

War fatalities in Russia in 2022 estimated via excess male mortality

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Abstract

In this paper, we used excess deaths among young males to estimate the number of Russian fatalities in the Russo-Ukrainian war in 2022. We based our calculations on the official mortality statistics in 2022, split by age and gender. To separate excess deaths due to war from those due to Covid-19, we relied on the ratio of male to female deaths, and extrapolated the 2015–19 trend to get the baseline value for 2022. We found noticeable excess male mortality in all age groups between 15 and 49, with $20\,600 \pm 1\,000$ excess male deaths overall. This estimate was obtained after excluding all HIV deaths that showed complex dynamics unrelated to the war. Depending on the modelling assumptions, the estimated number of deaths varied from about 15,700 to about 23,600, with 20,600 corresponding to our preferred model. Our estimate should be treated as a lower bound on the true number of deaths as the data do not include either the Russian military personnel missing in action and not officially declared dead, or the deaths registered in the Ukrainian territories annexed in 2022.

Introduction

Russia launched an invasion of Ukraine in February 2022, and at the time of writing (November 2023), the war still continues. Neither Russia nor Ukraine normally release official data on their casualties. The aim of this paper is to use statistical analysis of the Russian all-cause mortality data in 2022 to estimate war fatalities via *excess mortality*.

Excess mortality is defined as the increase in all-cause mortality over mortality otherwise expected based on historic trends. Subtracting the counterfactual expected number of deaths from the actually observed number of deaths allows us to estimate the death toll of epidemics, natural disasters, and armed conflicts. Excess mortality has been used to estimate the number of deaths caused by plague (Boka and Wainer, 2020), influenza epidemics (e.g. Housworth and Langmuir, 1974; Murray et al., 2006; Simonsen et al., 2013), Covid-19 pandemic (e.g. Kontis et al., 2020; Islam et al., 2021; Karlinsky and Kobak, 2021; Msemburi et al., 2023), hurricanes (e.g. Rivera and Rolke, 2019), heat waves (e.g. Robine et al., 2008), etc.

In the examples above, excess mortality is computed over the entire population. Recently, Karlinsky and Torrisi (2023) used excess mortality among young males to estimate war fatalities in Armenia and Azerbaijan during the 2020 Nagorno-Karabakh War, reasoning that it was mostly young males who contributed to war casualties.

In this work, we use the official all-cause number of deaths in Russia in 2022, split by age, gender, and region, to estimate excess male mortality in 2022, which we interpret as war deaths. Our analysis is complicated by the Covid-19 pandemic that strongly increased the number of deaths in Russia in 2020, 2021, and 2022 (Kobak, 2021; Karlinsky and Kobak, 2021). Indeed, according to Karlinsky and Kobak (2021), Russia had 1.3 million excess deaths due to Covid, including 190,000 in 2022. To separate the effect of war from the effect of Covid, we rely on the ratio of male to female deaths (‘M/F ratio’) to compute *excess male mortality* on top of what could be expected based on observed female mortality.

