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LEADING CAUSES OF DEATH IN KAZAKHSTAN BEFORE AND DURING THE COVID-19 PANDEMIC: A POPULATION-BASED STUDY

Resume: *Changes in the leading causes of death inevitably occur during global pandemics, such as COVID-19. We aimed to examine the dynamics and structure of deaths and characteristics of survival among the population of the Republic of Kazakhstan before and during the COVID-19 pandemic.*
Methods. *Data on 248,494 deaths retrieved from the population register of the Republic of Kazakhstan during the years 2019 and 2020 were analyzed to examine the structure and dynamics of deaths by gender, place, and cause of death. Survival analysis was performed using the Kaplan-Meier method.*
Results. *The number of deaths among the Kazakhstani population in 2020 increased 1.32-fold compared with 2019. This increase was due to an increase in infectious mortality and an increase in deaths from common comorbidities of COVID-19: circulatory diseases, respiratory diseases, and diseases of the nervous system. A greater increase in male deaths and out-of-hospital mortality (at home and elsewhere) was also observed. We also observed a significant ($p \leq 0.001$) shift in the median survival time in males and females from 2019 to 2020. The probability of death for males and females increased in the 40-50 and 80-90 years age groups. The male population was characterized by lower survival rates for all causes of death (except for deaths from malignant neoplasms and infectious diseases) compared with the female population.*
Conclusions. *The COVID-19 pandemic precipitated changes in the survival rate by gender, leading cause of death, and place of death among the Republic of Kazakhstan population. This knowledge will help develop differentiated measures to improve the health of the population of Kazakhstan.*
Keywords: *COVID-19, death rate, survival rate, population study, Republic of Kazakhstan, survival analysis*

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ҚАЗАҚСТАНДА COVID-19 ПАНДЕМИЯСЫНА ДЕЙІН ЖӘНЕ КЕЗІНДЕГІ ӨЛІМ-ӨЛІМДЕРДІҢ НЕГІЗГІ СЕБЕПТЕРІ: ХАЛЫҚТЫ ЗЕРТТЕУ

Түйін: Өлімнің жетекші себептерінің өзгеруі міндетті түрде COVID-19 сияқты жаһандық пандемия кезінде болады. Біздің мақсатымыз COVID-19 пандемиясына дейінгі және оның кезеңінде өлім-жітімнің динамикасы мен құрылымын және Қазақстан Республикасы халқының өмір сүру ерекшеліктерін зерттеу болды.
Әдістері. Жынысы, өлген жері мен себебі бойынша өлім-жітімнің құрылымы мен динамикасын зерделеу үшін 2019 және 2020 жылдардағы Қазақстан Республикасының халық тізілімінен алынған 248 494 өлім туралы деректер талданды. Тірі қалу талдауы Каплан-Майер әдісімен жүргізілді.
Нәтижелер. 2020 жылы Қазақстан халқы арасындағы өлім-жітім 2019 жылмен салыстырғанда 1,32 есеге өсті. Бұл өсім жұқпалы өлім-жітімнің артуы және COVID-19 жиі кездесетін қатар жүретін аурулар: қан айналымы жүйесі аурулары, тыныс алу органдары-

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ОСНОВНЫЕ ПРИЧИНЫ СМЕРТИ В КАЗАХСТАНЕ ДО И ВО ВРЕМЯ ПАНДЕМИИ COVID-19: ПОПУЛЯЦИОННОЕ ИССЛЕДОВАНИЕ

Резюме: Изменения основных причин смерти неизбежно происходят во время глобальных пандемий, таких как COVID-19. Нашей целью было изучить динамику и структуру смертельных исходов и особенности выживания населения Республики Казахстан до и во время пандемии COVID-19.
Методы. Для изучения структуры и динамики смертности по полу, месту и причине смерти были проанализированы данные о 248 494 случаях смерти, полученные из регистра населения Республики Казахстан за 2019 и 2020 годы. Анализ выживаемости проводили с использованием метода Каплана-Мейера.
Результаты. Количество случаев смерти среди казахстанского населения в 2020 г. увеличилось в 1.32 раза по отношению к 2019 г. Это увеличение произошло за счет роста инфекцион-

