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Comparative Structure of Male Mortality From Cardiac Causes in Five-Year Age Groups

Aim	To study the nosological structure of male mortality in 5-year age groups (15–85+) and the contribution of cardiac causes to all-cause mortality in 2020; to discuss the correctness of statistical recording of causes of cardiac death.
Material and Methods	Data source: Center for Demographic Research of the Russian School of Economy http://demogr.nes.ru/index.php/ru/demogr_indicat/agreement. The selected indexes were all-cause death, causes of the class of circulatory diseases (CD) according to the International Classification of Diseases, Tenth Revision (ICD-10) (class IX, codes I00 – I99), and cardiac causes of death (codes I00 – I40, I70, I67.4, Q20–28) in 5-year age groups.
Results	Proportions of CD and cardiac causes in the male all-cause mortality were almost identical in the age groups younger than 30 years. Then the proportion of cardiac deaths remained almost unchanged (30–34%) in contrast to the rapid growth of the CD proportion (to 51% with a maximum at 75–79 years). Until the age of 45 years, more than 50% of cardiac deaths were caused by heart defects and cardiomyopathies and more than 25% by acute forms of ischemic heart disease (IHD); in older groups, their proportions decreased but the mortality increased. In the age groups younger than 50 years, the mortality from «Other forms of acute IHD» (ICD codes I20, I24.1–9 counted as one line) was higher than the mortality from myocardial infarction (MI); after 50 years, the MI mortality became higher. The combined proportion of two groups in the mortality from cardiac causes was maximal at the age of 20–24 years (31%), then it decreased to a minimum of 9% at the age of 85+. The mortality from and the proportions of chronic forms of IHD (more than 50% of which have no clear criteria for diagnosis and death), arterial hypertension, "Myocardial degeneration" (ICD code I51.5), and "Pulmonary heart and pulmonary circulation disorders" (ICD codes I26 – I28) rapidly grow with increasing age. Existing approaches to recording the causes of death do not allow assessment of the contribution and mortality rates from a number of cardiac diseases.
Conclusion	Mortality reduction programs should provide more accurate recording of the causes of death and take into account age-related features of the nosological structure of cardiac mortality.

Keywords	Male mortality; heart diseases; cardiac causes of death
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Circulatory system diseases (CSDs) make up a significant part of the causes of death worldwide [1, 2]. As we previously pointed out, the notion of CSDs is, however, distinct from the notions of cardiovascular or cardiac disorders. [3]. The International Classification of Diseases 10th Revision (ICD 10) and the Brief Nomenclature of the Causes of Death (BNCD) of the Russian Federal State Statistics Service (Rosstat) are not optimal for understanding the contribution of cardiovascular causes to mortality. Nevertheless, no other data are available, neither in Russia nor in other countries [2, 4]. According to a 2016 study conducted in France under the auspices of the World Health Organization, the percentage of deaths from CSDs recorded as the underlying cause of death (UCD) is 26.4% and as any cause of death in 80% of cases. It was shown that the methods applied can have affect the contribution of various causes, including those from the CSD class [5].

We have previously noted [6] chronic forms of ischemic heart disease (IHD) make the greatest contribution to the standardized coefficients of regional mortality from cardiac causes: 60.9 ± 13.8% in 2019 and 62.5 ± 12.8% in 2020. The percentage of deaths from acute IHD and sudden cardiac death was 17.3 ±9.7% in 2019 and 16.1 ± 9.6% in 2020 [6]. However, we could not find the published studies assessing the nosological structure of cardiac mortality based on age-specific mortality rates. Moreover, the mortality in men has been significantly higher than that in women in all regions of the Russian Federation (RF) for decades [7].

Objective

Study the nosological structure of cardiac mortality in male patients in five-year age groups (15–85+) and the contribution of cardiac causes to all-cause mortality in 2020; discuss the correctness of the statistics of the cardiac causes of death.

Material and Methods

No data on deaths based on all four-digit ICD-10 codes are available to the public. The Rosstat generates data according to the BNCD, in which some of the ICD-10 codes are combined in one line. The data on mortality in the RF by five-year age groups in accordance with the BNCD are available on the website of the Center for Demographic Research at the New Economic School at http://demogr.nes.ru/index.php/ru/demogr_indicat/agreement.