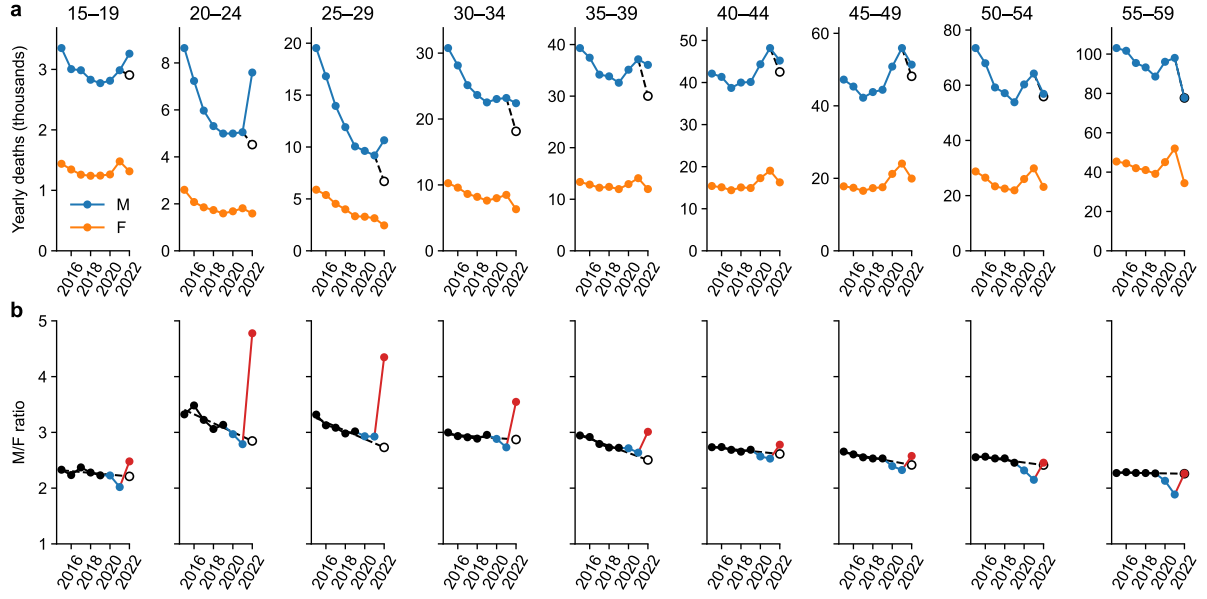


Figure 1: (a) The number of male and female deaths in Russia in 2015–22, by age group. Open circles show the baseline (counterfactual) number of male deaths in 2022, used for computing excess mortality. Note that the y -scale is different in each subplot. (b) The ratio of male to female death numbers. Dashed line shows linear fit to 2015–19, extrapolated to 2022 (open circle). Covid-19 years (2020 and 2021) are shown in blue. The war year (2022) is shown in red.

We take excess male deaths as an estimate of all war-related deaths because known war fatalities in Russia are almost exclusively male.

Overall, assuming linear trends in M/F ratios and excluding HIV deaths that showed complex dynamics unrelated to the war, we estimate 20.6 ± 1.0 thousand excess male deaths in Russia in 2022, spread over the age groups from 15 to 49 years old. All our data and analysis are openly available at <https://github.com/dkobak/excess-mortality-war>.

Results

We obtained all-cause mortality data for the period from 1990 to 2022, split by year, gender, and age group (in 5-year age brackets), from the Federal State Statistics Service of Russia (Rosstat). The raw data in nine age groups from 15 to 59 years old are shown in Figure 1a from 2015 onward. The dataset covers the Russian Federation as well as Crimea and Sevastopol (annexed by Russia in 2014), but does not cover the Ukrainian regions annexed in 2022 (for which Rosstat provides no data). Rosstat likely keeps track of the number of military deaths, as it does for any other cause of death, but did not provide this information upon our request.

Comparing the number of male deaths in the 20–24 age group in 2022 and in the preceding years suggests an obvious excess of ~3000 deaths. Similar excess is visible in the 25–29 age group. However, estimating excess mortality in older groups is difficult due to the effect of the Covid-19 pandemic. The number of deaths in 2020 and 2021 was much higher due to Covid-19 excess mortality (Kobak, 2021; Karlinsky and Kobak, 2021), so these two years cannot provide a robust basis for comparison. Moreover, Russia experienced another Covid wave in the early 2022, meaning that 2022 also showed some Covid-related excess mortality, and not the entire 2022 excess was due to war.

To get around this problem, we based our calculations on the ratio of the number of male deaths to the number of female deaths ('M/F ratio'). This ratio was above 1 in all age groups between 15 and 59 (Figure 1b). Prior to 2022, it was slowly decreasing in most age groups (Figure 1b). This monotonic decrease has been happening for over 20 years (Figures S1, S2), due to decreasing male mortality. In 2020 and 2021, during the height of the Covid-19 pandemic, the M/F ratio strongly decreased in older age groups as the number of deaths went up both in men and women (Figure 1a), reducing the ratio. However, in 2022 the ratio increased above the pre-pandemic levels, suggesting male-specific excess mortality.

