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RESEARCH ARTICLE

Evaluation Criteria for Undercounting of Age-Specific Suicide Mortality

Victoria G. Semyonova [1], Aleksandr V. Zubko [1, 2], Tamara P. Sabgayda [1, 2]

1 *Institute for Demographic Research of the Federal Center of Theoretical and Applied Sociology of the Russian Academy of Sciences, Moscow, 119333, Russia*

2 *Russian Research Institute of Health, Moscow, 125206, Russia*

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Abstract

The paper analyses the age structure of mortality from suicide, injuries with undetermined intent in general, as well as hanging or jumping/falling from heights with undetermined intent as a potential indicator of latent suicides.

It is shown that the age profile of suicide mortality has fundamentally changed over the last 30 years: during the 1990s crisis, a sigmoidal mortality curve with a peak in middle age developed among men, while at the height of the crisis, in the mid-1990s, the maximum age-specific mortality rates were observed among the 50-54-year-olds.

Fundamental gender differences in the age profile were only noted during the systemic crisis of the 1990s: as Russian men developed a sigmoidal suicide mortality curve, the age profile of mortality of Russian women was characterised by a stable increase in age-specific indicators starting from age 25-29, while in the mid-1990s women, too, experienced a mortality peak among the 50-54-year-olds.

In the 2000s, a gradual flattening-out of the mortality peak in middle age and reaching a maximum at old age took place. Post-2010, a further normalisation of the suicide mortality profile with formation of a plateau at working ages was observed.

A comparative analysis of the age profile of suicide mortality and mortality from hanging and jumping/falling from heights with undetermined intent corroborated the hypothesis of these causes being a potential reservoir of latent suicide, which raises the suicide losses of men, from 80% among the 15-24-year-olds to 50% in older individuals, while among women the suicide mortality rate doubles at all ages above 15 years.

Keywords

suicide mortality, undercounting of suicide mortality, injuries with undetermined intent, age profile of suicide mortality

JEL codes: J1, J11, J19.

Introduction

Suicide is the only external cause which is covered in the Sustainable Development Goals presented to the UN General Assembly in 2015 as a "blueprint for achieving a better and more sustainable future for all" [UN 2015].

This seems more than justified: according to the WHO estimates, suicide is currently the fourth leading cause of loss of life among young people (age group 15-29) [WHO 2014], and the losses from suicide are projected to further grow [Cavanagh et al. 2003; Akyuz et al. 2020].

This certainly requires special efforts on the part of society to reduce the suicide mortality; thus, only two external causes were included in the Demographic Policy Concept of the Russian Federation until 2025, road traffic accidents and suicide [Decree of the President... 2007].

At present, the relevance of suicide mortality research is obvious: Russia is going through a difficult period due to both geopolitical and socio-economic factors, a kind of "change of era," and during such periods one cannot deny the risks of suicide mortality growth [Semyonova et al. 2020a].

In this context, the fact that the previous "change of era", the reforms of the 1990s, saw a sharp increase in suicide mortality [Leon & Shkolnikov 1998; Semenova et al. 2005] is particularly alarming, and avoiding a return to a similar situation seems essential.

That said, however, when developing programmes and measures towards reduction of suicide mortality, it should be remembered that, paradoxically, suicides are perhaps the only external cause where a Net Zero goal cannot possibly be set, unlike in the case of road traffic accidents: suicides have been and will continue to be. This predetermination is inherent in the very nature of suicide, the only external cause of death with an essential endogenous component [Durkheim 1994; Conner et al. 2003].

These circumstances bring to the forefront a question of the real level of losses from suicide among the Russian population.