All-cause mortality, CSD mortality (class IX, codes I00 – I99), and mortality from cardiological causes (I00-I40, I70, I67.4, Q20-28) were selected for the analysis; this approach to the grouping of cardiological causes has been used in other studies [5, 7].

Group 1 (Table 1) includes a code used for atherosclerosis, since it probably corresponds to the causes of death associated with multivessel atherosclerosis, as well as the codes of chronic IHD (I25). This group is called "Causes related to with chronic diseases mainly associated with atherosclerosis", since according to the consensus of Russian cardiologists and pathologists, IHD pathogenesis is based on narrowing or obstruction of coronary arteries of the heart caused by atherosclerotic plaques.

Group 2 combines myocardial infarction (MI), other forms of acute IHD (according to the BNCD) and sudden cardiac death, since all of the listed causes of this group are associated with acute diseases/conditions on the one hand and not all cases of MI are caused by coronary atherosclerosis on the other hand arteries (pathogenesis of a number of MI type 2 cases is not associated with coronary atherosclerosis).

Group 3 combines the causes of death in which atherosclerosis is unlikely to play a leading role. This group includes more heterogeneous causes, because the underlying causes associated with individual causes cannot be selected based on the BNCD. Some forms of cardiomyopathy are listed in the BNCD in a separate line, others are combined with heart failure and some heart valve diseases; rheumatic and atherosclerotic heart diseases are not separated. This group also includes congenital heart defects, which are

Table 1. Groups of cardiac causes of death

Group no.	Explanation	Cause provided in a separate line in the BNCD	ICD-10 code
1	Causes associated with chronic diseases related to atherosclerosis	Atherosclerotic heart disease	I25.1
		Atherosclerotic cardiovascular disease, so described	I25.0
		Chronic ischemic heart disease, unspecified	I25.9
		Other forms of chronic ischemic heart disease	I25.2–6, 8
		Atherosclerosis	I70
2	Causes of death related to acute diseases/conditions	Acute myocardial infarction, including certain complications following acute myocardial infarction	I21
		Recurrent myocardial infarction	I22
		Other forms of acute ischemic heart disease	I20, I24.1–9
		Sudden cardiac death, so described	I46.1
3	Causes not related to atherosclerosis (cardiomyopathy, heart defects, and heart failure)	Acute rheumatic fever	I00–I02
		Chronic rheumatic heart diseases	I05–I09
		Pulmonary heart disease and diseases of pulmonary circulation	I26–I28
		Alcoholic cardiomyopathy	I42.6
		Cardiomyopathy, unspecified	I42.9
		Myocardial degeneration	I51.5
		Heart failure, unspecified	I50.9
		Other heart diseases	I30–I41, I42.0–5, 7, 8, I43–I45, I46.0, 9, I47–I49, I50.0, 1, I51.0–4, I51.6–9
		Congenital malformations of the heart	Q20–Q24
		Other congenital malformations of the circulatory system	Q25–Q28
4	Arterial hypertension	Hypertensive heart disease	I11
		Hypertensive renal disease	I12
		Hypertensive heart and renal disease	I13
		Other and unspecified forms of hypertension	I10

BNCD, Brief nomenclature of causes of death of the Rosstat;
ICD-10, International Statistical Classification of Diseases and Related Health Problems, 10th revision.

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Figure 1. Contribution of cardiac causes and CSDs (circulatory system diseases) in male all-cause mortality by five-year age groups (2020)