To get the baseline M/F ratio for 2022, we fitted a linear trend to the 2015–19 values and extrapolated

Age	Raw	non-HIV	10-year trend	exp. trend	no trend
15–19	350 ± 120	340 ± 120	270 ± 130	340 ± 130	330
20–24	3 070 ± 270	2 870 ± 330	2 410 ± 370	2 830 ± 350	2 610
25–29	3 960 ± 220	3 440 ± 140	2 980 ± 260	3 390 ± 140	3 260
30–34	4 260 ± 360	3 400 ± 170	4 250 ± 420	3 390 ± 180	3 740
35–39	6 050 ± 560	4 470 ± 400	4 730 ± 630	4 410 ± 420	3 440
40–44	2 690 ± 560	3 060 ± 510	3 770 ± 510	3 040 ± 530	1 470
45–49	3 210 ± 580	3 050 ± 590	3 390 ± 480	2 900 ± 610	880
50–54	990 ± 840	1 040 ± 780	−60 ± 620	990 ± 830	30
55–59	80 ± 380	60 ± 380	−1 590 ± 620	60 ± 390	−120
Sum 15–49	23 590 ± 1 110	20 620 ± 970	21 790 ± 1 130	20 300 ± 1 010	15 720

Table 1: Excess male deaths in 2022 by age group (estimate ± standard error). Five columns correspond to five methods of computing counterfactual number of male deaths: (1) based on the 2015–19 linear trend in M/F ratios without subtracting HIV deaths; (2) the same but after subtracting HIV deaths (our preferred method); (3) based on the 2010–19 linear trend in M/F ratios after subtracting HIV deaths; (4) based on the 2010–19 exponential trend in M/F ratios after subtracting HIV deaths; (5) based on the 2019 M/F ratios without any extrapolation, after subtracting HIV deaths. The last row gives the sum over 15–49 age groups. All numbers were rounded to tens.

it to 2022, assuming that the decrease of M/F ratios would have continued after the pandemic, if not for the war. Note that we only used the pre-Covid data to estimate the trend, and not the Covid years (2020 and 2021). Multiplying the projected M/F ratio by the actual number of female deaths in 2022 gave the projected (counterfactual) number of male deaths in 2022, in the absence of war (open circles in Figure 1a). Finally, subtracting the baseline from the actual number of male deaths gave an estimate of excess male mortality. We estimated statistical uncertainty using predictive uncertainty of the linear fit (see Methods).

We estimated the number of excess deaths for men in all age groups from 15–19 to 55–59 (Table 1). The excess was clearly above zero in all age groups from 15–19 to 45–49, but not statistically distinguishable from zero in the age groups above 50. The sum of excess deaths over 15–49 age groups was $23\,590 \pm 1\,110$ (estimate ± standard error), corresponding to the 95% confidence interval of [21.4, 25.7] thousand.

To make this calculation more precise, we subtracted the number of HIV deaths from the number of all deaths for each gender, age group, and year (Figure S3). In Russia, male HIV deaths every year peak in the cohort born in ~1979 and female HIV deaths peak in the cohort born in ~1983 (Figure S4). This affects M/F ratios in a time-dependent way, and hence can bias our estimates as HIV deaths are unrelated to war fatalities. Summed over the same 15–49 age groups as above, we obtained $20\,620 \pm 970$ excess male non-HIV deaths, corresponding to the 95% confidence interval of [18.7, 22.6] thousand.

For sensitivity analysis, we considered several alternative modelling strategies (Table 1), always subtracting HIV deaths. First, we used a longer 2010–19 trend, obtaining $21\,790 \pm 1\,130$ excess deaths over the same age groups. This showed that our results were robust with respect to the choice of the trend length: the 5-year and 10-year trends gave very close results. Second, we used a 5-year exponential trend instead of the linear trend. Specifically, we used linear regression to predict $\log(M/F - 1)$ from year Y , assuming that $M/F = 1 + \exp(aY + b)$. This resulted in $20\,300 \pm 1\,010$ excess deaths over the same age groups, showing that the specific trend shape did not play a major role either. Third, we used the 2019 M/F ratios without any extrapolation, obtaining 15 380 excess deaths. We consider this a substantial underestimate because the M/F ratios have been decreasing in all age groups from 15–19 to 45–49 for over 20 years (Figures 1 and S1); in 2022, they should have been lower than in 2019, if not for the war.