ның ауруларынан болатын өлім-жітімнің артуы есебінен болды. , тыныс алу органдарының аурулары , жүйке жүйесінің аурулары. Сондай-ақ ерлер өлімінің және қоғамнан алынған өлімнің (үйде және басқа жерлерде) айтарлықтай өсуі байқалды. Біз сондай-ақ 2019 жылдан 2020 жылға дейін ерлер мен әйелдердің орташа өмір сүру уақытының айтарлықтай (p ≤ 0,001) ауысуын байқадық. Ерлер мен әйелдердің өлім ықтималдығы 40-50 және 80-90 жас топтарында өсті. Ерлер популяциясы әйелдер популяциясымен салыстырғанда өлімнің барлық себептері бойынша (қатерлі ісіктер мен жұқпалы аурулардан болатын өлімді қоспағанда) төмен өмір сүру деңгейімен сипатталды.

Қорытындылар. Динамика бойынша (өткен кезеңге қатысты COVID-19 пандемиясы кезінде) Қазақстан Республикасы халқының өлімі мен тірі қалу себептерінің құрылымы өзгерді деген қорытынды жасауға болады. Сонымен қатар, тірі қалу жынысына, сондай-ақ негізгі себепке (ICD-10) және өлім орнына байланысты айтарлықтай өзгереді.

Бұл білім Қазақстан халқының денсаулығын жақсарту бойынша сараланған шараларды әзірлеуде пайдалы болуы мүмкін.

Түйінді сөздер: COVID-19, өлім, өмір сүру, халықты зерттеу, Қазақстан Республикасы, өмір сүру талдауы.

ной смертности и роста смертности от общих сопутствующих заболеваний COVID-19: болезней системы кровообращения, болезней органов дыхания, болезней органов дыхания, болезней нервной системы. Также наблюдалось большее увеличение смертности мужчин и внебольничной смертности (дома и в других местах). Мы также наблюдали достоверный (p ≤ 0,001) сдвиг медианного времени выживания мужчин и женщин с 2019 по 2020 год. Вероятность смерти мужчин и женщин увеличивалась в возрастных группах 40-50 и 80-90 лет. Мужское население характеризовалось более низкими показателями выживаемости по всем причинам смерти (кроме случаев смерти от злокачественных новообразований и инфекционных заболеваний) по сравнению с женским населением.

Выводы. Основной вывод, который можно сделать, заключается в том, что в динамике (в период пандемии COVID-19 по отношению к предыдущему периоду), изменилась структура причин смерти и выживаемости среди населения Республики Казахстан. При этом, выживаемость существенно различается по признаку пола, а также по основной причине (МКБ-10) и месту смерти. Данные знания могут быть полезны при разработке дифференцированных мероприятий по оздоровлению населения Казахстана.

Ключевые слова: COVID-19, смертность, выживаемость, популяционное исследование, Республика Казахстан, анализ выживаемости.

Introduction. Understanding medical and demographic processes is important for determining population indicators and planning the long-term production of material resources (1, 2, 3, 4). Determining death and survival rates helps health researchers to identify vulnerable groups in the population and assess the quality of medical care (5, 6, 7, 8). In the context of the current COVID-19 pandemic, differences in deaths and survival rates between different groups of the population serve as criteria for the risk of death from the disease, which must be considered when making management decisions on the allocation of medical and non-medical resources (9, 10, 11, 12).

Over the past decade, cardiovascular diseases, cancer, and diseases of the digestive system were the leading causes of death in the Kazakhstani population (13). With the spread of COVID-19 in Kazakhstan since March 2020, the infectious mortality rate has increased. According to data from the Kazakh official register of deaths “Deaths Certifying Register” as of December 2021, the frequency of death from a confirmed COVID-19 infection was >12,500 cases in the Republic of Kazakhstan (14). At the same time, the incidence of disease was >1 million. These statistics vary depending on the source (15).

Much research has been conducted to assess mortality and population survival rates in different countries during the COVID-19 pandemic (16, 17, 18, 19, 20). Most studies have found that the excess mortality increased dramatically with age, and men were at increased risk of death in all age groups. Life expectancy at birth decreased by 0.9 and 1.2 years for women and men, respectively, compared to 2019 levels. Studies comparing COVID-19 with premature mortality caused by three other global common causes of death: cardiovascular diseases, road accidents, and seasonal influenza also exist. Statistical data on the indicators of morbidity, recovery, and the number of deaths from COVID-19 by region and life expectancy can be found in Kazakhstani scientific publications. However, few have assessed the structure and dynamics of death and survival rates among the Kazakhstani population in the context of the current pandemic. This knowledge gap makes it difficult to carry out targeted activities with effective management decisions in the field of public health. We thus aimed to study the characteristics of the structure and dynamics of deaths and survival rates among the population of the Republic of Kazakhstan before and during the COVID-19 pandemic.