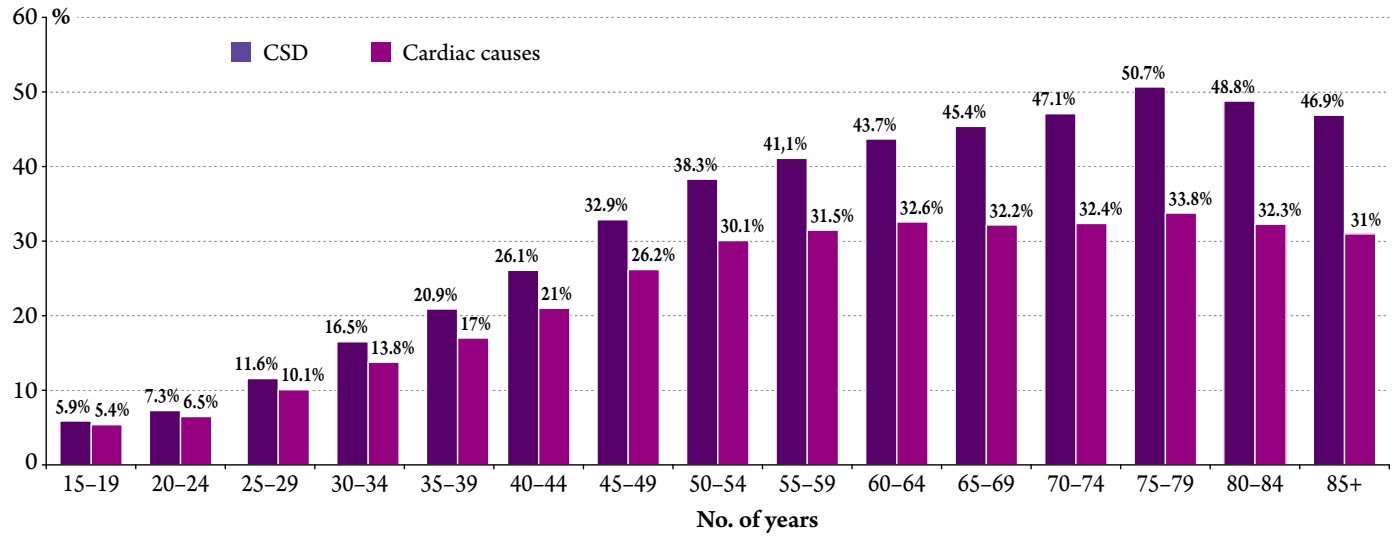
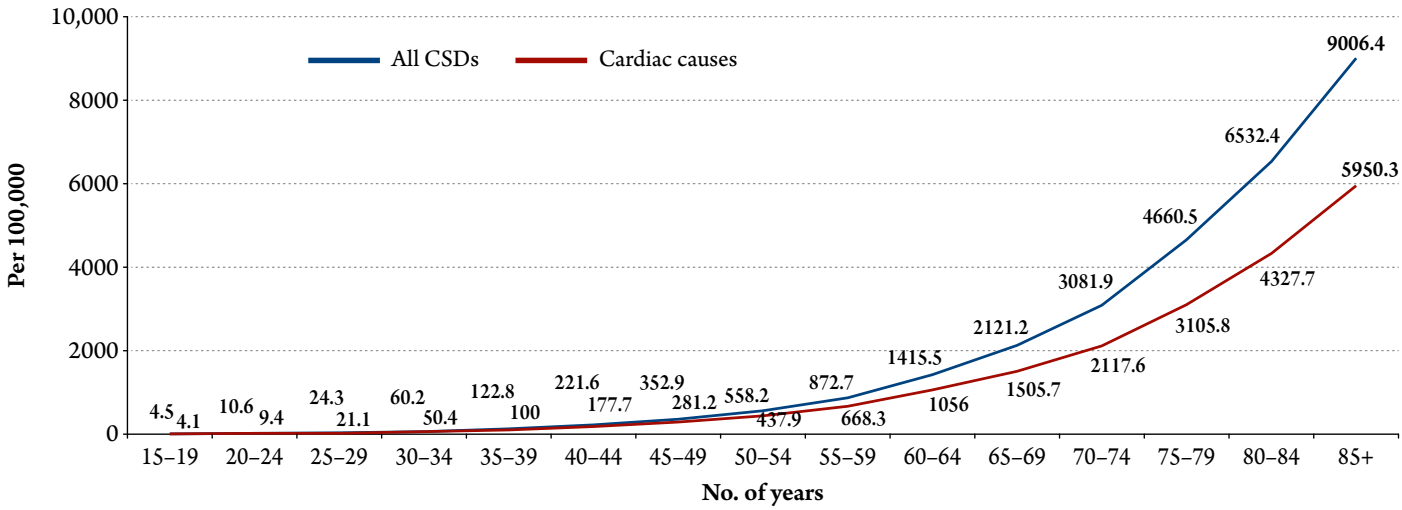


Figure 2. Смертность в пятилетних возрастных группах от БСК (болезни системы кровообращения и кардиальных причин) на 100 тыс. населения



actually cardiovascular diseases but listed in the ICD-10 as Congenital defects, deformations, and chromosomal abnormalities (Q00 – Q99).