We also obtained from Rosstat data on the number of deaths from external causes (2000–22) split by gender (Figure 2a). The M/F ratio of external deaths decreased from ~3.6 to ~3.2 over this time period, but jumped up to 3.8 in 2022 (Figure 2b). Using linear extrapolation to obtain the baseline M/F ratio, we estimated $20\,600 \pm 800$ excess male external deaths (when using 5-year trend; $20\,100 \pm 1700$ when using 10-year trend). This estimate of excess male external deaths was very close to our estimate of excess male non-HIV deaths, suggesting that most war fatalities have been correctly coded by Rosstat as deaths from external causes. See Figure S5 for the analysis of the number of ‘uncategorised’ deaths from external causes, after subtracting suicides, alcohol poisonings, murders, and road fatalities (but without information on the gender split).

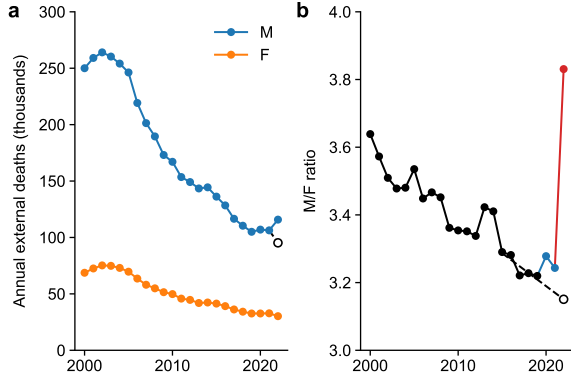


Figure 2: (a) The number of male and female deaths from external causes in Russia in 2000–22. Open circle shows the baseline (counterfactual) number of male deaths from external causes in 2022, used for computing excess mortality. (b) The ratio of male to female deaths from external causes. Dashed line shows the linear fit to 2015–19, extrapolated to 2022 (open circle). Covid-19 years (2020 and 2021) are shown in blue. The war year (2022) is shown in red.

Another data source on Russian war fatalities is a crowdsourced data set collected from obituaries on the social media and from photographs of burials taken at cemeteries in Russia, and published by the BBC News Russian and Mediazona (BBC News Russian and Mediazona, 2023). It contains records of about 14,800 Russian military personnel killed in Ukraine in 2022. This data set is incomplete; our analysis suggests that it may contain the records of up to 70% of all fatalities.

Discussion

Our paper makes two contributions. First, we introduced *excess male mortality* computed based on the male-to-female mortality ratio, as a novel method to estimate war fatalities. Second, we used this method to estimate Russian fatalities in the Russo-Ukrainian war in 2022, obtaining $20\,620 \pm 970$ excess male deaths, spread over the 15–49 age groups.

The key issue for our estimates is data reliability. Rosstat mortality data are sourced directly from the administrative IT system used to register deaths by local civil acts registration offices. Without a death certificate, it is officially not possible in Russia to organise a burial or to open a probate case. We are not aware of any evidence that military fatalities were not registered or that official mortality data were directly falsified.

Nevertheless, our estimate is likely to be a lower bound on the true number of fatalities. First, Rosstat mortality data do not include military personnel missing in action and not yet officially declared dead. According to the Russian legislation, soldiers missing in action could only be declared dead by a court order two years after the hostilities end (in April 2023 this period was changed to six months after going missing). Second, it is possible that some deaths could be registered in the regions of Ukraine annexed in 2022 (parts of the Donetsk, Kherson, Luhansk, and Zaporizhzhia regions). These deaths were not included in the Rosstat mortality statistics for 2022. We do not have data on the number of Russian missing military personnel or the number of fatalities registered in the annexed parts of Ukraine (except Crimea and Sevastopol), so we cannot directly assess the size of the downward bias in our estimates.

We performed all our calculations using the raw death numbers not normalised by population size. We did this to avoid relying on the population size estimates based on the much criticized 2021 Russian census. Note that our calculations relied on the male-to-female death ratios that implicitly accounted for changing population size (as long as the changes were the same for men and women). Indeed, the M/F ratio trend over the last 20 years was much smoother than the numbers of male and female deaths, because the latter were strongly affected by the dynamics of the population pyramid (Figures S1, S2).

