Drapkina O.M., Samorodskaya I. V.
National Medical Research Center of Therapy and Preventive Medicine, Moscow, Russia

Dynamics of Regional Mortality Rates From Cardiac Causes in Russia 2019–2020

Aim	To analyze the dynamics of standardized mortality ratios (SMR) (2019–2020) for the cardiological causes indicated as the primary (original) cause of death, in regions of the Russian Federation, based on the RF State Statistics Service Brief Nomenclature of Causes of Death (RFSSS BNCD). Reports have indicated substantial changes in the indexes and structure of mortality since the beginning of the COVID-19 pandemic in many countries.
Material and Methods	RFSSS data on numbers of deaths were analyzed according to BNCD and mid-year population in single year of age groups in 2019 and 2020. SMRs were determined for 23 cardiological causes of death listed in the BNSD in a separate line; the average regional SMR value and the standard deviation were provided; and SMRs were compared both among 4 groups (with a previously described method) and by 23 RFSSS BNCD causes using the Wilcoxon test.
Results	In 2020 vs. 2019, the mean regional SMR for cardiological causes increased by 12.07±9.86% (from 301.02±77.67 to 336.15±84.5%; p<0.0001). Decreases in SMR were found in 9 of 82 regions; however, only in two of them (the Republic of Ingushetia and the Sakhalin Region), SMR was decreased for all 4 groups of causes. In both 2019 and 2020 (60.9±13.8 and 62.5±12.8%, respectively), the highest proportion of deaths was related with the 1st group of causes (chronic ischemic heart disease, IHD), with an increase in SMR of 18.66±33.28% (p<0.0001). Increases in SMR were found in 75 regions while in the other regions, decreases in SMRs were observed. For the 2nd group of causes (myocardial infarction, other acute forms of IHD, sudden cardiac death), the mean regional SMR increased in 2020 by 3.2±18.1% (p=0.3). Increased SMRs were noted in 54 regions. The proportion of the 2nd group in cardiological mortality was 17.3±9.7% in 2019 and 16.1±9.6% in 2020. The mean regional SNR for the 3rd group of causes (heart defects, myocardial diseases, etc.) increased in 2020 by 11.6±23.1% (p=0.006). The mean regional proportion of causes for this group did not significantly changed compared to 2019 (17.5±8.2 and 17.1±7.3%, respectively); however, the contribution of this group was greater than the contribution of the 2nd group. Increases in SMR were observed in 65 regions, while the contribution of causes related with arterial hypertension did not significantly change. Significant mid-regional differences in SMR values, dynamics of SMRs for different causes, and increases in the coefficient of variation were noted for almost all causes of death. Significant differences between 2019 and 2020 were found for 3 of 23 causes: other forms of chronic IHD (decreased SMRs in 15 regions and increased SMRs in the others), atherosclerotic heart disease (decreased SMRs in 38 regions), and alcoholic cardiomyopathy (decreased SMRs in 28 regions).
Conclusion	During the COVID-19 pandemic, the SMR for cardiological causes was increased. Considerable regional differences in values and dynamics of SMR for individual causes call for attention to the unification of the criteria for clinical diagnosis.

Keywords	Mortality; heart diseases; cardiological causes of death
For citations	Drapkina O.M., Samorodskaya I.V. Dynamics of Regional Mortality Rates From Cardiac Causes in Russia 2019–2020. Kardiologiia. 2022;62(10):16–25. [Russian: Драпкина О.М., Самородская И.В. Динамика региональных показателей смертности от кардиологических причин в России в 2019–2020 гг. Кардиология. 2022;62(10):16–25].

Corresponding author Samorodskaya I. V. E-mail: samor2000@yandex.ru

Cardiovascular diseases (CVDs) are statistically the leading cause of mortality in the Russian population and differ significantly between the regions of the Russian Federation [1, 2]. Other authors and we drew attention in the previous publications to the fact that the standardized death rate (SDRs) from individual causes depend on many factors including different approaches to determining and coding the primary cause of death (PCD) [3–5]. 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. However, there are no other mortality statistics (in the selected cohort or register) either in Russia or in other countries.