Group 4 includes causes of death related to arterial hypertension (AH).

The contribution percentage of CSDs and cardiac causes in all-cause mortality in each five-year age group and the contribution of each of the four groups of causes in cardiac mortality was determined.

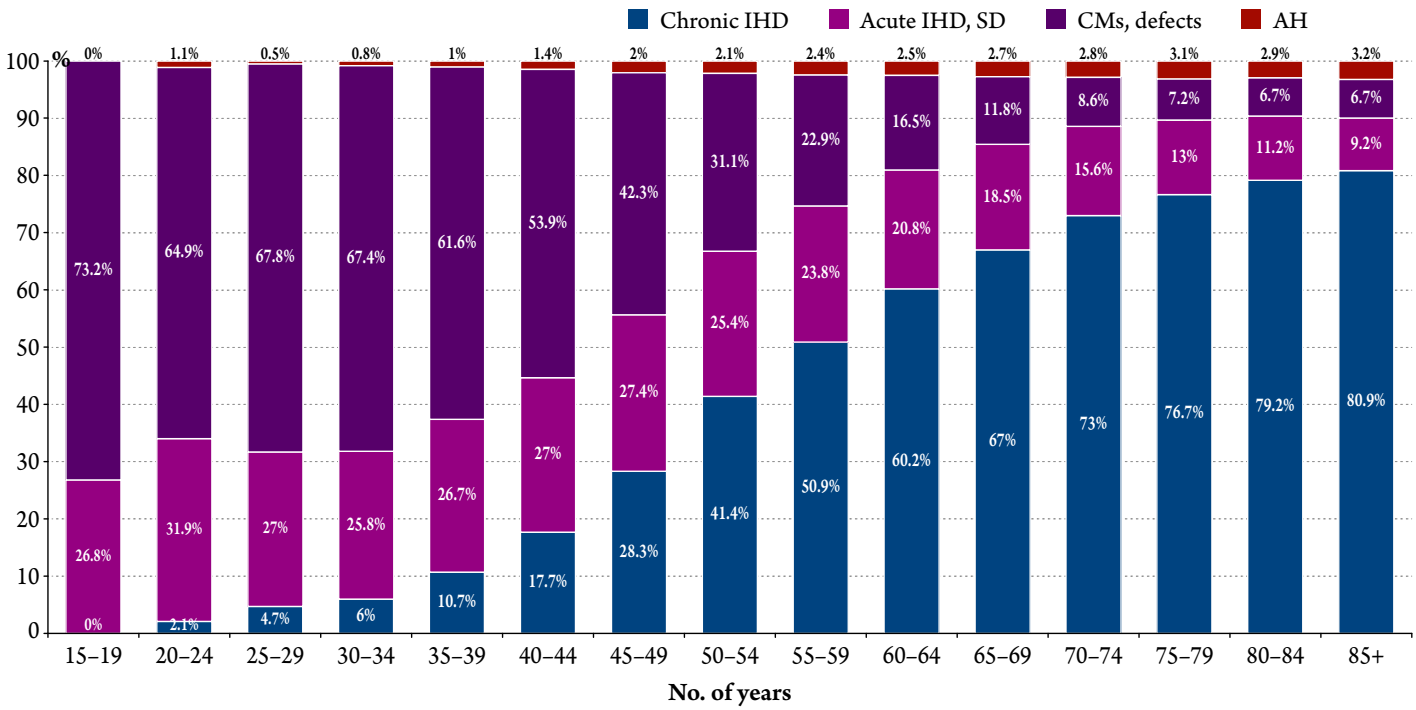
Results

Figure 1 shows the percentages of CSDs and cardiac causes in male all-cause mortality. The smallest differences are observed in younger age groups up to 30 years. The percentage of cardiac causes increases from 13.8% to 30% at the age of 50–54 years, with a very small increases (2–3%) in the subsequent age groups. The percentage of CSDs increases to almost 51% (maximum in the 75–79 year age group).

Figure 2 shows mortality from CSDs and cardiac causes per 100,000 of population in the five-year age groups. Mortality rates are higher in each subsequent age group despite the fact that the percentage of cardiac causes of death in all-cause mortality does not increase with age and decreases in the oldest age groups. Under the age of 30, mortality from CSDs is higher than mortality from cardiac causes by no more than 15%; in the age groups 30–50 years – by 25% and in the groups older than 50 years, the differences increase, reaching a maximum of 50% in the 75+ age groups.