Materials and Methods. This was a retrospective study using descriptive and analytical statistics. Data were retrieved from the official register ("Register of attached population") of the Republic of Kazakhstan on fatalities ("Register of death certificates") for 2019 and 2020. A total of 248,494 deaths were analyzed (continuous observation, population data).

The structure and dynamics of deaths among the Kazakhstani population were studied. The frequency of deaths was analyzed by gender, age, nosological forms [according to the International Classification of Diseases – 10th Revision (ICD-10)], and the place of death. Also, the fre-

quency of deaths among the younger population of Kazakhstan was examined. The specific gravity and standard error of the mean were calculated.

Survival analysis was performed using the Kaplan-Meier method. Survival plots were drawn, and the mean and median survival times, the proportion of survivors, and the survivorship function were calculated. The temporary variable was age (age-related survival). All deaths were uncensored. Differences in the survival rate depending on the year of death (2019 and 2020), gender, age (in 10-year intervals), nosological forms (according to ICD-10), and place of death (hospital, home, or elsewhere) were analyzed. Comparative analysis was carried out using the Wilcoxon test (Gehan) and the log-rank test. The null hypothesis (no difference) was rejected if $p < 0.05$. Microsoft Excel and the SPSS Statistics package (IBM) were used for statistical processing.

Results. In 2019, there were 107,314 deaths due to all causes among the population of the Republic of Kazakhstan. In 2020, there were 141,180 deaths, representing a 1.32-fold increase compared with 2019. The absolute increase in deaths in 2020 was 33,866; an increase of x % (Table 1). When segregating the data by sex, we found that the frequency of male deaths was 55,415 (51.6 ± 0.15%) in 2019 and 73,648 (52.2 ± 0.15%) in 2020, representing a 1.33-fold increase. Similarly, the frequency of female deaths was 51,899 (48.4 ± 0.15%) in 2019 and 67,532 (47.8 ± 0.15%) in 2020, representing a 1.30-fold increase.

Compared with 2019, in 2020, the number of deaths recorded both in the hospital and at home increased by 1.71-fold and 1.21-fold, respectively. The main cause of death in Kazakhstan in 2020 was due to circulatory diseases (7,593), respiratory diseases (6,803), and diseases of the nervous system (6,083). Compared with 2019, there was an increase in the number of deaths from respiratory diseases (1.48-fold), unspecified diseases/symptoms (1.42-fold), circulatory diseases (1.34-fold), diseases of the nervous system (1.33-fold), and diseases of the endocrine system, and digestive and metabolic disorders (1.32-fold) in 2020.

Deaths among the younger population of Kazakhstan were also analyzed. In 2020, the number of deaths in the 14-29 years age group was 2,170 (1,453 males and 717 fe-

Table 1 - Frequency of deaths among the population of Kazakhstan during the years 2019 and 2020 (total, by gender, place of death, and the leading causes of death)

	Year		Absolute increase in deaths
	2019	2020	
Total number of deaths	107314	141180	+33866
Gender			
Male	55415	73648	+18233
Female	51899	67532	+15633
Place of death			
Hospital	22752	38865	+16113
Home	75375	91307	+15932
Elsewhere	9187	11008	+1821
Leading causes of death (ICD-10 code)			
Diseases of the circulatory system (I00-I99)	22087	29680	+7593
Inflammatory diseases of the central nervous system (G00-G99)	18255	24338	+6083
Acute upper respiratory infections (J00-J99)	14099	20902	+6803
Malignant neoplasms (C00-C97)	13214	13425	+211
Other diseases of the digestive system (K00-K93)	10085	11814	+1729
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99)	7125	10114	+2989
Endocrine, nutritional and metabolic diseases (E00-E90)	4630	6106	+1476
Diseases of the genitourinary system (N00-N99)	4503	5233	+730
Injury, poisoning and some other consequences of external causes (T00-T98)	4051	4783	+732
Provisional assignment of new diseases of uncertain etiology or emergency use, Resistance to antimicrobial and antineoplastic drugs (U00-U85)	0	3440	+3440
Injuries, poisoning and certain other consequences of external causes (S00-S99)	1843	2177	+334
Mental and behavioral disorders (F00-F99)	2147	2088	-59
Diseases of the musculoskeletal system and connective tissue (M00-M99)	1481	1587	+106
Certain infectious and parasitic diseases (B00-B99)	401	1568	+1167
Other diseases	3393	3925	+532