ISSN 0022-9040. Kardiologiia. 2022;62(10). DOI: 10.18087/cardio.2022.10.n1926

Studies beginning during the COVID-19 pandemic showed that CVDs were risk factors for death in COVID-19, on the one hand, and COVID-19 had such cardiovascular complications as myocardial infarction (MI) of type 1 and type 2, myocarditis, pulmonary embolism, and stroke, on the other hand [6–8]. All researchers note that, during the COVID-19 pandemic, the amount of elective care for patients with chronic diseases, including CVDs and the availability of medical care decreased, and changes introduced in the system of medical care organization significantly reduced the all-cause mortality and mortality due to individual groups of diseases. For example, Zhu et al. [8] showed that mortality from circulatory diseases and mortality attributable to COVID-19 increased simultaneously in the United States. Mortality displacement (compared to the pre-pandemic period) among adults with acute cardiovascular diseases and conditions was 8% in the UK, of which 5.1% were related to COVID-19 [6]. It should be noted that the study is based on full electronic access to the information from medical death certificates (MDCs), which is not possible so far in the Russian Federation.

Objective

Given the available possibilities, the objective of this study is as follows: analyze changes in the SDRs (2019–2020) from cardiovascular causes identified as the main (primary) cause of death in the regions of the Russian Federation based on the Rosstat's BNCD.

Material and Methods

Cardiovascular causes of death were selected based on the 2019–2020 Rosstat data received at the request of the Russian National Medical Research Center for Therapy and Preventive Medicine on the mean annual population and the number of deaths in one-year age groups according to the BNCD. The approaches to the formation of group was justified in the previous article [9].

- In addition to the codes of chronic ischemic heart diseases (IHD) (I25), Group 1 includes a code used for atherosclerosis, since it probably corresponds to the causes of death associated with multivessel atherosclerosis (Table 1).
- Group 2 combines MI, other acute forms of IHD (as specified in the BNCD) and sudden cardiovascular death.
- Group 3 includes the causes of death, which are not clearly defined in the BNCD (some of them are given in separate lines in the BNCD, for example, alcoholic cardiomyopathy, others are combined with heart failure (HF) and other heart diseases, with heart defects (rheumatic and atherosclerotic defects are not separated, but probably atherosclerosis did not play a key role in the cause of death). Moreover, this group includes congenital heart defects, which are actually cardiovascular diseases but coded in the ICD-10 as Congenital malformations, deformations and chromosomal abnormalities (Q00 – Q99).
- Group 4 includes causes of death associated with arterial hypertension (AH).

Calculations were made using the software suite 'Calculation and analysis of mortality rates and years of life lost due to premature death in the federal subjects of the Russian Federation' developed at the Russian National Medical Research Center for Therapy and Preventive Medicine (computer software state registration certificate No. 201666114 dated September 30, 2016). The SDRs were calculated based on the European Standard Population. The regional mean, standard deviation, and coefficient of variation (CV) were determined for each «cause» and each of the four groups of causes. The means were compared in the SPSS suite using the non-parametric Wilcoxon test. The absolute numbers (n) and percentages (%), the means and standard deviations were used to express the obtained results. The differences were statistically significant with p value less than 0.05.

Results

In 2019, SDRs for all-cause and cardiovascular deaths were 985.64±143.16 and 301.02±77.67 per 100 thousand people in the Russian Federation. The percentage of cardiovascular causes was 30.5 ± 5.8%. CVs of regional SDRs for all-cause and cardiovascular deaths were 14.5% and 25.8%, respectively. In 2020, SDRs for all-cause and cardiovascular deaths were 1150.66±150.88 and 336.15±84.5 per 100 thousand people in the Russian Federation. The percentage of cardiovascular causes of death was 29.1±5.7%. CVs of regional SDRs for all-cause and cardiovascular deaths were 13.1% and 25.1%, respectively. The mean regional increase in cardiovascular SDR was 35.13±27.01 per 100 thousand people (p=0.0001) or 12.07±9.86% compared to 2019 (the maximum increase (43%) was registered in the Lipetsk region). However, SDRs did not increase in all regions: a decrease in cardiovascular SDR was registered in 9 regions (the Republic of Buryatia, the Republic of Ingushetia, Sakhalin Oblast, Irkutsk Oblast, Kirov Oblast, Kaluga Oblast, Sevastopol, Stavropol Krai and Chukotka Autonomous Okrug) while all-cause SDRs increased. SDRs for all 4 groups of causes of interest decreased in only 2 of these 9 regions (the Republic of Ingushetia and Sakhalin Oblast). For example, there was an increase in SDRs for the causes of Group 1, Group 2, and Group 4, and a decrease in SDRs, respectively, in Group 3. As a result, the all-cardiovascular SDRs decreased by 1%

Table 1. Main cardiovascular causes of death according to the BNCD of the Rosstat