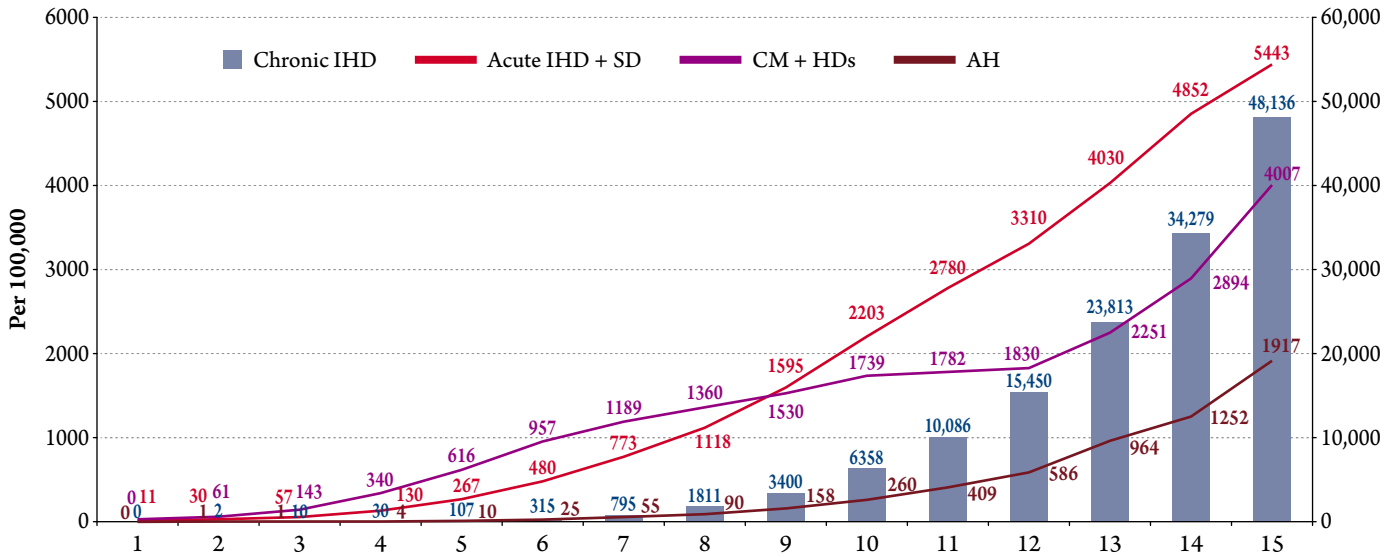
Figure 3 shows the structure of cardiac mortality consisting of four groups of causes by five-year age groups. More than 50% of deaths before the age of 45

Figure 3. Contribution of all four groups of cardiac causes in male mortality by five-year age groups (2020)



IHD, ischemic heart disease; SD, sudden death; CM, cardiomyopathy.

Figure 4. Mortality rates from four groups of cardiac causes by five-year age groups (2020)



years are due to heart defects (congenital and acquired), cardiomyopathy, endocardial and myocardial diseases. Interestingly, the percentage of diseases of this group is lower in the 20+ age groups, and the percentage of acute IHD consistently decreases from 55 years, the percentage of chronic IHD increases and reaches 81% in the 85+ age group. The contribution of AH is higher in older age groups, but its contribution in the structure of cardiac mortality is minimal compared with other causes (from 1% in the youngest age groups to 3% in the oldest age groups).

Despite lower percentages of the causes of Group 2 and Group 3 (Figure 3), the mortality from all four groups of causes increases with age (Figure 4). This is due to the changing ratio of IHD mortality to mortality from the causes of Group 2 and Group 3 in older age groups. Mortality at the age of 85+ is higher than at the age of 40–44 years: mortality from chronic IHD is 152 times higher, mortality from acute IHD is 11 times higher, and mortality from the Group 3 diseases is 4.2 times higher.