The study of Karlinsky and Torrissi (2023) used excess male mortality to estimate war casualties in Armenia and Azerbaijan in the 2020 Nagorno-Karabakh war. Even though that war also happened during the Covid-19 pandemic, Karlinsky and Torrissi (2023) found near-zero excess mortality among females under age 60, implying that the effect of Covid-19 in this age group was minimal. Also, they had to extrapolate death numbers only one year into the future (from 2015–19 to 2020). Our calculation was more complicated as the Covid-19 contribution to mortality was non-negligible and we extrapolated three years into the future. A simple linear extrapolation of male death numbers would be inadequate in our case, as can be seen in Figure 1a (e.g. in the 20–24 age group).

Our analysis suggests that the crowdsourced data set on Russian fatalities collected by BBC/Mediazona (BBC News Russian and Mediazona, 2023) is incomplete and may contain the records of up to 70% of all fatalities. As per 1 November 2023, the BBC/Mediazona data set included about 36,000 records; assuming the same proportion of missing data in 2023 as in 2022, we can estimate the total number of

officially registered Russian fatalities from February 2022 to October 2023 as around 50,000. This should be treated as a lower bound on the true mortality that would include deaths that were not (yet) officially registered or were registered in the territories of Ukraine annexed in 2022. In addition, the proportion of all fatalities included in the BBC/Mediazona data set could differ in 2023 compared to 2022, in particular as Russia started recruiting prisoners and sending them to combat during the 2022/23 winter season.

Our data were split by federal region, however we found that computing excess male mortality in individual regions was less reliable and resulted in noisy estimates. For that reason, we believe that the BBC/Mediazona dataset is better suited for comparisons between regions. Indeed, [Bessudnov \(2023\)](#) showed large regional inequalities in mortality, with particularly high fatality rates in Buryatia, Tuva, and some other regions in Eastern Siberia and the Russian Far East, and low fatality rates in Moscow and St. Petersburg.

Materials and methods

Data sources

We obtained from Rosstat the data on all-cause deaths, split by age group (5-year bands), gender, and federal region, from 1990 to 2022; the data on deaths from external causes, split by gender, from 2000 to 2022; and the data on HIV deaths split by age (1-year bands) and gender, from 2006 to 2022. In all cases, deaths were grouped by the date of death (as opposed to the date of registration): a death that happened in December 2022 but was registered in January 2023 is part of the 2022 data.

Some of these, and related, datasets are publicly available online (currently a Russian IP address may be required for access):

- <https://www.fedstat.ru/indicator/58775>: number of deaths per year split by age (5-year bands), gender, and federal region, 2015–22.
- <https://www.fedstat.ru/indicator/30974>: mortality rates per 100,000 population, split by age (5-year bands), gender, and federal region, 1990–2022.
- <https://www.fedstat.ru/indicator/33459>: male population size estimates on January 1st each year, split by age (5-year bands) and federal region, 1990–2023.
- <https://www.fedstat.ru/indicator/31548>: same for female population size.
- <https://www.fedstat.ru/indicator/31620>: number of deaths per year for different causes of death, split by federal region, 1990–2022. Used for Figure S5.
- <https://rosstat.gov.ru/folder/210/document/13215>: Various statistical data on males and females, including the number of deaths from external causes split by gender, until 2021.

Statistical analysis

To compute standard errors of our linear extrapolation, we followed the approach of [Karlinsky and Kobak \(2021\)](#) and used predictive uncertainty ([Abramovich and Ritov, 2022](#)). If \mathbf{X} is the matrix of predictors (in our case, a 5×2 matrix, one column for years and another filled with ones), \mathbf{y} is the response vector (5×1 vector of M/F ratios), and we want to extrapolate the model to $\mathbf{x} = [2022, 1]$, then

$$\begin{aligned}\hat{\mathbf{y}} &= \mathbf{X}(\mathbf{X}^\top \mathbf{X})^{-1} \mathbf{X}^\top \mathbf{y} \\ \hat{\sigma}^2 &= \|\mathbf{y} - \hat{\mathbf{y}}\|^2 / (n - p) \\ s^2 &= \hat{\sigma}^2 \mathbf{x}(\mathbf{X}^\top \mathbf{X})^{-1} \mathbf{x}^\top + \hat{\sigma}^2\end{aligned}$$

where n is the sample size ($n = 5$) and p is the number of predictors ($p = 2$). Here $\hat{\mathbf{y}}$ are fitted M/F ratios; $\hat{\sigma}^2$ is the unbiased estimate of the noise variance; and s^2 is the predictive variance. To compute excess male mortality, we multiplied the extrapolated M/F ratio with the number of female deaths in 2022 (call it f), so the resulting standard error is given by sf . When summing estimated excess deaths over several age groups, we summed their squared standard errors and took a square root.