Group #	Explanation	Cause provided in a separate line according to the BNCD	ICD-10 code
1	Causes associated with chronic diseases mainly associated with 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–I25.6, I25.8
		Atherosclerosis	I70
2	Causes of death related to acute diseases/conditions	Acute myocardial infarction, including certain current complications following acute myocardial infarction	I21
		Recurrent myocardial infarction	I22
		Other forms of acute ischemic heart disease	I20, I241 – I249
		Sudden cardiac death, so described	I461
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	I426
		Cardiomyopathy, unspecified	I429
		Myocardial degeneration	I515
		Heart failure, unspecified	I509
		Other heart diseases	I30–I41, I420–I425, I427, I428, I43–I45, I460, I469, I47–I49, I500, I501, I510–I504, I516–I519
		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 the Causes of Death; ICD-10, International Classification of Diseases 10th Revision.

(328.27 per 100 thousand people in 2019 and 325.04 per 100 thousand people in 2020).

Table 2 presents the means and CVs of cardiovascular SDRs in 2019 and 2020. The largest percentage of deaths (cardiovascular deaths 60.9±13.8% in 2019 and 62.5±12.8% in 2020) was registered in Group 1 (chronic diseases mainly associated with atherosclerosis). The mean regional SDRs increased in 2020 compared to 2019 by 27.67±26.5 per 100 thousand people or 18.66±33.28% (maximum increase in the Chechen Republic by 278%). SDRs decreased in 7 regions (Sakhalin Oblast, Amur Oblast, Irkutsk Oblast; the Republics of Buryatia, Tyva, Karelia, and Stavropol Krai). SDRs increased by 12.2 per 100 thousand people in Moscow and 28.4 per 100 thousand people in St. Petersburg (11.03% and 13.95%, respectively).

The percentage of the Group 2 causes of death (related to acute conditions likely associated with IHD) in the structure of cardiovascular causes was 17.3±9.7% in 2019 and 16.1±9.6% in 2020. The mean regional SDRs increased by 1.5±14.2 per 100 thousand people or 3.2±18.1% in 2020 compared to 2019. Thus, the mean regional SDRs increased to a lesser extent in Group 2 compared to other groups, which is why the percentage of causes of this group in the structure of cardiovascular deaths was slightly lower in 2020 than in 2019. The increase was observed in 54 regions and the decrease was registered in 25 regions. The maximum SDR increase was noted in the Republic of Tyva and the maximum decrease in the Chukotka Autonomous Okrug. SDRs increased by 2.46 per 100 thousand people in Moscow and 1.65 per 100 thousand people in St. Petersburg (11.0% and 4.77%, respectively).

The percentage of the Group 3 causes of death (malformations, cardiomyopathy, myocarditis, and other causes) in the structure of cardiovascular causes was 17.5±8.2% in 2019 and 17.1 ± 7.3% in 2020. The mean regional SDRs increased by 4.69±15.18 per 100 thousand people (11.6 ± 23.1%) in 2020 compared to 2019. The increase was noted in 65 regions (maximum in the Irkutsk Oblast), the decrease – in 18 (maximum in the Chechen Republic). The decrease in SDRs amounted to 2.1 per 100 thousand people in Moscow and there was an

