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Excess summer mortality at young ages: do long school holidays matter?

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Abstract: *In this paper we analyze the seasonality of total mortality at younger ages in Russia compared with other countries. To decompose the time series into a trend, seasonality, and a random component and to perform seasonality tests, the TRAMO SEATS procedure was applied to short-term mortality data from the Short-term Mortality Fluctuations Human Mortality Database in 2000-2020. Summer seasonality was estimated as the ratio of average mortality in summer to average mortality per year after the trend component was excluded from the time series.*

In Russia, there exists a significant summer seasonality of child and adolescent mortality: at the age of 5-9 years, mortality in the summer months exceeds the average mortality per year by 21%; at the age of 10-14 years old, by 32%; and at the age of 15-19 years old, by 19%. In the vast majority of countries included in the analysis, the seasonality of child mortality in general and the summer seasonality in particular are noticeably lower than in Russia, especially in the age groups of 5-9 and 10-14 years. It is only after the age of 15 that excess summer mortality at young ages becomes relatively common in other countries.

The pronounced seasonality of mortality in younger age groups may, among other things, be the result of long school holidays, during which many children find themselves without proper supervision and accompaniment. To test this hypothesis, we compared the length of summer holidays in the STMF countries with child and adolescent seasonality. We show that there is a significant positive relationship between these indicators: longer holidays correspond to more pronounced excess summer mortality, and this result remains stable for different age groups.

Keywords: *mortality, seasonality, adolescent mortality, TRAMO SEATS, Human Mortality Database, Russia.*

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Introduction

The mortality of the Russian population has a pronounced seasonality: deaths occur more often in winter, at the height of seasonal respiratory diseases. However, for certain age groups, this rule is not followed, and mortality in summer is noticeably higher. This can be seen in the weekly mortality data of the Short-term Mortality Fluctuations Human Mortality Database (hereinafter STMF, see (Human Mortality Database 2022)). The seasonality coefficients, calculated as the ratio of the average monthly number of deaths in June-August and the average monthly number of deaths in 2019, reach a maximum at the age of 5-14 years and then decrease to below one after the age of 45, which corresponds to the transition to the winter seasonality of mortality (Table 1).

Table 1. Seasonal mortality coefficients by age, Russia, men and women, 2000-2020

Year	Men						Women					
	2000	2005	2009	2015	2019	2020	2000	2005	2009	2015	2019	2020
0-4	0.99	1.02	0.99	0.99	1.00	1.04	1.02	1.01	0.97	0.97	1.03	1.02
5-9	1.52	1.39	1.32	1.30	**1.21**	**1.28**	1.36	1.36	1.14	1.02	**1.13**	**1.26**
10-14	1.38	1.43	1.34	1.34	**1.30**	**1.37**	1.40	1.33	1.28	1.10	**1.18**	**1.16**
15-19	1.24	1.28	1.20	1.25	**1.19**	**1.25**	1.22	1.24	1.10	1.03	1.06	**1.18**
20-24	1.19	1.20	1.17	1.14	1.09	1.16	1.15	1.09	1.02	1.06	1.03	1.08
25-34	1.10	1.07	1.06	1.04	1.05	1.06	1.10	1.05	0.96	0.99	1.01	1.03
35-44	1.01	1.00	0.99	1.00	1.02	1.01	0.99	0.95	0.94	0.96	1.00	1.00
45-54	0.97	0.96	0.95	0.96	0.97	0.97	0.92	0.94	0.91	0.93	0.96	0.94
55-64	0.94	0.96	0.96	0.95	0.96	0.93	0.91	0.91	0.92	0.94	0.95	0.91
65-74	0.92	0.95	0.93	0.94	0.97	0.91	0.91	0.92	0.92	0.93	0.96	0.91
75-85	0.91	0.94	0.92	0.92	0.96	0.90	0.90	0.92	0.92	0.93	0.95	0.93
85 years and older	0.88	0.93	0.92	0.93	0.93	0.89	0.88	0.91	0.91	0.91	0.94	0.93
Whole population	0.96	0.97	0.96	0.95	**0.97**	**0.93**	0.91	0.93	0.92	0.93	**0.95**	**0.93**

Source: Authors' calculations based on STMF data (Human Mortality Database 2022).

Note: Instead of 2010, which was characterized by extreme weather conditions in the European part of the country, 2009 was used. Data for 2019 were added to the pandemic 2020 data.

In the 2010s, the improvement in mortality in the general population and in adolescents in particular contributed to a slight decrease in the seasonality of mortality in 5-year age groups from 5 to 19 years; however, its absolute values, especially for males, still remain high (see highlighted values in table 1). In our opinion, this may be one of the consequences of children being unsupervised during long school holidays, as a result of which boys, often more active and more prone to risky behavior (Weden, Zabin 2005; Chun, Mobley 2010; Knyazev et al. 2004; Boriskin et al. 2018), can suffer more. It should be especially noted that a significant excess of the number of summer deaths over winter ones occurs against the background of a significant increase in mortality during the New Year holidays, which is concentrated, however, at older ages (Nemtsov, Fattakhov 2021).

When making calculations, it is necessary to use proper estimates of seasonality. In Table 1, we present estimates of seasonality based on a comparison of data from the initial time series of mortality, without taking into account long-term changes in its dynamics. In modern scientific research, econometric methods are used to extract individual components (trend, seasonality, random fluctuations) from the original time series, which makes it possible to more correctly assess seasonality and conduct intertemporal and intergroup comparisons (UNECE 2020).

Since we are interested in the relationship between the summer seasonality of mortality and the duration of summer holidays, this study will mainly study the age groups that are most related to school age: 5-9, 10-14 and 15-19 years old. Due to the relatively small contribution of these age groups to overall mortality, as well as to the lack of open data at the required level of detail, seasonality at younger ages in Russian data, as far as we know, has not yet been considered in detail. In this regard, of great interest is the STMF (Human Mortality Database 2022) database, which contains information on weekly mortality among various sex and age groups in several countries of the world, including Russia.

