1986). Prodolzhitel'nost' zhizni i prichiny smerti [Life expectancy and causes of death] // A.G. Volkov, ed. Demograficheskiye protsessy i ikh zakonomernosti [Demographic processes and their regularities] Moskva: Mysl': 110-130.

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

Demograficheskaya modernizatsiya Rossii, 1900-2000 [Demographic modernisation of Russia, 1900-2000] (2006) / A.G. Vishnevsky, ed. M.: Novoye izdatel'stvo. 601 p.

Editorials (1972). The epidemiologic revolution // American journal of public health. 62 (11): 1439-1441.

Frenk J., J. L. Bobadilla, C. Stern, T. Frejka, and R. Lozano (1991). Elements for a theory of the health transition // Health transition review. 1 (1): 21-38.

Meslé F., J. Vallin (2002). La transition sanitaire: tendances et perspectives // Démographie: analyse et synthèse. Sous la direction de G. Caselli, J. Vallin et G. Wunsch. INRD. Volume III, Chapitre 57: 439-461.

Murray C.J.L., and A.D. Lopez, eds. (1996). The global burden of disease. A comprehensive assessment of mortality and disability from diseases, injuries, and risk factors in 1990 and projected to 2020. Summary.

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

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

---------- (1998). The epidemiologic transition theory revisited thirty years later // World Health Statistics Quarterly. 51 (2-4): 99-119.

Semenova V.G. (2005). Obratnyy epidemiologicheskiy perekhod v Rossii [Reverse epidemiological transition in Russia]. M.: TsSP.

Terris M. (1976). The Epidemiologic Revolution, National Health Insurance and the Role of Health Departments. American Journal of Public Health. Vol. 66, number 12: 1155-1164.

Vishnevsky A. (2009). Nezavershennaya demograficheskaya modernizatsiya v Rossii [Incomplete demographivc modernisation of Russia] // SPERO.10: 55-82.

---------- (2014). The demographic revolution is changing the reproductive strategy of the species Homo sapiens // Demographic review. English selection: 3-24.

Vishnevsky A., V. Shkolnikov (1997). Smertnost' v Rossii: glavnyye gruppy riska i prioritety deystviya [Mortality in Russia: main risk groups and priorities of action]. Nauchnyye doklady Moskovskogo Tsentra Karnegi [Scientific reports of the Carnegie Moscow Center]. Vyp.19: 83.

Vishnevsky A., V. Shkolnikov, S. Vassin (1991). Epidemiologicheskiy perekhod i prichiny smerti v SSSR [Epidemiologic transition and causes of death in the USSR] // Ekonomika i matematicheskiye metody [Economics and mathematical methods]. 27 (6): 1013-1021.

WHO HFA-DB (2014). European “Health for All” database. URL: http://www.euro.who.int/en/data-and-evidence/databases/european-health-for-all-databasehfa-db (data accessed: 20.07.2014).