males), whereas, in 2019, there were 1,886 deaths (1,281 males and 605 females). The leading causes of death were injuries, poisoning, and other consequences of external causes (46.2 ± 1.15% or 871 cases in 2019 and 45.8 ± 1.07% or 994 cases in 2020), malignant neoplasms (10.7 ± 0.71% or 201 cases in 2019 and 8.8 ± 0.61% or 192 cases in 2020), diseases of the nervous system (8.4 ± 0.64% or 158 cases in 2019 and 6.9 ± 0.54% or 149 cases in 2020), and circulatory diseases (7.3 ± 0.60% or 138 cases in 2019 and 8.2 ± 0.59% or 178 cases in 2020).

We next determined the average survival rates (Table 2). After analyzing the statistical data, we found that the average survival time in the Kazakhstani population did not markedly increase between 2019 and 2020: 67.0 years (CI 95% 66.9 ÷ 67.1) versus 66.7 years (CI 95% 66.6 ÷ 66.8), respectively (W = 1.532, df = 1, p = 0.216).

The dynamics of the average survival rates were next studied separately for males and females. Compared with 2019, in 2020, the average and median survival times increased in the male population but decreased in the female population. These differences were statistically significant (W = 26.910, df = 1, p ≤ 0.001 for males; W = 36.446, df = 1, p ≤ 0.001 for females). Consistently, the median survival time in the female population was significantly higher compared with the male population (W = 8470.366, df = 1, p ≤ 0.001 for 2019; W = 9441.914, df = 1, p ≤ 0.001 for 2020).

Compared with 2019, in 2020, the median survival time increased significantly for deaths in the hospital (W = 261.383, df = 1, p ≤ 0.001) and decreased slightly for deaths at home (W = 0.189, df = 1, p = 0.663).

We next looked at median survival time. We found that in the period 2019-2020, there was a significant shift in the median survival time for respiratory diseases (W = 219.400, df = 1, p ≤ 0.001), malignant neoplasms (W = 3.742, df = 1, p = 0.053), diseases of the digestive system (W = 10.849, df = 1, p ≤ 0.001), unspecified diseases/ symptoms (W = 24.232, df = 1, p ≤ 0.001), diseases

Table 2 - Average and median survival times for the population of Kazakhstan in 2019 and 2020