ISSN 0022-9040. Kardiologiia. 2022;62(10). DOI: 10.18087/cardio.2022.10.n1926

Table 2. Changes in mean regional cardiovascular mortality rates

Group	Group's mean ± σ		p	Coefficient of variation		Cause (according to the BNCD)	Mean ± σ	Mean ± σ	p	Coefficient of variation	
	2019	2020		2019	2020		2019	2020		2019	2020
1	184.69± 64	212.29± 73.82	< 0.0001	34.66	34.8	Atherosclerotic heart disease	109.89 ± 64.27	122.43 ± 78.61	< 0.0001	58.49	70.62
						Other forms of chronic ischemic heart disease	57.21 ± 27.5	71.22 ± 38.09	< 0.0001	48.06	58.83
						Atherosclerosis	7.86 ± 6.94	8.02 ± 7.47	0.6	88.24	102.59
						Chronic ischemic heart disease, unspecified	6.01 ± 13.44	6.61 ± 15.98	0.2	223.75	265.71
						Atherosclerotic cardiovascular disease, so described	3.71 ± 5.98	3.98 ± 6.65	0.3	161.08	183.62
2	52.3± 33.72	53.84± 36.17	0.3	64.47	67.2	Acute myocardial infarction	23.59 ± 11.01	24.85 ± 10.92	0.1	46.69	48.36
						Other forms of acute ischemic heart disease	19.47 ± 26.17	19.78 ± 27.45	0.3	134.37	152.61
						Recurrent myocardial infarction	7.19 ± 5.38	6.97 ± 5.97	0.7	74.89	94.18
						Sudden death, so described	2.05 ± 3.02	2.23 ± 3.53	0.4	147.73	174.25
3	51.69± 26.36	56.39± 29.34	0.006	50.99	52	Other heart diseases	27.06 ± 17.81	29.29 ± 15.85	0.9	65.79	59.55
						Alcoholic cardiomyopathy	12.38 ± 10.52	13.8 ± 15.54	0.026	84.94	107.94
						Cardiomyopathy, unspecified	5.38 ± 6.38	6.23 ± 7.61	0.06	118.45	134.23
						Myocardial degeneration	2.93 ± 7.33	3.52 ± 9.65	0.1	250.48	301.57
						Heart failure, unspecified	1.53 ± 3.52	1.2 ± 2.3	0.2	229.81	211.20
						Chronic rheumatic heart diseases	1.24 ± 0.67	1.2 ± 0.68	0.6	53.54	62.76
						Congenital malformations of the heart	0.85 ± 0.39	0.84 ± 0.39	0.8	45.69	51.27
						Other congenital malformations of the circulatory system	0.29 ± 0.23	0.26 ± 0.21	0.4	78.15	87.46
						Acute rheumatic fever	0.02 ± 0.04	0.02 ± 0.02	0.5	203.99	217.25
4	12.34± 15.14	13.64± 17.04	0.2	122.7	124.9	Hypertensive heart disease	8.79 ± 11.94	10.11 ± 15.18	0.7	135.81	165.05
						Hypertensive heart and renal disease	1.87 ± 5.16	1.71 ± 2.79	0.06	276.4	180.05
						Hypertensive encephalopathy	1.11 ± 1.84	1.17 ± 1.73	0.2	165.86	162.16
						Hypertensive renal disease	0.33 ± 0.51	0.41 ± 0.69	0.6	154.25	187.42
						Other forms of hypertension	0.24 ± 0.42	0.23 ± 0.45	0.8	173	212.19
Total	301.02± 77.67	336.15± 84.5	< 0.0001	25.8	25.1	–	–	–	–	–	–

BNCD, Brief Nomenclature of the Causes of Death

increase by 6.57 per 100 thousand people in St. Petersburg (–7.04% and +13.79%, respectively).

The percentage of the Group 4 (AH) causes in the cardiovascular SDRs reached 4.2±5.2% in 2019 and 4.3±5.4% in 2020. The mean regional SDRs increased by 1.29±9.57 per 100 thousand people (17.5±47.1%) in 2020 compared to 2019. The increase was noted in 49 regions (maximum in the Chechen Republic), the decrease – in 33 regions (maximum in the Karachay-Cherkess Republic). SDRs increased by 0.78 per 100 thousand people in Moscow and 0.69 per 100 thousand people in St. Petersburg (8.76% and 22.28%, respectively).

Table 3. Changes in mortality in the regions (beginning)