The purpose of this study is to analyze the seasonality of mortality at younger ages in Russia and, if possible, to test the hypothesis about the effect of the duration of school holidays on the range of intra-annual fluctuations. The article includes a brief review of recent work on seasonality in mortality, a description of the data and methodology of the empirical part of our study, a presentation of the results and a brief discussion. The main conclusions of the work are presented in the final section.

Seasonality of Mortality in Children and Adolescents: A Brief Review of Current Research

The seasonality of mortality is a well-known and well-studied phenomenon. Currently, in countries with a temperate climate, for the population as a whole it is usually expressed in a winter peak and a summer minimum of mortality. For example, in a number of developed countries with different climates, annual mortality minima between the ages of 2 and 57 are most often reached in late summer or early autumn, due to favorable weather conditions, as well as to the positive effect of summer holidays (Falagas et al. 2009). (Healy 2003), which compared the seasonality of mortality in 14 countries, observed the highest winter seasonality in Portugal (21% higher).

In Russia, the situation is similar: during the epidemiologically more or less safe pre-COVID period, the number of deaths in January, March and, to a lesser extent, December, consistently exceeded the average annual level, and in July-October was usually below it (Shcherbakova 2010). Researchers also note an increase in mortality during heat waves, including in Russia in 2010, when a long period of hot weather and atmospheric pollution caused by forest fires in Moscow alone caused 11,000 excess deaths (Shaposhnikov et al. 2014). Another important factor in the seasonality of mortality in Russia is the significant excess mortality during the New Year holidays (Nemtsov, Fattakhov 2021).

Information concerning the seasonality of mortality in children and adolescents (with the exception of infant mortality) in the scientific literature is noticeably more fragmented. In the United States, there is a pronounced summer seasonality in adolescent and young adult mortality, driven primarily by external cause mortality (Parks et al. 2018). In particular, the peak of mortality at the age of 5–14 years from all causes occurs in the summer and coincides in time with the peak of mortality from external causes.

In Japan (Shinsugi 2015) in 2000-2010 the main cause of death in children and adolescents was external causes, some of which have a pronounced seasonality. Thus, the peak of deaths from transport accidents and drownings occurs in the summer, suicides in the spring, and accidents with respiratory risks in the winter.

In the third most populous city in China (Guangzhou), in 2008-2018 the mortality of children aged 0-14 years from external causes of death increased significantly during the summer holidays and especially in August. Of the three most common causes of death from injuries (transport accidents, accidents with a threat to breathing, and drowning), the most pronounced seasonality of mortality is that from drowning, the local maximum of which (more than 35% of all deaths per year) occurs in July-August (Xu et al. 2020).

In Hungary the annual maximum mortality of children aged 0-14 years from transport accidents and drownings is observed in July (Lantos, Nyári, McNally 2019).

There is a small number of works that analyze the effect of vacations and holidays on mortality in younger ages. The analysis carried out on the data for 2012-2015 in Fiji (Murray, Carter 2017) found that deaths from accidental drowning between the ages of 1 and 29 were significantly higher in months with a high number of holidays and weekends. In a study on mortality from unintentional drowning among 5–17-year-olds, carried out on Australian data (Peden, Barnsley, Queiroga 2019), it was shown that the relative risk of drowning on a holiday is 2.4 times higher than on a school day, which probably says something about the protective effect of formal schooling. The authors of a study on the seasonality of mortality among children aged 0-14 years in the Chinese city of Guangzhou also emphasize that there is a higher risk of drowning during school holidays (Xu et al. 2020).

There are relatively few studies on the seasonality of mortality in Russia. They are mainly devoted to excess winter mortality of the population as a whole, the level of which is noticeably lower than in many European countries (McKee et al. 1998; Kontsevaya et al. 2014), as well as to the impact of extreme weather conditions on mortality (Revich, Shaposhnikov 2010; Shaposhnikov et al. 2014). (McKee et al. 1998) also noted significant excess summer mortality in young adults, especially from alcohol-related causes.

In a study of the mortality of adolescents aged 15-17 in the Omsk region in 2000-2012, (Zakorkina 2015) demonstrated a significant seasonal component in the number of deaths from external causes. For the three causes that make the greatest contribution to traumatic mortality, the share of seasonal fluctuations was: for suicide - 7% (local maxima both in May, August and September, and in December), for transport accidents - 35% (seasonal rise in May -September), for events of undetermined intent - 30% (seasonal rise in June-September with a local maximum in August). Among the reasons for the pronounced summer seasonality of mortality from a number of external causes, the author names the absence of classes in educational institutions and adolescents' relative lack of activities.

The seasonality of demographic processes in Russia is studied in (Rodionova, Kopnova 2019). The authors apply seasonal ARIMA models to monthly Rosstat data on the number of births, deaths, and marriages. The application of this method makes it possible to obtain models with good predictive and statistical properties. In particular, it is shown that the time series of the number of deaths contains a deterministic seasonality, while there is no seasonality for infant mortality.

Of interest to our study are also works concerning the dynamics and structure of mortality in children and adolescents from external causes, since it is mortality from a number of external causes that has a pronounced summer seasonality. A report by the World Health Organization

(Sethi et al. 2017) compares the dynamics of traumatic mortality among children aged 0-14 years in the countries of the European region. It is shown that from 2000 to 2015 the region had increased inequality between high-income countries and low- and middle-income countries in the level of deaths from unintentional injuries (accidents, poisoning, falls, accidents caused by fire and heat, drowning). In part, this increase in inequality could be due to the persistence of the unfavorable situation in Russia (a large middle-income country in the region), where mortality from unintentional injuries during the study period decreased more slowly than in developed countries.