	Year			
	2019		2020	
	Average survival (years) [CI]	Median survival (years) [CI]	Average survival (years) [CI]	Median survival (years) [CI]
Total for Kazakhstan	66.7 [66.6÷66.8]	70.0 [69.9÷70.1]	67.0 [66.9÷67.1]	70.0 [69.9÷70.1]
Gender				
Males	62.5 [62.3÷62.6]	65.0 [64.8÷65.2]	63.3 [63.2÷63.4]	66.0 [65.9÷66.1]
Females	71.2 [71.1÷71.4]	77.0 [76.8÷77.2]	71.1 [70.9÷71.2]	75.0 [74.8÷75.2]
Place of death				
Hospital	56.1 [55.8÷56.4]	62.0 [61.7÷62.3]	60.0 [59.8÷60.2]	64.0 [63.8÷64.2]
Home	71.6 [71.5÷71.7]	74.0 [73.8÷74.2]	71.6 [71.5÷71.7]	73.0 [72.8÷73.2]
Elsewhere	52.8 [52.4÷53.2]	54.0 [53.5÷54.5]	53.3 [52.9÷53.6]	54.0 [63.5÷54.5]
Leading causes of death (ICD-10 code)				
Diseases of the circulatory system (I00-I99)	66.7 [66.5÷66.9]	68.0 [67.8÷68.2]	66.6 [66.4÷66.7]	68.0 [67.8÷68.2]
Inflammatory diseases of the central nervous system (G00-G99)	74.3 [74.1÷74.5]	79.0 [78.9÷79.1]	74.8 [74.6÷75.0]	79.0 [78.8÷79.2]
Acute upper respiratory infections (J00-J99)	70.1 [69.8÷70.4]	73.0 [72.6÷73.4]	68.7 [68.5÷68.9]	70.0 [69.8÷70.2]
Malignant neoplasms (C00-C97)	62.1 [61.9÷62.3]	63.0 [62.8÷63.2]	61.9 [61.7÷62.2]	63.0 [62.8÷63.2]
Other diseases of the digestive system (K00-K93)	63.4 [63.1÷63.7]	64.0 [63.7÷64.3]	62.7 [62.4÷63.0]	64.0 [63.7÷64.3]
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99)	82.2 [81.8÷82.6]	87.0 [86.8÷87.2]	81.8 [81.5÷82.1]	86.0 [85.8÷86.2]
Endocrine, nutritional and metabolic diseases (E00-E90)	69.6 [69.3÷70.0]	71.0 [70.6÷71.4]	69.4 [69.1÷69.7]	70.0 [69.7÷70.3]
Diseases of the genitourinary system (N00-N99)	71.1 [70.7÷71.5]	73.0 [72.4÷73.6]	70.2 [69.9÷70.6]	72.0 [71.6÷72.4]
Injury, poisoning and some other consequences of external causes (T00-T98)	44.1 [43.5÷44.7]	44.0 [43.3÷44.7]	44.7 [44.2÷45.2]	45.0 [44.4÷45.6]
Provisional assignment of new diseases of uncertain etiology or emergency use, Resistance to antimicrobial and antineoplastic drugs (U00-U85)	-	-	66.9 [66.5÷67.3]	68.0 [67.5÷68.5]
Injuries, poisoning and certain other consequences of external causes (S00-S99)	45.6 [44.7÷46.5]	45.0 [43.7÷46.3]	44.6 [43.8÷45.4]	44.0 [43.0÷45.0]
Mental and behavioral disorders (F00-F99)	80.3 [79.8÷80.7]	82.0 [81.7÷82.3]	80.5 [80.0÷80.9]	82.0 [81.7÷82.3]
Diseases of the musculoskeletal system and connective tissue (M00-M99)	74.7 [74.0÷75.4]	78.0 [77.5÷78.5]	74.3 [73.6÷75.0]	78.0 [77.4÷78.6]
Certain infectious and parasitic diseases (B00-B99)	31.6 [29.6÷33.6]	38.0 [36.6÷39.4]	58.4 [57.4÷59.3]	61.0 [60.2÷61.8]

of the genitourinary system (W = 9.164, df = 1, p = 0.002), diseases of the endocrine system, eating disorders and metabolic disorders (W = 462.295, df = 1, p ≤ 0.001).
Having found the average survival time, we looked at the average survival rates taking into account gender and main causes of death for 2019 and 2020 (Table 3). We detected significant differences in the median survival times for males and females with: circulatory diseases (leading cause of death in males and second leading cause of death in females) (log-rank for 2019, χ 2 = 2009.619, df = 1, p ≤ 0.001; log-rank for 2020, χ 2 = 2320.555, df = 1, p ≤ 0.001); diseases of the nervous system (third leading cause of death in males and leading cause of death in females) (log-rank for 2019, χ 2 = 1405.046, df = 1, p ≤ 0.001; log-rank for 2020, χ 2 = 1801.158, df = 1, p ≤ 0.001; and respiratory diseases (second leading cause of death in males and third leading cause of death in females) (log-rank for 2019, χ 2 = 861.425, df = 1, p ≤ 0.001; log-rank for 2020, χ 2 = 604.781, df = 1, p ≤ 0.001).
We also found that the median survival times for all caus-

Table 3 - Average and median survival times of the population of Kazakhstan during 2019 and 2020