In the Group 2 of causes, deaths from "Other forms of acute IHD" (one line in BNCD corresponding to ICD codes

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I20 and I24.1–9) prevail rather than from MI in the age groups up to 60 years. Codes I20, I24.1–9 represent from 45.5% of deaths from the Group 2 causes at the age of 15–19 years to 60.4% (maximum) at the age of 40–44 years. However, despite decreasing percentage of "Other forms of acute IHD" in the structure of Group 2 of cardiac causes mortality from these causes increase in each age group (Figure 5) but not as quickly as mortality from MI. Mortality from MI is 0.1 per 100,000 of the population in the 15–19 year age group and 380 per 100,000 in the 85+ age group. Mortality from "Other forms of acute IHD" varies from 0.5 to 161.7, respectively (Figure 5).

In Group 3 of cardiac causes of death, the percentage of deaths from congenital defects of the heart and vascular system is high in the 15–19 year age group (16.7%, or 0.5 per 100,000 of the population), then the percentage of these causes decreases quickly and significantly to 6.6% at the age of 20–24 years, 3.5% at the age of 25–29 years, and less than 1% in the subsequent age groups. At the same time, mortality from congenital defects varies little, ranging from 0.5 to 0.7 per 100,000 of male population in the age groups from 19 to 74 years and reaching the maximum (1 per 100,000 of the population) at the age of 75–79 years. Alcoholic cardiomyopathy (ACM) presents a significant percentage of deaths in the Group 3 causes: 3.3% at the age of 15–19 years, constantly increasing to the maximum of 31.9% at the age of 50–54 years. The percentage of deaths from this cause is lower in older age groups. At the same time, mortality increases from 0.1 per 100,000 in the 15–19 year age group to 50 per 100,000 in the 65–69 year age group, and decreases to the minimum (0.2 per 100,000 of the population) at the age of 85+ (Figure 6). A similar

Figure 5. Male mortality rates from MI and other forms of acute IHD by five-year age groups (2020)

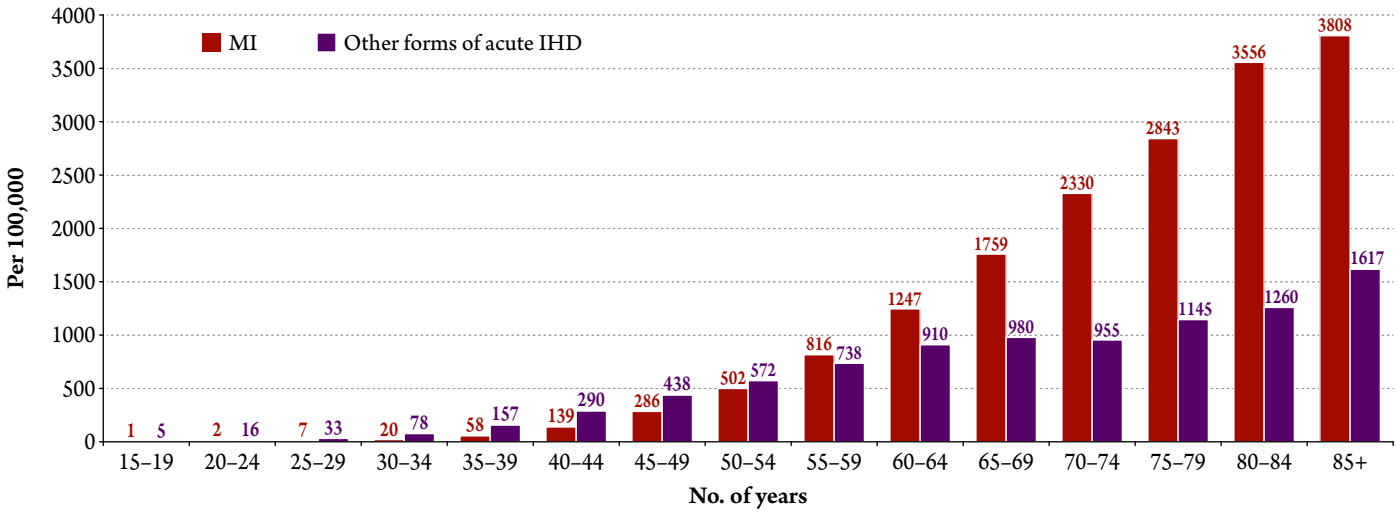
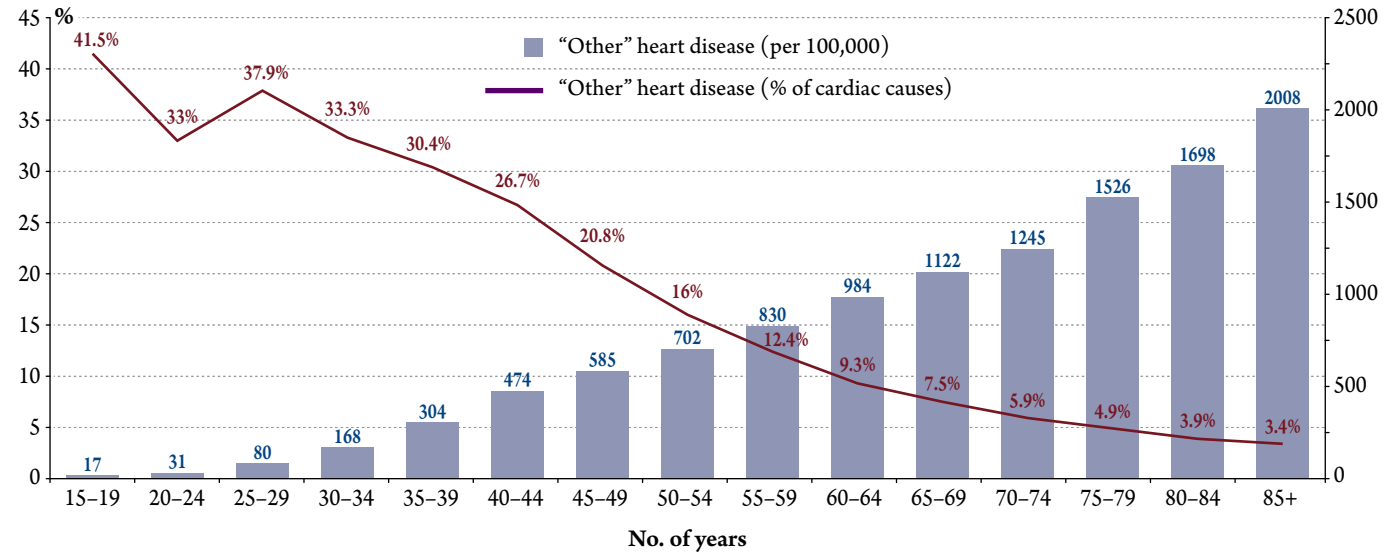