The problem of evaluating and assessing suicide mortality is relevant not only for Russia, but for most post-industrial societies too, as evidenced by a number of publications on the accounting for losses from suicide in a number of European countries [Andreev 2016; Vasin 2015; Ivanova et al., 2013; Semenova et al. 2019; Golenkov et al. 2021; Yumaguzin & Vinnik 2017, 2019; Björkenstam et al. 2014; Kapusta et al. 2011; Rockett 2010; Rockett et al. 2011, 2014; Semyonova et al. 2020a; Värnik et al. 2010a, 2010b, 2012].

Most researchers point to "injuries with undetermined intent" (according to ICD-9, "injury by unspecified means") as a reservoir of latent suicides [Golenkov et al. 2021; Yumaguzin & Vinnik 2019; Björkenstam et al. 2014; Gavrilova et al. 2008]. Indeed, according to ICD-10, "This section covers events where available information is insufficient to enable a medical or legal authority to make a distinction between accident, self-harm and assault", i.e., by stipulation, suicide falls under this heading.

Earlier studies indicate that the above undercounting has been systematically persistent in Russia, which makes it necessary to reconstruct the real scale of losses due to suicide [WHO 2011; Semenova et al. 2004, 2005; Yumaguzin & Vinnik 2017].

Our approach to evaluating the potential reservoir of latent suicide mortality is based on the analysis of incident realisation [CDC 2013; Semenova et al. 2004; Daine et al. 2013; Huguet et al. 2014]. Fundamental differences between homicidal and suicidal methods have been shown to exist, which made it possible to distinguish hanging/suffocation (Y20) and

jumping/falling from heights (Y30) with undetermined intent from incidents of injuries with undetermined intent as latent suicides.

The proposed approach to assessing latent suicide mortality is based on its nosological aspects. However, the age context should not be ignored too: regularities of the age profile formation of the officially registered and presumed latent suicide mortality are major arguments to corroborate or refute this hypothesis [Semenova & Evdokushkina 2003].

Therefore, this study aims at identifying the specificities of suicide mortality during a crisis or stable periods of socio-economic development, as well as verifying a possible undercounting of suicide mortality due to its transition into latent form.

Materials and methods

The analysis relies on Rosstat data on age- and gender-specific mortality from suicides or injuries with undetermined intent for 1989-2021. Furthermore, relevant indicators from the Human Mortality Database were used (the time series of data for Russia ends in 2018).

Results

The timeline of suicide mortality of the Russian population in the post-Soviet period can be divided into two parts: a period of short-term multidirectional trends of the late 1980s – early 2000s, and a period of sustainable positive trends that emerged in the early 2000s and has persisted to date. The most adverse situation undoubtedly took place in the first half of the 1990s, at the height of the crisis caused by the "shock therapy": in 1989-1994 the suicide mortality rate of the Russian population grew by 63 per cent for men and 20.2 per cent for women. A compensatory decline in the indicators followed in the second half of the 1990s, but the 1998 default led to a synchronous increase in suicide mortality. So, the suicide mortality grew almost 1.5 times for men and more than 10% for women during the first post-Soviet decade.

In the 2000s, the suicide mortality rate of the Russian population demonstrated stable positive trends, which were not subsequently interrupted by either the 2008 global crisis or the social impact of the COVID-19 pandemic. From 2010 to 2019, the rate of positive trends markedly accelerated: in the 2000s, the average annual rate of decline of the above indicators was 3.7% for men and 3% for women, whereas in 2010-2019 these reached 4.9% and 5.2%, respectively. Moreover, during the COVID-19 pandemic crisis, the rate of positive trends slowed only slightly in the first year of the pandemic, to 4% and 3.1%, before showing a kind of record highs in 2020-2021, at 5.2% and 6.5% per year (Fig. 1).

Therefore, in the 2000s, the suicide mortality of the Russian population decreased 3.8 times for men and 3.6 times for women, i.e. the rates of Russia's positive trends were several times better than those observed in Western Europe: for example, the rates of suicide mortality decline in the European Union over 2000-2018 before May 2004 were 18.6% and 17.8% vs. 3.3 and 3 times, respectively (Fig. 2).