	Year			
	2019		2020	
	Average survival (years) [CI]	Median survival (years) [CI]	Average survival (years) [CI]	Median survival (years) [CI]
Leading causes of death in the male population (ICD-10 code)				
Diseases of the circulatory system (I00-I99)	63.3 [63.0÷63.5]	64.0 [63.7÷64.3]	63.4 [63.2÷63.6]	64.0 [63.8÷64.2]
Inflammatory diseases of the central nervous system (G00-G99)	69.7 [69.3÷70.1]	73.0 [72.5÷73.5]	70.9 [70.6÷71.2]	73.0 [72.7÷73.3]
Acute upper respiratory infections (J00-J99)	67.5 [67.2÷67.9]	70.0 [69.7÷70.3]	67.0 [66.8÷67.3]	69.0 [68.7÷69.3]
Malignant neoplasms (C00-C97)	62.2 [61.8÷62.5]	63.0 [62.7÷63.3]	62.3 [62.0÷62.6]	64.0 [63.7÷64.3]
Other diseases of the digestive system (K00-K93)	60.8 [60.4÷61.1]	62.0 [61.6÷62.4]	59.6 [59.3÷60.0]	61.0 [60.6÷61.4]
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99)	75.1 [74.3÷75.9]	83.0 [82.5÷83.5]	75.6 [75.0÷76.2]	83.0 [82.7÷83.3]
Endocrine, nutritional and metabolic diseases (E00-E90)	66.0 [65.3÷66.6]	68.0 [67.3÷68.7]	66.5 [66.0÷67.0]	68.0 [67.5÷68.5]
Diseases of the genitourinary system (N00-N99)	69.5 [68.9÷70.0]	71.0 [70.3÷71.7]	69.5 [69.0÷70.0]	71.0 [70.4÷71.6]
Injury, poisoning and some other consequences of external causes (T00-T98)	43.6 [43.0÷44.2]	43.0 [42.3÷43.7]	44.4 [43.9÷45.0]	45.0 [44.3÷45.7]
Provisional assignment of new diseases of uncertain etiology or emergency use, Resistance to antimicrobial and antineoplastic drugs (U00-U85)	-	-	66.3 [65.7÷66.8]	67.0 [66.4÷67.7]
Injuries, poisoning and certain other consequences of external causes (S00-S99)	43.6 [42.6÷44.5]	43.0 [41.6÷44.4]	43.1 [42.3÷43.9]	43.0 [42.0÷44.0]
Mental and behavioral disorders (F00-F99)	76.4 [75.5÷77.3]	80.0 [79.5÷80.5]	76.7 [75.8÷77.5]	80.0 [79.5÷80.5]
Diseases of the musculoskeletal system and connective tissue (M00-M99)	72.4 [71.2÷73.7]	76.0 [74.4÷77.6]	72.2 [71.0÷73.3]	75.0 [73.2÷76.8]
Certain infectious and parasitic diseases (B00-B99)	33.9 [31.6÷36.2]	39.0 [37.9÷40.1]	57.5 [56.3÷58.7]	60.0 [58.8÷61.2]
The main causes of death in the female population				
Diseases of the circulatory system (I00-I99)	71,2 [70.9÷71.5]	74,0 [73.5÷74.5]	70.8 [70.5÷71.0]	73.0 [72.7÷73.3]
Inflammatory diseases of the central nervous system (G00-G99)	77,6 [77.3÷77.8]	81,0 [80.8÷81.2]	77.7 [77.5÷78.0]	81.0 [80.9÷81.1]
Acute upper respiratory infections (J00-J99)	73,6 [73.2÷74.0]	78,0 [77.7÷78.3]	70.8 [70.5÷71.1]	73.0 [72.6÷73.4]
Malignant neoplasms (C00-C97)	62,0 [61.7÷62.4]	63,0 [62.6÷63.4]	61.5 [61.1÷61.8]	63.0 [62.6÷63.4]
Other diseases of the digestive system (K00-K93)	66,6 [66.1÷67.0]	68,0 [67.4÷68.6]	66.6 [66.2÷67.0]	68.0 [67.5÷68.5]
Symptoms, signs and abnormal clinical and laboratory findings, not elsewhere classified (R00-R99)	86,0 [85.7÷86.4]	88,0 [87.8÷88.2]	85.6 [85.3÷85.9]	87.0 [86.8÷87.2]
Endocrine, nutritional and metabolic diseases (E00-E90)	71,7 [71.3÷72.2]	73,0 [72.3÷73.7]	71.1 [70.8÷71.5]	72.0 [71.6÷72.4]
Diseases of the genitourinary system (N00-N99)	72,9 [72.3÷73.4]	76,0 [75.1÷76.9]	71.1 [70.6÷71.7]	73.0 [72.2÷73.8]
Injury, poisoning and some other consequences of external causes (T00-T98)	45,7 [44.3÷47.2]	47,0 [44.9÷49.1]	45.6 [44.3÷46.9]	46.0 [44.2÷47.8]
Provisional assignment of new diseases of uncertain etiology or emergency use, Resistance to antimicrobial and antineoplastic drugs (U00-U85)	-	-	67.6 [67.0÷68.2]	69.0 [68.3÷69.7]
Injuries, poisoning and certain other consequences of external causes (S00-S99)	52,2 [49.9÷54.5]	55,0 [51.6÷58.4]	49.6 [47.4÷51.8]	50.0 [46.8÷53.2]
Mental and behavioral disorders (F00-F99)	82,3 [81.8÷82.8]	83,0 [82.6÷83.4]	82.5 [82.0÷82.9]	83.0 [82.6÷83.4]
Diseases of the musculoskeletal system and connective tissue (M00-M99)	75,7 [74.9÷76.6]	80,0 [79.4÷80.6]	75.4 [74.5÷76.2]	80.0 [79.4÷80.6]
Certain infectious and parasitic diseases (B00-B99)	28,1 [24.4÷31.7]	33,0 [29.1÷36.9]	59.5 [58.0÷61.0]	63.0 [61.7÷64.3]