The work (Ivanova et al. 2009) presents an analysis of the mortality of the Russian population aged 15-19 years. The positive dynamics observed in the mid-2000s largely affected endogenous causes of death (neoplasms and diseases of the nervous system). At the same time, there was an increase in mortality from cardiovascular diseases, which, according to the authors, may partly mask mortality from drug poisoning. An important change in post-Soviet teenage mortality statistics has been an increase in mortality from events of undetermined intent, which in turn may include a proportion of deaths from murder and drug poisoning. Another possible reservoir of masked mortality from external causes is the group of ill-defined conditions (see also (Semenova et al. 2018; Semenova et al. 2021) about this).

Data and methodology

The calculations used weekly data on mortality in 2000-2020 from the Short-term Mortality Fluctuations (STMF) Human Mortality Database. Weekly data on the number of deaths were converted into monthly data, which were then normalized according to the length of the months, i.e., recalculated for 30 days.

To decompose the time series of the number of deaths by age groups, we used the parametric TRAMO-SEATS procedure developed by the Central Bank of Spain (Caporello, Maravall 2004; Maravall, López-Pavón, Pérez-Cañete 2015). We used its implementation in the JDemetra software (Grudkowska 2015; UNECE 2020). The procedure uses a seasonal autoregressive integrated moving average model (SARIMA) and makes it possible to select 3 components from the initial time series X_t: trend-cyclical T_t, which includes both a long-term trend and smooth cyclical fluctuations around it, seasonal S_t and irregular I_t. We used the multiplicative decomposition $Xt = T_t * S_t * I_t$, which assumes that the time series does not take negative values and that seasonal fluctuations increase with the growth of the indicator.

The TRAMO-SEATS method is one of the seasonal adjustment procedures for data. JDemetra also implements the X13 semiparametric method developed by the US Census Bureau. Each method has its advantages and disadvantages; both are actively used in scientific expertise and researchers have no clear preferences in favor of one or the other. In practice, they often give similar results (UNECE 2020).

In the implementation of the TRAMO-SEATS procedure in the JDemetra statistical package, the presence of seasonality is determined based on 6 tests. These include seasonal lag autocorrelation, the Friedman test, the Kruskal-Wallis test, spectral peaks, a periodogram and seasonal dummies (UNECE 2020: 56). A decision on the need for seasonal adjustment of the original time series is made if the majority of tests confirm the existence of seasonality (UNECE 2020: 57, table 4.2). A detailed description of the tests is given in (Grudkowska 2015: 106-110); for examples of calculations see (O'Keeffe 2017; Asif et al. 2019).

We defined the coefficient of summer seasonality of mortality as the ratio of the average monthly number of deaths in June-August 2015-2019 to the average monthly number of deaths over the entire period.

When conducting international comparisons, data on mortality in countries with small populations were also used. Of the 26 countries included in the analysis of the seasonality of mortality by 5-year age groups, in 5 (Croatia, Slovenia, Latvia, Lithuania, Estonia) the population does not exceed 5 million people, and in 3 more countries (Denmark, Finland, Slovakia) does not exceed 6 million. To increase the absolute values of the mortality rate at younger ages, we tried to enlarge the groups studied by combining men and women, comparing data for a three-month period (summer), and also calculating the seasonality indicator for the total values of the indicator for 5 years from 2015 to 2019.

When conducting a comparative analysis, we used data on the length of school summer holidays in different countries, collected from open sources. The main source was a site[1] which provides data on the length of summer holidays for younger students in European countries. We collected the missing information for each country separately, using data from the world-schools website[2], as well as Wikipedia. In some countries, vacation length varies by region. In such cases, we tried to take the average of the observed values.

Table 2. Duration of summer holidays in the countries included in the comparative analysis (for countries located in the Southern Hemisphere, the duration of winter holidays)

Name	Duration of summer holidays, weeks	Name	Duration of summer holidays, weeks	Name	Duration of summer holidays, weeks
Australia	5	France	8	Norway	8
Austria	9	Germany	6	Poland	13
Belgium	9	Greece	12	Portugal	11
Bulgaria	13.5	Hungary	11	Russia	14
Canada	9	Israel	10	Scotland	6.5
Chile	11	Italy	14	Slovakia	9
Croatia	10	Korea	8	Slovenia	10
Czech Republic	9	Latvia	13	Spain	13
Denmark	6	Lithuania	13	Sweden	6
England	6.5	Netherlands	6	Switzerland	6
Estonia	12	New Zealand	6	Taiwan	9
Finland	10.5	Northern Ireland	6.5	USA	10.5

Source: Compiled by the authors based on information from websites: https://jakubmarian.com/school-holidays-by-country-in-europe-map/, https://world-schools.com; https://www.aucklandforkids.co.nz/new-zealand-school-and-public-holiday-dates; https://holidayswithkids.com.au/school-holidays-and-australian-public-holidays

As can be seen from the data in Table 2, the countries included in the analysis differ significantly in terms of vacation duration. The shortest summer school holidays (no more than 7 weeks) are found, as a rule, in countries where the predominant religion is Protestantism: in Great Britain (England, Northern Ireland, Scotland), former English colonies (Australia and New

[1] https://jakubmarian.com/school-holidays-by-country-in-europe-map/
[2] https://world-schools.com

Zealand), countries of Northern Europe (Denmark, Sweden) and several countries of Western Europe (Germany, the Netherlands, Switzerland).

On the contrary, the longest vacations (12 weeks or more) are found in the countries of the former USSR (Russia, the Baltic countries), Eastern Europe (Bulgaria, Poland) and countries of Southern Europe (Greece, Spain, Italy). The longest holidays (14 weeks) in the sample of countries considered are in Russia and Italy.