Regions	Group 1 "Atherosclerosis"	Group 2 "Acute cardiovascular death"	Group 3 "Other heart diseases"	Group 4 "AH"	Group 1 "Atherosclerosis"	Group 2 "Acute cardiovascular death"	Group 3 "Other heart diseases"	Group 4 "AH"
	2019				2020			
Altai Krai	156,292	138,246	18,085	7,012	214,798	144,549	20,915	4,774
Amur Oblast	192,862	42,830	63,302	3,173	190,857	51,184	73,765	7,332
Arkhangelsk Oblast	252,351	66,092	56,217	5,545	261,263	65,964	52,895	4,594
Astrakhan Oblast	218,431	29,685	48,012	0,544	263,826	28,115	53,398	0,257
Belgorod Oblast	280,247	27,199	47,231	3,206	298,038	31,228	27,429	2,984
Bryansk Oblast	144,984	53,891	64,067	17,860	160,025	51,990	61,337	14,518
Vladimir Oblast	241,619	48,849	31,095	6,245	300,540	43,139	41,872	7,968
Volgograd Oblast	173,918	72,501	55,371	1,176	231,362	86,014	67,506	1,693
Vologda Oblast	220,875	69,940	48,433	8,951	238,813	72,764	50,479	9,690
Voronezh Oblast	112,404	92,972	37,888	2,501	140,660	84,827	46,377	1,925
Jewish Autonomous Oblast	337,502	71,697	75,954	14,132	369,271	67,405	109,156	21,706
Zabaykalsky Krai	192,255	100,665	52,032	8,666	204,538	98,494	69,928	12,775
Ivanovo Oblast	121,262	21,671	74,849	1,682	126,901	22,754	78,688	1,519
Irkutsk Oblast	185,870	76,071	176,809	7,252	132,115	71,935	226,111	5,954
Kabardino-Balkarian Republic	102,419	25,175	28,753	24,525	115,488	19,586	52,165	42,596
Kaliningrad Oblast	196,922	22,671	55,691	3,847	225,175	19,946	60,176	7,514
Kaluga Oblast	219,697	52,304	51,643	4,627	220,611	54,486	45,030	4,913
Kamchatka Oblast	231,805	73,618	75,515	41,839	246,740	78,087	56,630	51,328
Karachay-Cherkess Republic	90,639	34,851	35,183	71,959	92,423	56,923	36,573	51,787
Kemerovo Oblast	170,628	75,945	55,477	12,243	208,514	107,924	56,865	20,379
Kirov Oblast	198,871	31,799	48,362	1,092	219,116	33,961	21,501	1,994
Kostroma Oblast	225,620	84,96 7	29,229	15,371	271,339	86,640	35,872	12,460
Krasnodar Krai	151,333	28,824	51,790	3,855	172,537	32,294	58,254	4,772
Krasnoyarsk Krai	109,640	222,165	18,544	10,300	135,179	226,134	22,183	12,691
Kurgan Oblast	122,934	29,292	49,830	32,220	132,941	25,840	60,247	38,222
Kursk Oblast	208,626	41,185	31,310	8,230	231,969	55,258	46,003	12,262
Leningrad Oblast	162,400	24,170	21,979	12,990	193,122	18,623	33,062	13,179
Lipetsk Oblast	199,846	27,083	22,474	4,041	293,596	31,116	36,247	3,436
Magadan Oblast	141,716	117,807	71,143	14,596	167,569	101,979	92,069	23,789
Moscow	110,613	22,277	29,182	8,872	122,812	24,735	27,128	9,648
Moscow Oblast	168,163	50,316	23,865	5,940	181,674	54,964	27,435	7,308
Murmansk Oblast	252,275	39,182	57,112	4,756	261,178	42,474	62,811	6,963
Nizhniy Novgorod Oblast	238,001	28,113	56,519	18,806	252,429	30,788	61,094	22,023
Novgorod Oblast	233,263	51,411	88,702	9,385	280,347	48,054	108,049	6,363
Novosibirsk Oblast	278,503	36,606	31,178	3,608	355,185	36,274	40,499	3,808
Omsk Oblast	156,493	45,071	40,996	8,301	202,112	44,655	38,779	7,242
Orenburg Oblast	199,930	47,258	61,005	13,729	253,336	49,754	83,341	15,454
Orel Oblast	265,931	51,426	82,244	31,537	345,666	47,441	86,825	24,124
Penza Oblast	281,294	25,288	18,919	0,137	341,364	30,272	29,586	0,123
Perm Oblast	225,041	35,714	50,687	3,008	279,118	34,826	49,543	3,657
Primorsky Krai	184,784	101,580	63,628	16,897	207,247	115,301	73,680	15,971

The increase in SDRs for all four groups of causes was observed in the following regions: the Republic of Dagestan, the Republic of Kalmykia, the Republic of Adygea, the Republic of Bashkortostan, Rostov Oblast, Vologda Oblast, Smolensk Oblast, Chelyabinsk Oblast, Orenburg Oblast, Nizhny Novgorod Oblast, Sverdlovsk Oblast, Tver Oblast, Moscow Oblast, Yaroslavl Oblast, Tomsk Oblast, Volgograd Oblast, Murmansk Oblast, Kursk Oblast, Kemerovo Oblast, Ryazan Oblast, Amur Oblast, Tula Oblast, St. Petersburg, Krasnoyarsk Krai, and Krasnodar Krai (Table 3, see Appendix in the journal website). However, some SDRs decreased and others increased even in these regions. For example, in St. Petersburg, there was a decrease in SDRs for such causes as atherosclerosis, other chronic forms of IHD, hypertensive heart and renal disease, unspecified cardiomyopathy, and unspecified HF.