es of death were significantly shorter in the male population than in the female population, except for malignant neoplasms (ICD-10 codes C00-C97) and infectious and parasitic disease (ICD-10 codes B00-B99).

In our final analyses, we calculated the probabilities of survival (proportion of survivors and the cumulative survival function) for Almaty residents during the years 2019 and 2020 (Table 4). In both 2019 and 2020, the highest proportion of survivors was in the 10-20 years age group, and the lowest proportion of survivors was in the ≥90 years age group. In the male population, the number of survivors in the <10 years, 40-50 years, and 50-60 years age groups increased by 1%, and the number of survivors in the 70-80 years and 90-100 years age groups decreased by 1% in 2020 compared to 2019. In the female population, the number of survivors in the 50-60 years and 80-90 years age groups decreased by 1%, the number of survivors in the 60-70 years age group decreased by 2%, the number of survivors in the 100-110 years age group increased by 5% and the number of survivors in the 110-120 age group increased by 7% in 2020 compared to 2019.

The probability of survival in 2019 and 2020 was significantly less for males than for females in all age groups. When comparing the indicator, the proportion of survivors for 2020, the probability of survival in males was less than for women in the age groups: 30-40 years (by 3%), 40-50 years (by 4%), 50-60 years (by 9%), 60-70 years (by 18%) 70-80 years (by 18%), and 80-90 years (by 9%).

Calculation of the cumulative survival function showed that, in general, the cumulative survival rate in the male population increased by 1-2% over time. In the female population, the dynamics of survival were ambiguous; the survival rate increased by 1% in the 10 to 40 years age group and decreased by 1% in the 60 to 90 years age group.

Discussion. Numerous countries have reported that as a result of the COVID-19 pandemic, significant changes in population health, namely the leading causes of death, death rates, and survival rates, have occurred. Here, we aimed to examine these parameters among the popu-

Table 4 - Probabilities of survival for the population of Kazakhstan during the years 2019 and 2020 (in age intervals, by gender)

Gender	Age interval (years)	2019		2020	
		Proportion of survivors (probability that the event will not occur in the studied age range)	Survival function (probability of survival; cumulative proportion)	Proportion of survivors (probability that the event will not occur in the studied age range)	Survival function (probability of survival; cumulative proportion)
Male	0	0.97	0.97	0.98	0.98
	10	0.99	0.96	0.99	0.97
	20	0.98	0.94	0.98	0.96
	30	0.95	0.90	0.95	0.91
	40	0.90	0.81	0.91	0.82
	50	0.79	0.64	0.80	0.66
	60	0.59	0.38	0.59	0.39
	70	0.47	0.18	0.46	0.18
	80	0.14	0.02	0.14	0.02
	90	0.02	0.00	0.01	0.00
	100	0.00	0.00	0.00	0.00
Female	0	0.98	0.98	0.98	0.98
	10	1.00	0.97	1.00	0.98
	20	0.99	0.96	0.99	0.97
	30	0.98	0.94	0.98	0.95
	40	0.95	0.90	0.95	0.90
	50	0.90	0.81	0.89	0.81
	60	0.79	0.63	0.77	0.62
	70	0.64	0.40	0.64	0.39
	80	0.24	0.10	0.23	0.09
	90	0.03	0.00	0.03	0.00
	100	0.03	0.00	0.08	0.00
	110	0.00	0.00	0.07	0.00
	120	-	-	0.00	0.00

lation of the Republic of Kazakhstan before and during the COVID-19 pandemic to study and compare the main death causes.