Because of the above trends, Russia's gap with Western Europe in the 2000s narrowed from more than four times to 60 per cent for men in 2018; among women, Russia's gap in 2000 was greater than twofold, while in 2018 the gap was, on the contrary, in favour of Russia, by nearly 20 per cent.

However, suicide mortality rates, as well as their rates of decline, require careful verification: as mentioned above, the ICD-10 lists a reservoir of latent suicides such as injuries with undetermined intent (Y10-Y34), and, unfortunately, the mortality rates from these vague causes are abnormally high and hardly declining.

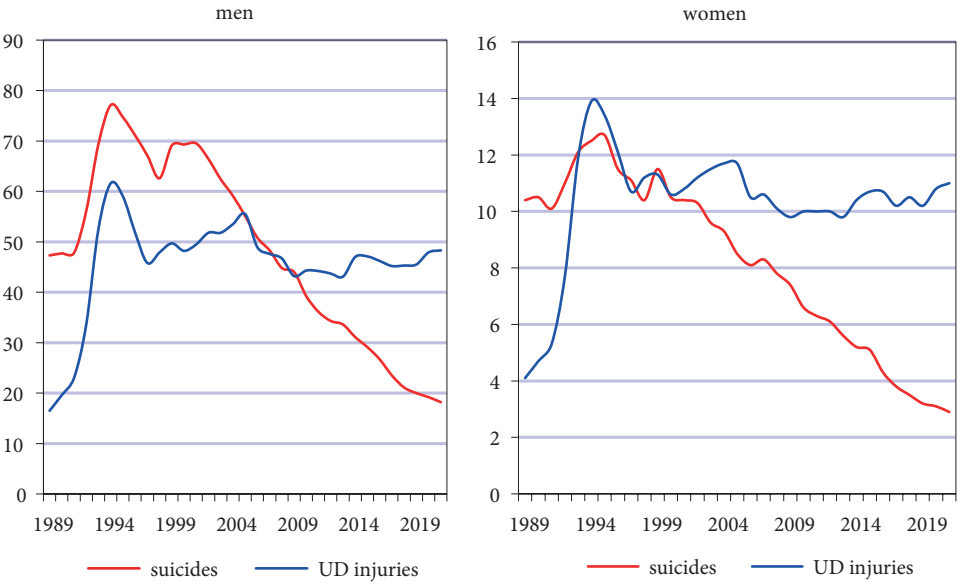

Figure 1. Mortality trends for suicides or injuries with undetermined intent (UD) of the Russian population in 1989-2021 (standardised mortality rate per 100,000). *Source*: Rosstat data