Results and discussion

Seasonality of mortality in Russia

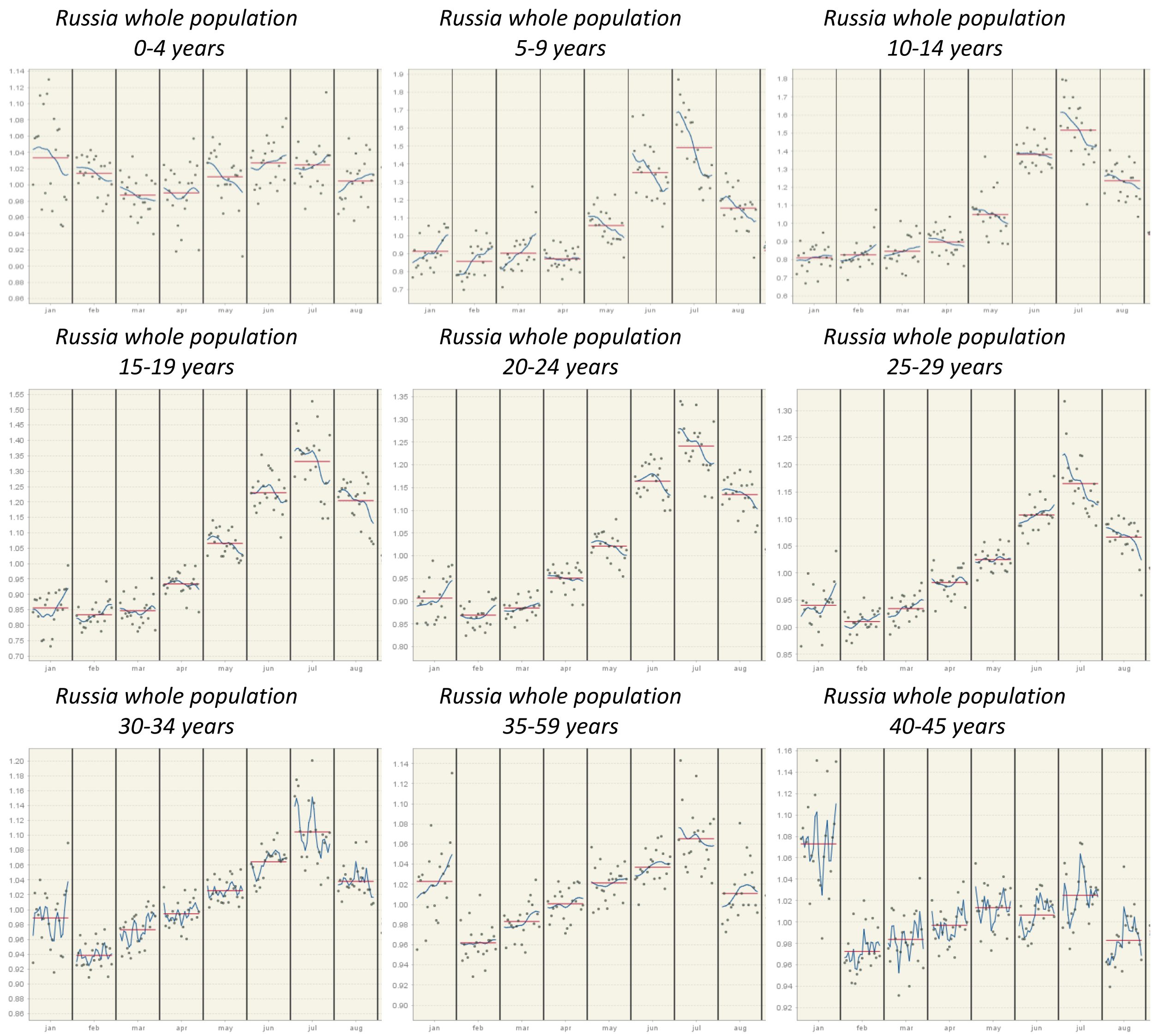
To assess the seasonality to the baseline mortality data in 5-year age and sex groups, the iterative procedure TRAMO SEATS (RSA3) was applied. With its help, the initial series was decomposed into a trend, seasonal and random (irregular) components. Seasonally adjusted was defined as the ratio of the observed mortality value to the trend value; in the literature, it is called the seasonal-irregular (S-I) component. Figure 1 shows the seasonally adjusted data for the population aged 0-44 years, calculated on the 2015-2019 data obtained for the original series from 2000 to 2020.

The data are presented by months, with individual points corresponding to the values of the seasonally irregular component in 2000–2020, the red line to its average value, and the blue line to the trend during the observation period.

Figure 1 clearly shows how the summer seasonality increases at younger ages: first appearing in the group up to 5 years (along with the summer local peak, there is also a winter peak observed in January-February), it then increases sharply at the age of 5-9 years and reaches a maximum for 10-14-year-olds. The highest mortality values are in July. Further, the summer peaks of mortality decrease relative to the average values and the factor of increased January mortality and overall mortality of the winter and cold season as a whole begins to manifest itself more and more.

The data in Figure 1 also shows that in the 2010s the summer seasonality of mortality in the age groups of 5–9 and 10–14 years decreased, as evidenced by a declining trend (blue lines) for the summer months and, conversely, an increasing trend for the winter months. We assume that this decrease was due to the favorable dynamics of mortality from external causes, including those for which annual maxima occur during the warm season.

Figure 1. Seasonally irregular component of mortality in age groups from 0 to 44 years, males and females, 2000-2020