We leveraged data available from the official registers of the Health Ministry of the Republic of Kazakhstan, "Register of population" and "Death certifying register," and found that the number of deaths in the Kazakhstani population in 2020 increased by 1.32-fold (33,866 cases) compared to 2019. The increase in the number of deaths was largely due to deaths among the male population due to stationary mortality, at the expense of those who died from circulatory diseases, diseases of the respiratory system, diseases of the nervous system, and diseases with the ICD-10 code U00-U85, used for provisional assignment of new diseases of uncertain etiology or emergencies. It is noteworthy that the listed causes of death are common comorbidities of COVID-19. There may be inaccuracies/errors in the statistical recording of deaths, such as erroneous registration of nosological forms instead of COVID-19. Additional research is needed to verify this possibility.

Young people aged between 14 and 29 years in Kazakhstan are characterized by a high frequency of deaths in the male population; the leading causes of death are injuries, poisoning, and other consequences of external causes, malignant neoplasms, diseases of the nervous system, and deaths from circulatory diseases. These results highlight the need to develop appropriate preventive measures.

Results from our analysis also revealed interesting changes in the places of death. During the COVID-19 pandemic, healthcare systems around the world, including Kazakhstan, were overburdened, increasing out-of-hospital mortality. Consistently, our results indicated an increase in the number of deaths at home and elsewhere.

Analysis of the average survival rates indicated no change in the median survival time of the Kazakhstani population before and during the current pandemic. However, significant ($p \leq 0.01$) shifts in the median survival times of the male (65 years → 66 years) and female (77 years → 75 years) populations were observed. Significant differences in survival (in structure and dynamics) by gender contributed to the smoothing of the nationwide survival rate, resulting in changes in overall survival before and during the COVID-19 pandemic being invisible.

The difference in the median survival times in males and females, taking into account the causes of death, is convincing evidence that gender is of predictive value. Gender inequality in survival should be highlighted; the male population is characterized by lower survival rates compared with the female population. In addition, the leading causes of death in males and females were established as circulatory diseases and diseases of the nervous system, respectively. Consequently, we would urge the improvement of preventive measures by optimizing early detection and dynamic monitoring of these diseases at the primary level of medical care.

Examination of the probabilities of survival for certain age groups, taking into account gender, indicated significant differences in survival for male and female populations. The probability of survival for Kazakhstani males is significantly lower than for females in all age groups. The probability of death (averaged for the years 2019 and 2020) was 9.5% for males and 5% for females aged 40–50 years, 20.5% for males and 10.5% for females aged 50–60 years, 41% for males and 22% for females aged 60–70 years, 53.5% for males and 36% for females aged 70–80 years, and 86% for males and 76.5% for females aged 80–90 years.

Compared with 2019, during the COVID-19 pandemic in 2020, the male population of Kazakhstan was characterized by an increase in cumulative survival of 1–2% in the 0–60 years age group and no change in cumulative survival in the over 60 years age group. The female population was characterized by an increase in cumulative survival of 1% in the 0–40 years age group, an absence of dynamic changes in survival in the 40–60 years age group, and a decrease in cumulative survival of 1% in the 60–90 years age group.

In summary, the results of this study can be applied to the formation of health policy. A limitation of the study is the inadequacy of material in the statistical register, which made it difficult to conduct a larger-scale study with the inclusion of more predictors in the analysis.

Conclusions. In conclusion, the dynamics of the structure of causes of death and survival rate among the population of the Republic of Kazakhstan was changed during the COVID-19 pandemic in 2020 compared with the pre-pandemic year of 2019. Also, the survival rate differed significantly by gender, main cause (according to ICD-10), and place of death.

This knowledge will help develop differentiated measures to improve the health of the population of Kazakhstan.

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