Figure 6. Mortality (per 100,000 of the population) and the contribution of "Other heart diseases" in male cardiac mortality by five-year age groups



trend exists for mortality from I42.9 – Cardiomyopathy, unspecified (ICD). Mortality from I51.5 – Myocardial degeneration (ICD) before the age of 45 years does not exceed 0.1 per 100,000 of the population, then it increases then in each age group, with the maximum in the 85+ age group (156.4 per 100,000 of the population).

The BNCD does not include separate lines of acquired heart defects, dilated and hypertrophic cardiomyopathy. These causes are included in the line "Other heart diseases». Mortality from these causes increases in each age group. It is about 50% of all deaths of this group of cardiac causes of death (Group 3) or 41.5% of deaths from all cardiac causes at the age of 14–19 years.

Discussion

The differences in the rates of mortality from CSDs and cardiac causes and their percentages in all-cause mortality are mainly caused by the fact that a significant number of deaths in the CSDs group are due to cerebrovascular diseases, with the mortality increasing with age. The codes and terminology of diseases related to damage to the central nervous system and cerebrovascular diseases will be amended in ICD-11. However, discussions are still under way [8].

The identified age-specific variations in the nosological structure of cardiac mortality point to the necessity of age-specific prevention and treatment programs as well as a more thorough investigation of the causes of death.

As we have previously noted, a majority of cases of death caused by chronic IHD do not have clear criteria and are never established as clinical diagnoses [1–3, 6]. Only three causes of the codes and terms related to chronic IHD have counterpart clinical terms (cardiac aneurysm, ischemic cardiomyopathy, and a history of MI), but these codes are not listed in separate lines in the BNCD. The contribution of these three causes in combination with two less definite codes I25.8 and I25.8 (Silent myocardial ischemia in ICD-10) is listed in one line and totals to about 40%. At the same time, other codes (I25.1, I25.0, I25.9) that do not have clinical characteristics and diagnostic criteria present more than 50% of deaths from IHD. It cannot be excluded that some deaths are from MI or so-called sudden cardiac death, which requires conducting population studies and applying more clear rules of registering the causes of death.