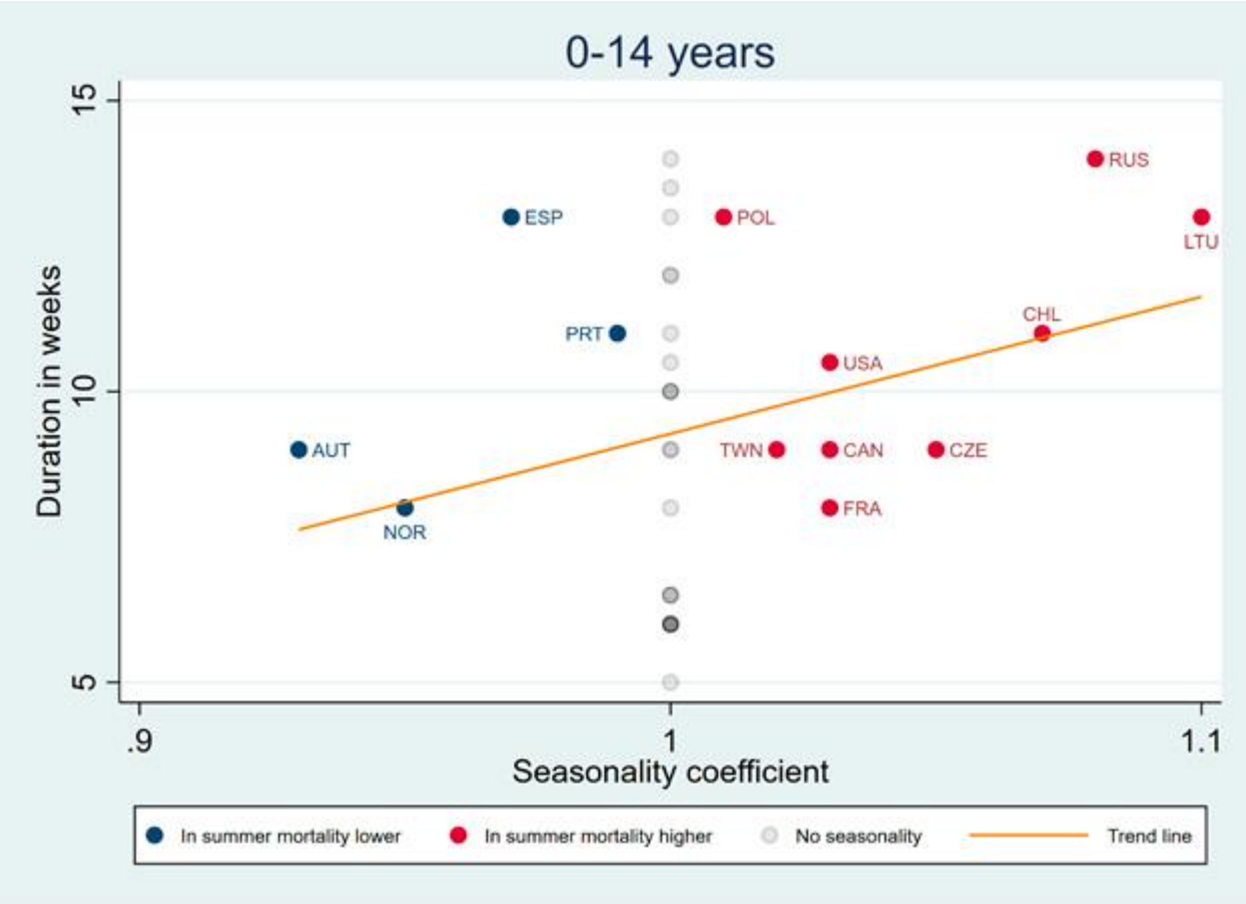
Source: Authors' calculations based on STMF (Human Mortality Database 2022) data using JDemetra software.

Seasonality of mortality between the ages of 0-14 years in 38 STMF countries

In order to compare the seasonality of mortality in Russia with other countries, we first reviewed STMF data for 36 countries on mortality by months at age 0-14 years (Iceland and Luxembourg were excluded from the analysis due to their small populations). We supplemented this data with information on the duration of summer vacations collected from open sources.

Figure 2 shows the relationship between the length of summer holidays and the summer seasonality factor for the population aged 0-14 years. Values for countries with summer seasonality are in red, with winter seasonality in blue and no seasonality in gray (darker shading corresponds to values from multiple observations).

Figure 2. Coefficient of mortality seasonality at the age of 0-14 years (mortality in the summer months in relation to the average annual mortality), males and females, 2015-2019



Source: Authors' calculations based on STMF data (Human Mortality Database 2022).

Note: AUT - Austria, CAN - Canada, CHL - Chile, CZE - Czech Republic, ESP - Spain, FRA - France, LTU - Lithuania, NOR - Norway, POL - Poland, PRT - Portugal, RUS - Russia, TWN - Taiwan, USA - USA.

From the data presented, it can be seen that summer maxima in mortality are more common in countries with longer summer holidays. Apart from Russia, summer seasonality in mortality for those aged 0-14 years in 2015-2019 is also observed in Lithuania, as well as, though less pronounced, in Chile, the Czech Republic, the USA, Canada, France, Poland and Taiwan. A lack of seasonality is more common in countries with relatively shorter holidays (darker gray dots at the bottom of Figure 2, corresponding to larger groups of countries with undetectable mortality seasonality).

In order to take into account possible gender differences, we also considered the ratio of the seasonality of mortality and the duration of holidays separately for men and women (Figure A1 of the Appendix). The main difference was that for males the seasonality confirmed by tests is always summer, while for female mortality this is not necessarily the case. For example, in Austria, Norway, Spain and Portugal, mortality in summer is less than the average during the year. We explain this by the higher contribution of external causes of death to male mortality. Diseases rather than injuries play a greater role in female mortality, and therefore the effect of adverse weather and epidemiological conditions characteristic of the cold season is stronger.

However, it should be noted that the seasonality of mortality in the extended age group from 0 to 14 years is a composite of the seasonality of infant, child and adolescent mortality, which differ significantly in structure. In mortality at the age of 0-4 years, over 90% are endogenous (not external) causes, and in groups of 5-9 and 10-14 years, their share falls below 60% (Figure 3). In this regard, the seasonality of schoolchildren's mortality may differ significantly from the seasonality of mortality in the aggregated group from 0 to 14 years. Thus, the result obtained - the presence of a positive relationship between the length of school holidays and the pronounced excess summer mortality of children - needs to be examined.