ISSN 0022-9040. Kardiologiia. 2022;62(10). DOI: 10.18087/cardio.2022.10.n1926

Table 3. Changes in mortality in the regions (ending)

Regions	Group 1 "Atherosclerosis"	Group 2 "Acute cardiovascular death"	Group 3 "Other heart diseases"	Group 4 "AH"	Group 1 "Atherosclerosis"	Group 2 "Acute cardiovascular death"	Group 3 "Other heart diseases"	Group 4 "AH"
	2019				2020			
Pskov Oblast	414,377	51,941	27,636	4,759	491,755	58,736	25,901	4,584
Republic of Adygea (Adygea)	142,792	39,335	62,061	28,024	150,766	44,373	74,079	35,243
Altai Republic	180,551	47,866	76,195	16,517	202,912	52,537	62,366	18,597
Republic of Bashkortostan	105,694	60,074	38,798	6,136	128,576	60,801	48,027	12,265
Republic of Buryatia	184,417	43,836	31,278	0,872	176,454	44,169	33,783	1,508
Republic of Dagestan	141,729	14,197	27,710	6,255	162,873	14,342	39,896	6,420
Republic of Ingushetia	12,133	38,885	51,316	22,825	25,183	28,354	38,453	18,775
Republic of Kalmykia	163,002	24,373	43,803	1,730	179,240	24,946	50,683	2,195
Republic of Karelia	143,856	106,422	49,256	24,676	135,067	123,485	64,391	15,885
Komi Republic	189,492	38,627	36,581	15,370	206,604	44,493	39,605	12,197
Republic of Crimea	321,772	23,019	64,343	1,674	351,457	25,001	64,543	1,448
Republic of Mari El	153,178	20,882	47,616	3,454	176,255	20,047	61,306	3,235
Republic of Mordovia	122,119	16,097	46,534	7,058	132,180	14,030	54,399	9,109
Republic of Sakha (Yakutia)	188,670	43,092	93,487	24,118	204,141	41,269	111,488	22,982
Republic of North Ossetia-Alania	152,056	41,314	41,863	62,381	167,613	51,312	33,829	48,490
Republic of Tatarstan (Tatarstan)	138,982	33,282	39,770	22,154	181,449	26,354	55,806	23,086
Republic of Tuva	215,277	103,944	58,230	3,481	213,450	150,519	62,889	2,536
Republic of Khakassia	182,644	128,956	36,115	18,259	202,897	133,641	41,315	10,923
Rostov Oblast	224,731	39,628	42,192	18,384	256,966	40,305	45,546	19,692
Ryazan Oblast	83,229	83,637	39,748	1,088	116,063	112,557	46,197	1,831
Samara Oblast	151,951	22,757	20,437	1,095	215,060	26,055	18,502	1,919
Saint Petersburg	203,848	34,654	47,652	2,665	232,292	36,308	54,223	3,259
Saratov Oblast	231,478	45,334	17,428	1,062	301,141	44,333	13,449	1,687
Sakhalin Oblast	66,271	55,479	33,107	4,458	64,470	48,622	32,136	2,806
Sverdlovsk Oblast	208,718	46,984	60,973	1,394	249,004	50,512	70,239	1,660
Sevastopol	176,913	31,026	50,179	30,888	179,984	29,547	36,073	34,560
Smolensk Oblast	273,025	36,727	55,940	2,218	286,813	38,010	61,708	2,415
Stavropol Krai	198,398	43,625	49,574	3,371	179,900	48,105	60,921	3,189
Tambov Oblast	177,833	24,539	52,726	3,558	216,609	23,814	64,051	3,996
Tver Oblast	160,685	50,121	74,022	10,782	173,666	58,877	82,000	12,867
Tomsk Oblast	172,954	75,129	30,256	3,953	207,648	81,515	30,978	5,358
Tula Oblast	177,069	22,949	59,635	0,539	184,721	23,676	66,180	1,310
Tyumen Oblast	238,427	28,530	43,583	7,767	258,152	31,408	49,702	7,189
Udmurt Republic	195,505	29,183	50,542	4,117	233,903	21,311	65,211	5,944
Ulyanovsk Oblast	155,902	67,313	37,614	4,322	182,255	71,336	38,145	2,809
Khabarovsk Krai	252,629	63,529	68,132	8,224	257,650	60,470	73,719	7,071
Chelyabinsk Oblast	188,286	55,582	54,490	24,567	222,226	62,023	54,624	27,610
Chechen Republic	42,012	26,462	158,056	29,048	159,200	17,287	67,775	103,986
Chuvash Republic	107,684	29,806	53,202	4,529	140,658	32,066	56,511	3,953
Chukotka Autonomous Okrug	210,929	121,611	124,615	85,129	303,200	24,084	141,589	72,405
Yaroslavl Oblast	134,835	39,363	41,926	14,531	155,365	45,822	49,839	19,496

In the Moscow region, there was a decrease in SDRs for such causes as atherosclerosis, recurrent MI, hypertensive encephalopathy, hypertensive disease with renal failure, other forms of hypertension, congenital malformations of heart, unspecified cardiomyopathy, myocardial degeneration, chronic rheumatic heart disease, and unspecified HF.