When using exponential trend, we used linear regression to predict $\log(M/F - 1)$ from year. We then computed the baseline number of male deaths as $(\exp(\hat{y}) + 1)f$. The uncertainty s we computed as above, and took $(\exp(\hat{y} + s) - \exp(\hat{y}))f$ as the uncertainty of the excess estimate.

We used NumPy (Harris et al., 2020), Pandas (McKinney, 2010), scikit-learn (Pedregosa et al., 2011), and Matplotlib (Hunter, 2007).

Data and code availability

All the data and code for the analysis (as Python notebooks) are available at <https://github.com/dkobak/excess-mortality-war>.

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Supplementary Figures

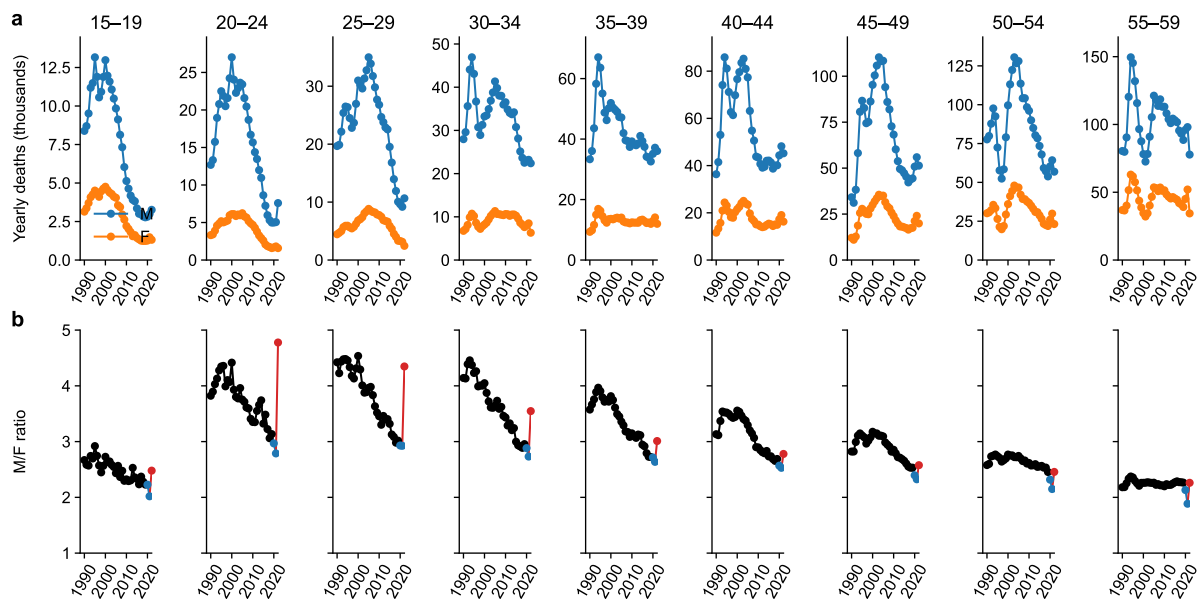


Figure S1: Same as Figure 1, but showing 1990–2022 values.