Seasonality of mortality in 5-year age groups for 28 STMF countries

In a more detailed analysis of the seasonality of mortality at younger ages, a reduced sample of 28 countries was used for which data on mortality in 5-year age groups at younger ages are available. Large countries such as the United States (STMF contains only raw data on mortality of those aged 0-24 years) and Germany (only data on mortality for ages 0-29 years) did not meet this criterion. The list of countries selected for comparison includes France, Italy, Spain, Poland, Taiwan, Chile, the Netherlands, Belgium, Greece, Czech Republic, Portugal, Sweden, Hungary, Austria, Switzerland, Bulgaria, Croatia, Denmark, Estonia, Finland, Latvia, Lithuania, Norway, Slovenia and Slovakia, as well as parts of the UK (England and Wales; Scotland and Northern Ireland). Due to their small populations, Iceland and Luxembourg were not included in the analysis.

Table 3 provides information on the seasonality of mortality in four 5-year age groups in the countries of this list (in cases where seasonality was confirmed by statistical tests). Confirmed seasonality of mortality at the age of 10-14 years is observed in 5 countries - Lithuania, Poland, Russia, France and Croatia. In Russia, it is the highest - mortality in summer exceeds the annual average by 32% (in Lithuania by 24%, in Croatia by 15%, in Poland and France by 5% or less). It should be noted that Croatia and Lithuania are countries with small populations and the results obtained should be treated with caution.

At the age of 15-19 years, seasonality is more common: in 11 out of the 26 cases examined. In Russia, summer seasonality at this age is also higher than in other countries - 1.19 (1.18 in Bulgaria, 1.15 in Croatia, 1.12 in Hungary, 1.09 in Sweden, 1.08 in Poland and France, 1.05 in Lithuania).

Why is the mortality of children and adolescents in Russia higher in better weather? Unlike older people, they die more often from a number of external causes, for which the peak values of mortality occur in the warm season: from suicide in May (less often June or July), from transport injuries in August-September (Shcherbakova 2010), and from events of undetermined intent in June-September (Zakorkina 2015: results for the Omsk region).

In 2019, the proportion of suicides, transport accidents and deaths with undetermined intent in the mortality of males for those aged 10-14 years was 5%, 11% and 15%, respectively, and 14%, 17% and 21% for those aged 15-19 years. Thus, the total share of these three causes with presumably summer seasonality in male mortality was 31% for those aged 10-14 and 52% for those aged 15-19 years. For female mortality, the share of these three causes is also high: 26% at the age of 10-14 and 48% at the age of 15-19. In addition, common causes of accidental death (W00-X49) at these ages are "accidental drowning and submersion while in a natural body of water" and "falling from one level to another" (correspondingly 5% and 2% of all male deaths for those aged 10-14 years, as well as 3% and 2% of all male deaths for those aged 15-19), both of which may also have a summer seasonality.

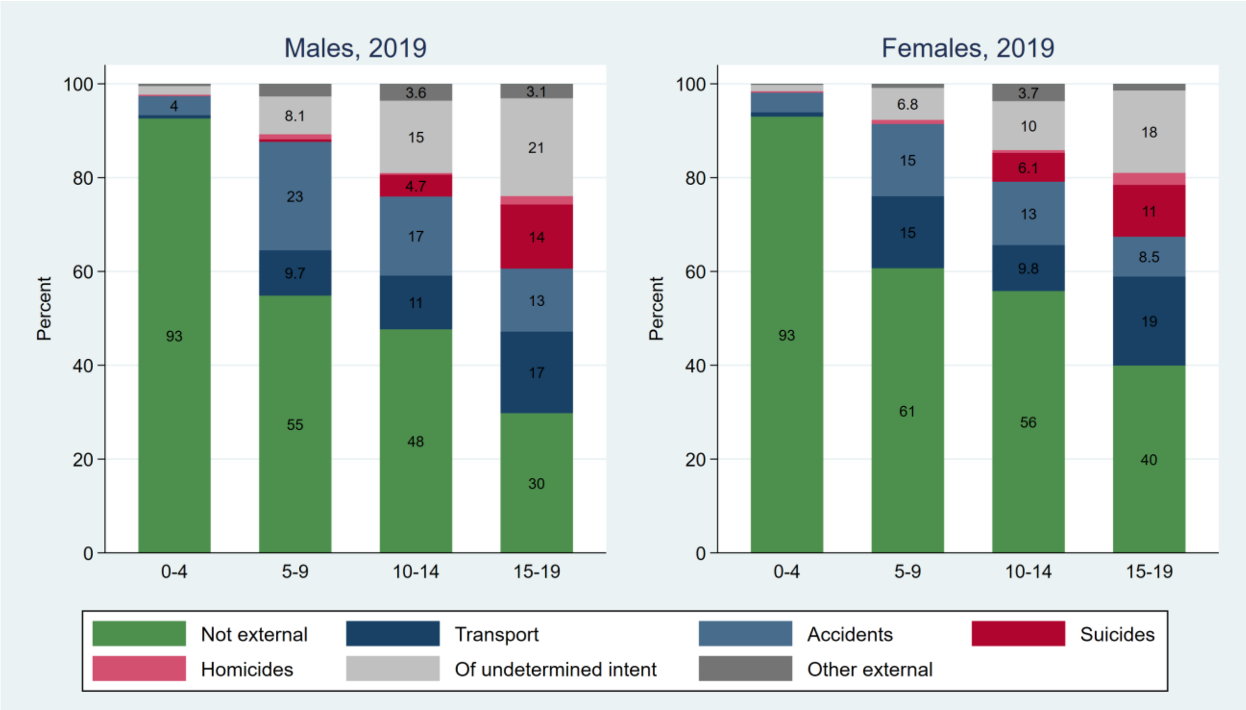
Table 3. Information on the seasonality of mortality at younger ages, countries from the STMF database, 2015-2019