Particular attention should be paid to clarification (establishment of formalized criteria) of such causes of death as "Other forms of acute IHD", "Cardiomyopathy, unspecified", ACM. These causes of death make a significant contribution in the mortality in young men, so this is obvious that the prevention programs that are aimed only at identifying and treating atherosclerosis should be corrected. Needless to say that such programs should be developed simultaneously with the clarification of the causes of death, because experts who fill in medical death certificates (MDC) in different countries, different regions, and different medical facilities interpret UCD in different ways [4, 9]. In some cases, it is not possible to differentiate between MI, "Other forms of acute IHD", "Cardiomyopathy, unspecified", ACM using the internationally established criteria for the diagnosis of MI. According to Timonin et al. [9], the lack of standardized approaches to indicating the diagnosis of MI in the MDC causes significant differences in the rates of mortality from MI in Russia and Norway. There are even fewer formalized criteria for indicating ACM as the cause of death. Zaridze et al. [10] convincingly proved almost 10 years ago that alcohol abuse one of the most significant factors of male mortality in Russia. However, the relation of alcohol abuse to mortality is not direct [11]. Alcohol is still often seen as a factor rather than a cause of death, since there is no distinct definition of ACM as a UCD.

Attention should also be paid to "Myocardial degeneration", and the criteria for establishing it as a UCD should be clarified. This term is not clear to clinicians but present in ICD-10. Mortality from this cause is significantly lower than from the entire chronic IHD group but is comparable in older age groups to "I25.0 Atherosclerotic cardiovascular disease, so described". "Myocardial degeneration" may refer to cases of transthyretin amyloid cardiomyopathy (ATTR-CM), the diagnosis and treatment of which has been much discussed in recent publications [12, 13]. Studies show that the incidence of ATTR-CM increases with age. However, ICD-10 does not include this cause of death. The available literature and coding guidelines do not provide clarification for this issue. ICD-10 contained code "E85 Amyloidosis", but it belongs to Endocrine, nutritional and metabolic diseases rather than to the CSD (cardiac causes) class. In Russian in 2020, this code is not listed among the causes of male mortality. In Sweden, for example, according to Lauppe et al. [14], cases of ATTR-CM can be coded by the cardiomyopathy codes and the E85 codes. Researchers use software algorithms to isolate the ATTR-CM cases from databases because there is no common principle for determining the prevalence of this condition [15]. Experts dispute whether ATTR-CM is a risk factor or the cause of death. Therefore, it is necessary to develop guidelines on harmonization of criteria and rules for coding and establishing ATTR-CM as the cause of death.

It is important to clearly understand the role of chronic heart failure (CHF) and its contribution in mortality and distinct between deaths caused by life-threatening arrhythmias in the absence or presence of congestive heart failure, because this can influence decision making on measures to reduce mortality. Despite the available

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guidelines on the management of patients with CHF, there are no criteria for recording deaths from CHF, because is considered as a complication of the underlying disease and this not included in the causes of death statistics. Currently, CHF-related mortality is determined based on expert estimates rather than MDC data. Despite the fact that it is planned to expand codes and terms in ICD-11, there are no international rules so far on what code should be used in which cases in MDCs in the presence of CHF [16, 17].

It is very important to clarify criteria of recording the causes of death from chronic IHD: the percentage of deaths in chronic IHD related end-stage CHF, sudden cardiac death in arrhythmia or deaths due to complications of cardiac surgery, is still unknown. The latter is especially relevant, since studies show the advantages of surgical and endovascular treatments over lifestyle changes and the best-possible drug therapy, with only minimal surgical mortality [18].

Conclusion

Male cardiac mortality is generally age-specific, with younger age groups being predominately affected by heart valve defects, cardiomyopathy, and acute ischemic heart disease. At the same time, when considering the cardiological causes of death in older age groups, terms and codes are frequently used that are not clearly defined in terms of clinical diagnosis and the organization of medical care. Current approaches to recording causes of death challenge the estimation of the contribution of some cardiac diseases in the mortality rates. Mortality reduction programs should be age-specific and be based on recording of causes of death in terms of modern scientific knowledge of cardiac diseases.

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