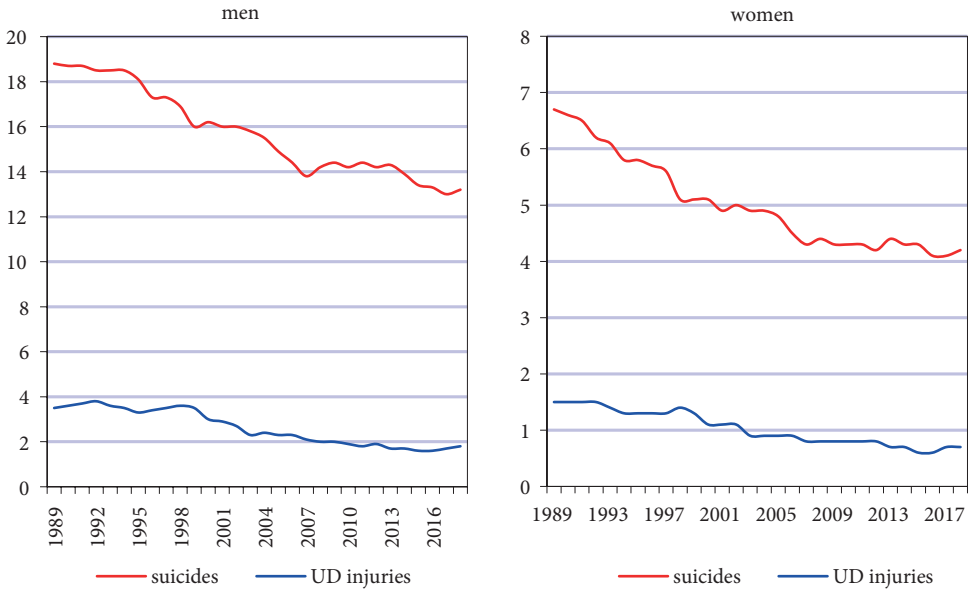

Figure 2. Mortality trends for suicides or injuries with undetermined intent (UD) of the EU-15 population over 1989-2018 (standardised mortality rate per 100,000). *Source*: Rosstat data

Therefore, in Russia in the 1990s, the mortality rate from injuries with undetermined intent (according to ICD-9, unspecified injuries) increased 3-fold among men and 2.8-fold among women; in the 2000s, it decreased but slightly (by 10.4% and 7.5%, respectively), which, however, was compensated by a 9% and 10% growth in 2010-2021, respectively. Note that, unlike suicide mortality, the losses from events with undetermined intent continued to grow during both the first and the second year of the COVID-19 pandemic, so that the mortality from injuries with undetermined intent grew by 6.2% among men and 7.8% among women in 2019-2021 (Fig. 1).

Due to the above trends, the 2021 rates are almost identical to the 2000 mortality rates, being equal to 48.3 vs. 48.2 for men and 11 vs. 10.6 for women per 100,000 of the corresponding population. During the 2000s (2000-2018), mortality from injuries with undetermined intent in Western Europe declined by 39.7% among men and 39% among women, which resulted in Russia's gap growing over the period from 16- to 25-fold among men and from 9- to 15-fold among women in 2018 (Fig. 2).

When comparing the situations in Russia and the EU-15, it should be pointed out that in Western Europe in the 2000s the suicide mortality significantly and steadily exceeded the losses from injuries with undetermined intent, whereas in Russia the same among men was only observed until the early 2000s, while among women the mortality from injuries with undetermined intent exceeded the losses from suicide as early as the mid-1990s. Post-2005, these changes developed into a steady trend, and at present the excess of mortality from injuries with undetermined intent over suicide deaths is 2.7 and 3.8 times, respectively (against the reverse ratio in Western Europe, at 7.3 times among the men and 6 times among the women) (see Fig. 1-2).

Therefore, undercounting of the loss of the Russian population from suicide seems to be a relevant issue. In this context, let us point out that an approach based on the similarity of the officially established methods of suicides and incidents classified as injuries with undetermined intent was proposed previously.

The previously proposed approach addressed the nosological aspects of incident verification. However, age-related aspects should not be neglected, which would allow to corroborate or refute classification of such incidents as latent suicides.

A marked transformation of the age profile of suicide mortality over the last 30 years, especially among men, is rather unexpected. Fig. 3 shows that the age profile of suicide mortality of Russian men in 1989-1999 was characterised by a pronounced peak at age 50-54, as a result of which the 1993-1995 rates at these ages exceeded the suicide mortality in the oldest group (age 85 and above), being equal to 128.1 versus 125.3; 138.4 versus 132.2; and 131.1 versus 120.7 per 100,000, respectively, for each of the above three years.

As the suicide mortality declined, a relative normalisation of the age-specific mortality curve was observed; however, the comparison of the data for 1989 (the last stable year of the Soviet period) and those for 1999 shows marked differences: at ages up to 75, the 1999 data are significantly higher than the 1989 data, with the reform period's gap varying from more than two-fold among the 20-24-year-olds to more than 25% among the 70-74-year-olds. However, at older ages the situation is reversed: suicide mortality of the 80-84-year-olds of both sexes in 1999 was almost a quarter, and that of men aged 85 and above, 8% lower than in 1989.