Changes in the mortality even from acute MI differs in the regions (Table 3, see Appendix in the journal website). There was a decrease in SDRs in 24 regions (Chukotka Autonomous Okrug, Magadan Oblast, Kamchatka Oblast, Leningrad Oblast, Vladimir Oblast, Orel Oblast, Belgorod Oblast, Kurgan Oblast, Novosibirsk Oblast, Jewish Autonomous Okrug, Vologda Oblast, Saratov Oblast, Tambov Oblast, Voronezh Oblast, Stavropol Krai, the Republics of Karelia, Tatarstan, Mordovia, Kalmykia, Yakutia, Mari El, Dagestan, Udmurtia, and the Kabardino-Balkarian Republic).

Statistically significant differences in the mean regional SDRs values were identified for three causes between 2019 and 2020: other chronic forms of IHD (a decrease in 15 regions, an increase in the other regions), atherosclerotic heart disease (a decrease in 38 regions, an increase in the other regions), and alcoholic cardiomyopathy (a decrease in 28 regions, an increase in the other regions).

Generally, CV for all cardiovascular causes and the Group 4 causes changed insignificantly (Table 2), but there were significant changes in CV for the causes provided in the BNCD in separate lines. CV increased for all causes, except for three lines of the BNCD (hypertensive encephalopathy, unspecified HF, and other heart diseases). The highest values of CV (more than 100) were observed for the following causes: acute rheumatic fever, myocardial degeneration, HF of unspecified origin, chronic IHD unspecified, atherosclerotic cardiovascular disease, other acute IHDs, cardiomyopathy unspecified, and for all Group 4 causes (associated with AH).

Discussion

Several publications discussing the impact of the COVID-19 pandemic on society as a whole, the health system, and mortality rates highlighted an increase in both all-cause and cardiovascular mortality. According to the researchers, the increase in mortality from CVDs listed as PCDs indicates delayed seeking emergency care due to fear of contracting COVID-19 in the hospital, due to cutdown routine care for lack of resources and the conversion of beds, a restrictive policies of visiting hospitals and caring for family members in the hospital, and, probably in some cases, due to undiagnosing COVID-19 [6]. Chin and Dongshan Zhu et al. [7, 8] analyzed the changes in mortality and noted that researchers from different countries did not have so far a clear understanding of whether increased mortality from cardiovascular (and other) diseases reflected the true increase in mortality from these causes or whether such changes were associated with inadequate coding of deaths associated with COVID-19. In our opinion, the variety of regional trends in mortality rates from individual cardiovascular causes and all cardiovascular causes in general (a decrease rather than an increase was identified in 9 regions), indicates precisely the problems with determining the logical sequence of the development of diseases and conditions that result in patient's death, the problems of isolating and coding of a disease as the only cause of death in the presence of several life-threatening diseases and conditions. Wu et al. [6] showed based on the analysis of MDCs that the most common cause of sudden cardiovascular death during the pandemic was stroke (35.6%), acute coronary syndrome (ACS) (24.5%), HF (23.4%), pulmonary embolism (9.3%), and cardiac arrest (4.6%). At the same time, HF and ACS cannot be the primary cause of death, since the former is a complication of cardiovascular disease or a mechanism of death, and the latter is a temporary (not final) diagnosis [4, 5]. Experts disagree about whether thromboembolism is the primary cause of death or a complication of the underlying diagnosis. In a recent study, Timonin et al. [10] compared the mortality from MI in Russia and Norway. In Russia, MI is reported in only 12% of MDCs, in which IHD codes were indicated as the main (primary) cause of death, and in 63% MDCs in Norway. Death due to IHD occurring outside the hospital were classified without autopsy as MI in Russia (2%) much less frequently than in Norway (59%). The authors note, as we did in our previous papers, that despite the international MI criteria (the third and fourth universal definitions), experts filling in MDCs in different countries can interpret these criteria in different ways [1–3]. Moreover, the international criteria for the diagnosis of MI are difficult to use in case of death outside the hospital (at the same time, in the study by Wu et al., most cardiovascular deaths, which were classified in that study as sudden and excessive in relation to the previous periods, occurred at home, in the hospice or nursing homes) [6]. According to Timonin et al. [10], in Russia, there is likely a low percentage of false positive cases (coding a death as caused by MI in its absence), but a higher percentage of false negative cases (MI is not indicated in the case of death outside the hospital and a lack of confirmation in the autopsy). The exact opposite is true in Norway. The authors raise the question whether the efforts of the expert groups to develop formal criteria for causes of death are sufficient to compare rates of death from individual causes based on the MDC data by countries. This issue is particularly relevant during the pandemic. Given the significant variability of the mean regional SDRs from MI (not only in magnitude, but also in the upward or downward direction of changes in the indicators), it can be assumed that experts filling in MDCs are not always sure what was the primary (main) cause of death, whether COVID-19 or acute MI.