Country	Age	Seasonality coefficient (average mortality in June-August 2015-2019/average mortality in 2015-2019)	Month with minimum mortality	Month with maximum mortality
Bulgaria	15-19	1.18	11	8
Croatia	5-9	0.85	10	1
Croatia	10-14	1.15	9	1
Croatia	15-19	1.15	10	8
Denmark	15-19	0.81	9	1
Estonia	0-4	1.06	9	8
France	5-9	0.99	6	4
France	10-14	1.01	11	2
France	15-19	1.08	4	8
Hungary	5-9	0.92	8	3
Hungary	15-19	1.12	2	6
Lithuania	10-14	1.24	3	8
Lithuania	15-19	1.05	9	2
Poland	5-9	1.05	9	10
Poland	10-14	1.05	1	8
Poland	15-19	1.08	4	8
Portugal	0-4	0.99	10	1
Portugal	15-19	1.16	4	7
Russia	0-4	1.03	11	7
Russia	5-9	1.21	11	7
Russia	10-14	1.32	12	6
Russia	15-19	1.19	2	6
Spain	0-4	0.97	6	12
Spain	5-9	0.98	11	2
Spain	15-19	1.02	10	1
Sweden	15-19	1.09	12	11
Taiwan	0-4	1.02	11	2
Taiwan	5-9	1.02	3	2

Source: Authors' calculations based on STMF data (Human Mortality Database 2022).

As can be seen in Figure 3, the structure of mortality among children and adolescents has noticeable gender differences. For female mortality, the contribution of external causes in general and unintentional injuries in particular is lower. At the same time, regardless of gender, there is a very high proportion of events of undetermined intent: 21% of all deaths for those aged 15-19 years for men and 18% for women.

Figure 3. The contribution of various causes to the mortality of children and adolescents in Russia, males and females, 2019



Source: Authors' calculations based on RosBRiS data (CDI NES 2022)[3].

Figure A2 of the Appendix also displays information on changes in the structure of child mortality over the past 20 years. During this period, there was a decrease in the contribution of external causes to the mortality of children and adolescents, especially noticeable for younger groups. For example, the proportion of deaths from external causes for boys aged 5-9 decreased from 61% in 2000 to 45% in 2019. In addition to this positive trend, one can also note the deterioration in the quality of mortality statistics due to a significant increase in the share of events of undetermined intent. In particular, for boys aged 15-19 years, the proportion of deaths from events of undetermined intent increased from 9% in 2000 to 21% in 2019, which, according to experts, may mask some of the deaths from socially significant causes (homicides and suicides).

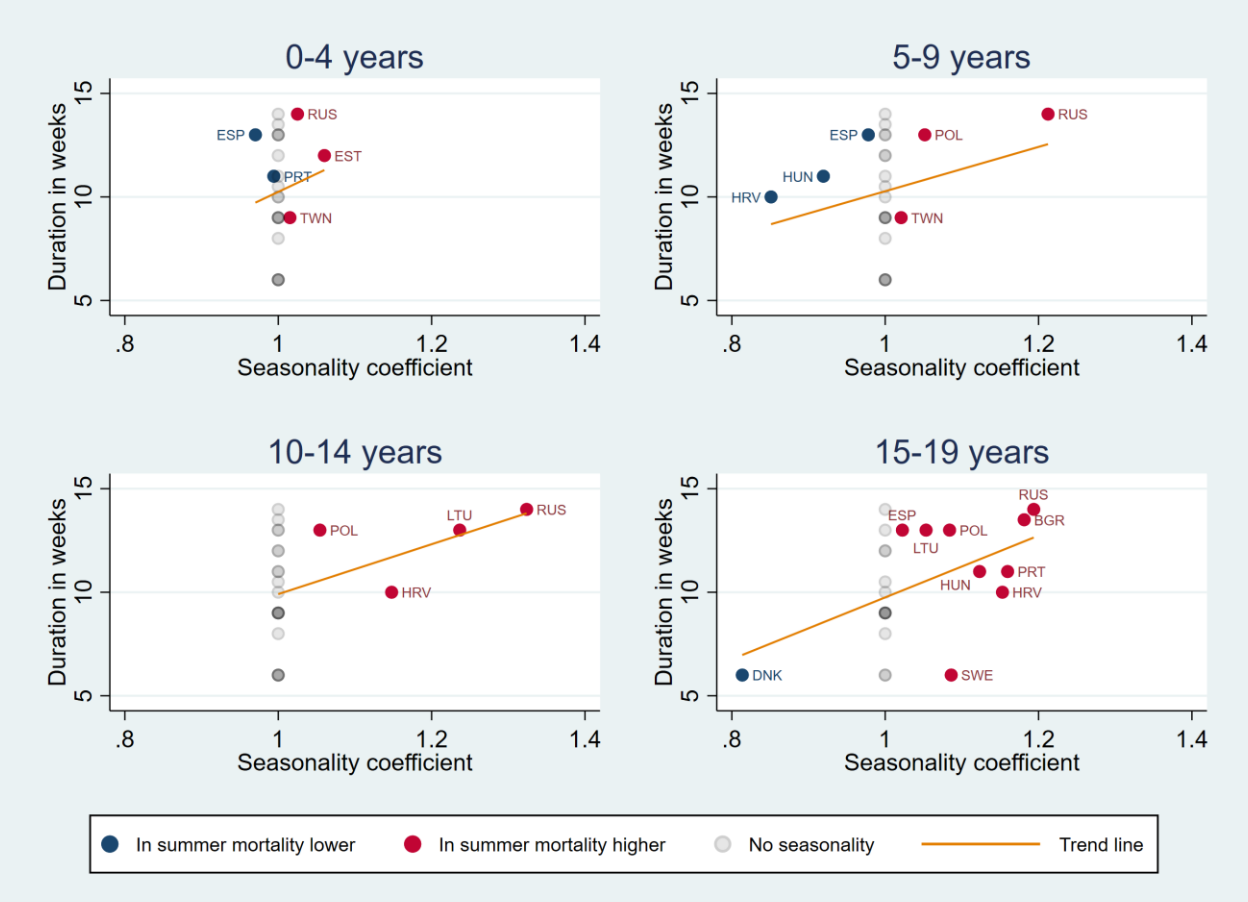
When analyzing the current state and dynamics of the structure of child mortality, it is useful to view the position of Russia in the context of other countries. Figure A3 of the Appendix displays information on the structure of child mortality in 6 countries of the world: 2 states of the Eurasian Economic Union (Belarus and Kazakhstan), two large countries of Eastern Europe (Poland and Romania) and the largest economies in Europe (Germany) and the world (USA). International comparisons, firstly, indicate the similarity of the structure of child mortality in Russia and its immediate neighbors. In addition, a comparison with the Eastern European countries that are members of the EU reveals a smaller contribution of external causes to the mortality of younger schoolchildren (5-9 years old) there than in Russia. By the age of 15-19, these differences are mostly smoothed out. However, the high contribution of events of undetermined intent, which was repeatedly mentioned above, remains a unique Russian phenomenon, not exceeding 10% in other countries (maximum values in Kazakhstan and Poland).