The following decade of 2000-2009 was characterised by an increase in the same indicators up to age 25-29, then a plateau that is formed with an unexpected decline in the indicators among the 60-64-year-olds, and then a growth of the indicators reaching the maximum

in the oldest ages. It is seen from Figure 3 that the age profiles for 2000-2002 featured a local rise at middle age, with a significant growth in mortality affecting men aged 45-59 in 2000, the 45-54-year-olds in 2001, and only the 45-49-year-olds in 2002, following which the age curve flattened out considerably.

Post-2010, the age profile of suicide mortality among Russian men is characterised by an increase in the rates to a local maximum at age 30-34 in 2010-2013, at age 35-39 in 2014-2017, and at age 40-44 after 2017. This is followed by an extremely slow decline in age-specific indicators, with a local minimum among the 60-64-year-olds, which had started to develop during the previous decade. After age 65, the age-specific rates rose to a maximum at the oldest age.

All age groups contributed to the above-mentioned decline in suicide mortality in 2010-2021, with the rate of positive change exceeding two-fold in ages under 55 while nearing three-fold among the 25-29-year-olds. Even at ages 85 and above, the 2021 rates were lower than those in 2010 by almost 20% for men and were almost halved for women.

Among men, there was a marked transformation of the age profile over time; among women, up until the early 2010s the age profile of suicide mortality differed markedly from other periods (Fig. 3). Therefore, Russian female suicide mortality grew with age on a nearly linear trajectory in the 1990s, with the maximum achieved in the oldest age group and a local peak at the age 50-54 developed in 1992-1997. It should be noted that among Russian women, as among men, the growth of suicide mortality in the 1990s was driven by the working-age groups, primarily the 20-29-year-olds, whose rates grew in 1989-1999 by 54.7 per cent and 69.3 per cent, respectively, as the suicide mortality of women aged 55 and above declined, ranging from 0.8 per cent among the 65-69-year-olds to 16.5 per cent among the 60-64-year-olds. Furthermore, even in 1995, when the suicide mortality rate of Russian women was at its maximum in more than 30 years, the growth of the indicators was determined by the suicide mortality of persons aged over 70.

In 2000-2009, the age curve of suicide mortality for both sexes was characterised by a significantly slower increase of the indicators with age among the working-age groups than in the previous decade, and the local peak among the 50-54-year-olds gradually flattened out producing a local minimum among the 55-59-year-olds. All ages showed a decline in suicide mortality between 2000 and 2009, but the maximum rate of positive change was found among the 50-69-year-olds, whose indicators fell by more than 40 per cent.

Post-2010, the age profile of suicide mortality among Russian women takes up conventional forms, being characterised by a plateau at working age and a stable increase with age above age 65. It should also be noted that women, like men, have a local minimum at age 55-64.

During 2010-2021, the age profile of suicide mortality of the Russian population was characterised by minimal gender differences: among men, we can only point out a growth in age-specific indicators up to age 30-34, which is not the case for women.

Due to the above changes, the decline in female suicide mortality between 2010 and 2021 was generally driven by a more than two-fold decline in the rates across all age groups.

In this context, the evolution of the age profile of mortality from injuries with undetermined intent, where a latent suicide component is inevitably present, is more than revealing.

As for the 1990s situation, it should be noted that the age profiles of mortality of Russian men during the last Soviet years (1989-1991) differ markedly from the indicators of the first post-Soviet decade (primarily in terms of their levels). The 1989 mortality curve has a different shape: a rise in the age-specific indicators up to age 40 with a plateau at age 40-69, and a rise in the indicators reaching the maximum at oldest ages (Fig. 4).