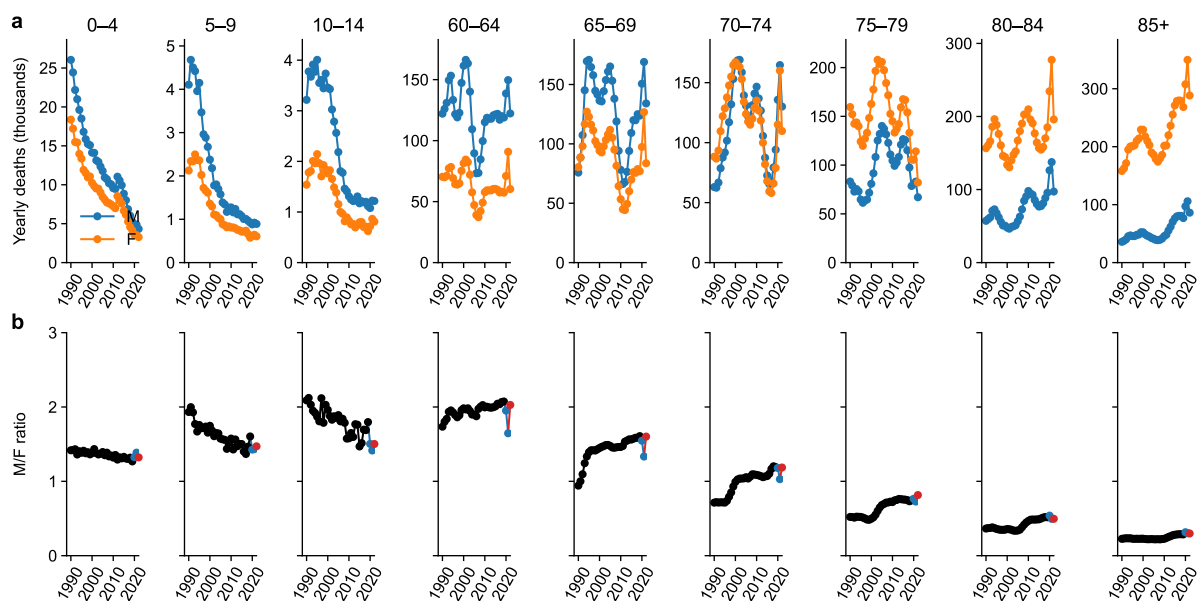


Figure S2: Same as Figure S1, but showing all other age groups: younger than 15 and older than 60. None of these groups shows any noticeable excess male mortality in 2022.

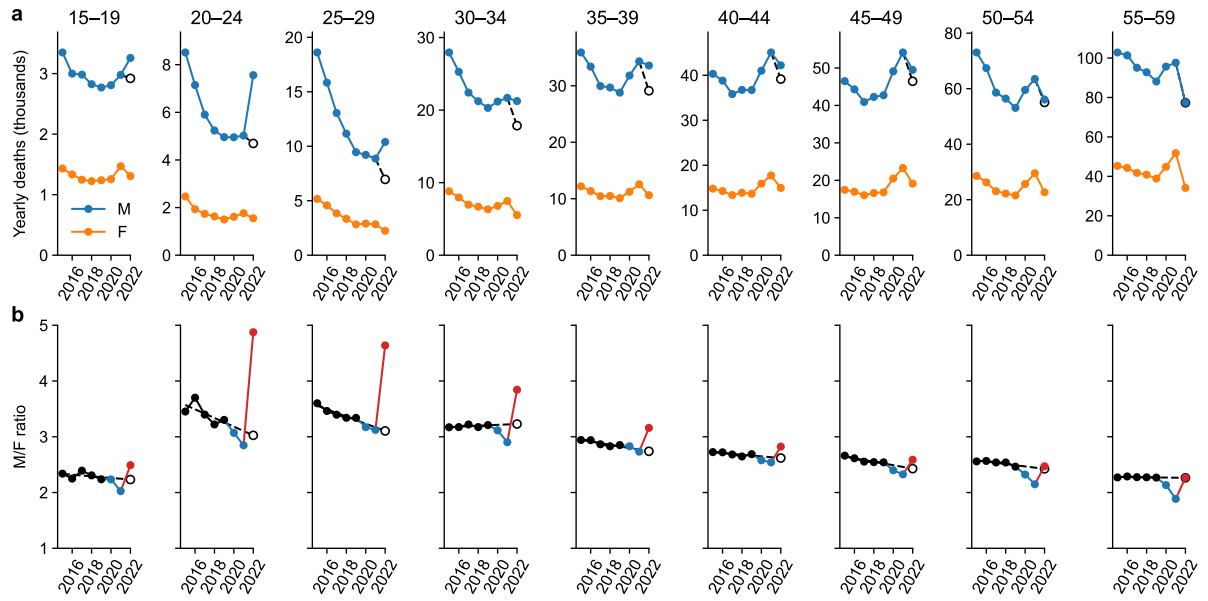


Figure S3: Same as Figure 1, but after subtracting HIV deaths.