The same can be said for death in the presence of chronic cardiovascular diseases. The uncertainty of the criteria is likely to play an even greater role in defining chronic forms of IHD as PCDs. Our study, as a study conducted in New Zealand [11], showed that the significant variability in the percentage of deaths from IHD was probably related to the criteria for diagnosing chronic forms of IHD and approaches to determining PCDs [12]. In Russia and other countries, there are no the WHO-level criteria for establishing atherosclerosis or atherosclerotic

ISSN 0022-9040. Kardiologiia. 2022;62(10). DOI: 10.18087/cardio.2022.10.n1926

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cardiovascular disease (with varying terminology) as PCD. In our study, a statistically significant increase in the mean regional SDRs for such uncertain causes as "other forms of chronic IHD" and "atherosclerotic heart disease" is consistent with the findings by Zhu et al. [8] in the absence of a statistically significant increase in the SDRs from MI. The authors note that it was very difficult to determine the PCD during the pandemic in most cases of deaths that occurred at home or in the nursing homes, including in case of hospital congestion, lack of health care professionals, fear of seeking medical care, delayed elective care, and a part of the deaths from COVID-19 (according to the authors) remained unrecognized.

Particular attention (in terms of the organization of medical care and prevention of premature death) should be paid to diseases and conditions constituting Group 3 of causes of death – mean regional SDRs and their contribution to cardiovascular mortality left behind the contribution and value of SDRs from acute forms of IHD (an increase in SDRs from alcoholic cardiomyopathy was statistically significant unlike other acute forms of IHD and other causes). In 2020, mortality from alcoholic cardiomyopathy exceeded mortality from acute MI (code I21) in the Chukotka Autonomous Okrug (14-fold), the Udmurt Republic (2.8-fold), the Republics of Karelia, Buryatia, and Yakutia (1.3-fold), Voronezh Oblast, Kaliningrad Oblast, and Novgorod Oblast (1.3-fold). In 2020, SDRs from the Group 3 causes exceeded SDRs from the Group 2 causes in more than half of the regions (46-fold). Attention currently paid to the Group 3 causes (Table 1) is not sufficient, since almost all measures are aimed at the prevention and treatment of atherosclerotic CVDs.

The problems of correct statistics of causes of death from individual causes and groups of diseases have been discussed many times in the past few years [1–5, 9]. However, the situation of determining PCDs and coding of causes of death has not significantly changed so far. Our and other findings show that the COVID-19 pandemic has only exacerbated the existing problems. For example, it is not possible to analyze the contribution of COVID-19 to cardiovascular mortality (Rosstat provides the possibility to obtain information only according to PCDs). But even in the countries where data on multiple causes of death (i.e., complications, causes contributing to death) are recorded and analyzed, researchers note the problems of such analysis related to the lack of clear criteria for determining PCDs and indicate that assessment of excess all-cause mortality remains the best way to evaluate the effects of COVID-19 [13, 14].

Conclusion

Significant regional differences in the standardized mortality rates from individual cardiovascular causes and their changes were identified. Despite the increase in the mean regional standardized death rates from all cardiovascular causes, variety of trends in standardized death rates from individual cardiovascular causes are observed in several regions. Our findings show that more than half of the deaths both in 2019 and in 2020 are due to chronic diseases associated with atherosclerosis. However, a more pronounced increase compared to acute forms of ischemic heart disease is noted in the group of causes associated with cardiomyopathy, myocarditis, and heart defects. The lack of standardized criteria and approaches to determining the main cause of death taking into consideration several diseases when death occurs in a multimorbid setting both before COVID-19 and during the pandemic, requires attention to solve this issue.

Funding

No funding was received for this study.

No conflict of interest is reported.

The article was received on 20/11/2021

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Клиническая, морфологическая и статистическая классификация ишемической болезни сердца. Консенсус Российского кардиологического общества, Российского общества патологоанатомов и специалистов по медицинской статистике. Доступно на: https://scardio.ru/content/Guidelines/Klass_IBS_2020.pdf]

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