[3] http://demogr.nes.ru/index.php/ru/demogr_indicat/data_description

One of the reasons for the high excess summer mortality of children and adolescents in Russia may be the long summer holidays, a period when children are more often left without adult supervision. As noted in the brief literature review, a number of studies based on data from other countries have demonstrated excess mortality of school-aged children on weekends and holidays, as well as during school holidays (Murray, Carter 2017; Xu et al. 2020; Parks et al. 2018).

Our estimates generally confirm this hypothesis. Figure 4 graphically shows the relationship between the coefficient of summer seasonality of mortality (the ratio of summer deaths to annual average deaths) and the length of summer vacation in the 28 countries of the STMF database. From the data presented, it is clearly seen how higher summer mortality, from being a relatively rare phenomenon under the age of 15 years, becomes very common at the age of 15-19 years. It can also be noted that the above average summer mortality at the age of up to 15 years in Russia is greater than in all 28 countries included in the comparative analysis.

Figure 4. Summer seasonality of early childhood mortality and duration of summer school holidays, males and females, 2015-2019, 28 countries from the STMF database



Source: Authors' calculations based on STMF data (Human Mortality Database 2022).

Note: AUT – Austria, BGR – Bulgaria, CAN – Canada, CHL – Chile, CZE – Czech Republic, DEU – Germany, DNK – Denmark, FRA – France, ESP – Spain, EST – Estonia, HRV – Croatia, LTU – Lithuania, NOR – Norway, POL – Poland, PRT – Portugal, RUS – Russia, SWE – Sweden, TWN – Taiwan, USA – USA.

The positive relationship between increased summer mortality and the length of school holidays, which we previously demonstrated for children aged 0 to 15 (Figure 2), also persists in the 5-year age groups. This is largely due to the lack of summer seasonality in mortality in countries where vacations are shorter. This is indicated, in particular, by the darker gray dots at the bottom of the figure, corresponding to several countries with undetectable seasonality in mortality.

Thus, we were able to find some empirical evidence that the increased summer seasonality of mortality at younger ages in Russia may be associated with long summer holidays. In Russia, summer school holidays last 14 weeks, which is considerably longer than in most other countries included in the comparative analysis.

Our study has a number of limitations. It should be noted that there is a lack of data with the necessary detail. In particular, it is not possible to analyze the seasonality of mortality in more detailed gender and age groups by groups of causes of death. When conducting international comparisons, it was necessary, among other things, to use data for countries with small populations, which could also affect the quality of the estimates. In addition, it should be noted that the STMF database includes mainly high-income countries, while comparisons would be more appropriate for middle- and upper-middle-income countries. In poorer countries, there may be fewer opportunities to institutionally support children's summer activities, but at the same time, other factors may become more important, for example, family resources for childcare, the use of child labor in the household, etc.

Conclusion

Russia is characterized by pronounced summer excess mortality at younger ages. According to our calculations in 2015-2019, the average mortality in summer exceeded the average mortality per year for the population aged 5-9 years by 21%, for those 10-14 years old by 32%, and for those 15-19 years old by 19%.

In most of the countries included in the comparative analysis, the seasonality of child mortality in general and the summer seasonality in particular are noticeably less pronounced than in Russia, especially in the age groups of 5-9 and 10-14 years. It is only after 15 years that excess summer mortality at younger ages becomes relatively common in other countries (Figure 4).

Gender differences in the seasonality of child mortality mainly consist in the fact that for males, the seasonality confirmed by tests is always summer, while for female mortality this is not necessarily the case (Figure A1 of the Appendix for 36 countries from the STMF database). We explain this feature by the higher contribution of external causes of death to male mortality. Diseases rather than injuries play a greater role in female mortality, and therefore the effect of unfavorable winter conditions on them is stronger.

The high excess summer mortality of children and adolescents in Russia is observed against the background of a significant contribution to mortality by external causes, including those for which the annual maximum falls on the warm season (Figure 3). About 50% of deaths at the age of 15–19 years in 2019 were due to transport accidents, suicides and events of undetermined intent, i.e., causes of death with presumably summer seasonality (Shcherbakova 2010; Zakorkina 2015).

The pronounced seasonality of mortality in younger age groups may, among other things, be the result of long school holidays, during which many children find themselves without family and school supervision. To test this hypothesis, we compared the length of holidays in the countries included in the STMF database with the seasonality of mortality in children and adolescents. It has been shown that there is a significant positive relationship between these indicators: longer holidays correspond to more pronounced summer seasonality in the number of deaths, and this result is maintained for different age groups.

In Russia, summer school holidays last 14 weeks, which is noticeably longer than in most other countries. It might be useful to have discussions among educators about the academic advisability of taking such a long break from classes. The problem of summer growth in child mortality requires reflection by both experts and the public. It is necessary to expand support for family and institutional leisure and recreation for children during the holidays and, if approved by experts in the field of education, gradually reduce the duration of summer holidays, focusing on the experience of other countries.

In the future, we plan to continue studying the seasonality of mortality in Russia. Among other things, the seasonality of mortality in middle and older ages is of interest. Thus, for example, also worthy of more detailed study is the fact that the significant summer seasonality characteristic of the mortality of children and adolescents persists for young adults, with the gradual transition towards excess winter mortality occurring only after age 45.

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