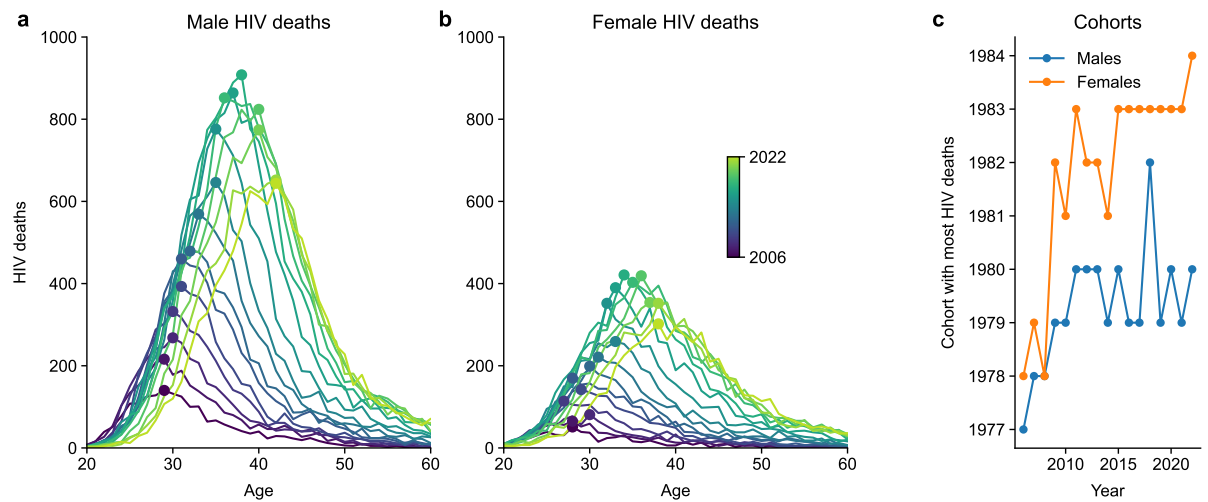


Figure S4: HIV deaths in Russia, 2006–2022. (a) Male HIV deaths by age (1-year age brackets), for all years from 2006 (blue) to 2022 (orange). Dots mark the peaks of each distribution. (b) The same for female HIV deaths. (c) The cohort (birth year) having peak HIV deaths, as a function of year. Male HIV deaths peak in the 1979–1980 cohort, female HIV deaths peak in the 1983 cohort.

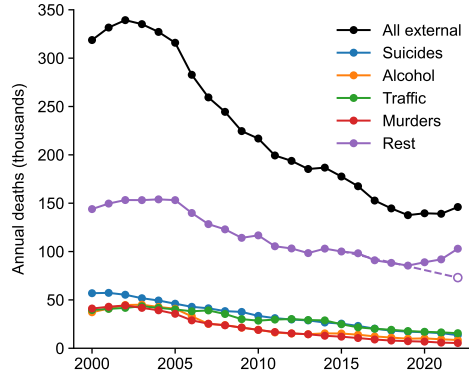


Figure S5: Number of deaths from external causes per year. Black line shows all deaths from external causes. Suicides, alcohol poisoning, traffic incidents, and murders are shown separately (further subcategories of external deaths are not available). We computed the remaining, uncategorised, external deaths by subtracting these four categories. Dashed line shows linear fit to these uncategorised external deaths over 2015–19. Open circle shows its extrapolation to 2022. Excess number of external deaths was 29 890. Note that Covid years (2020 and 2021) also showed some excess, and part of the 2022 excess could be due to the pandemic and not due to war. Applying the same procedure to the total number of external deaths yielded 41 440 excess deaths; here the effect of the pandemic may be stronger. See Figure 2 for the analysis of the number of external deaths split by gender; using M/F ratios allowed us to remove the effect of the pandemic.