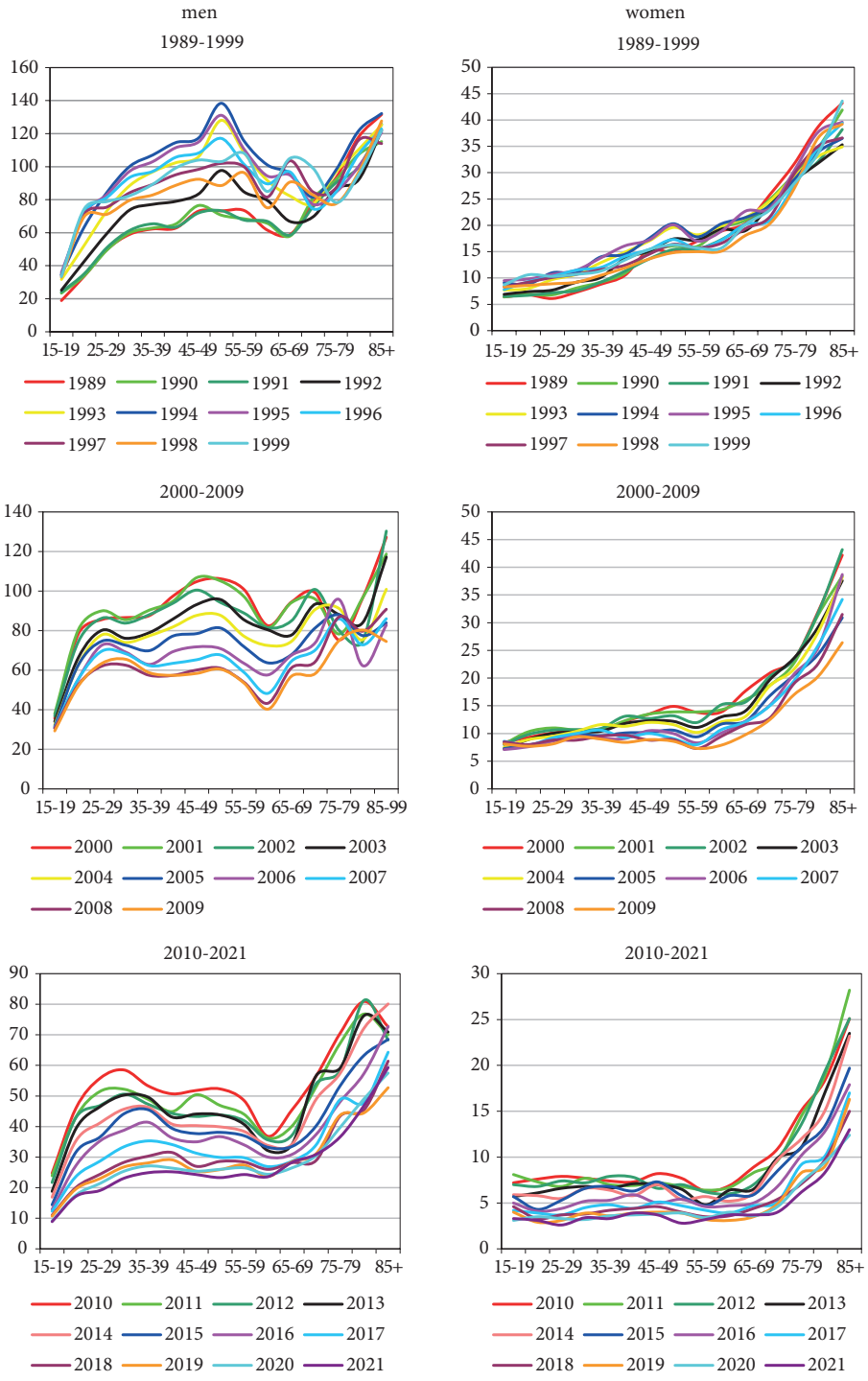

Figure 3. Age profile evolution of adult suicide mortality in Russia in 1989-2021 (age-specific mortality rates per 100,000). *Source*: Rosstat data

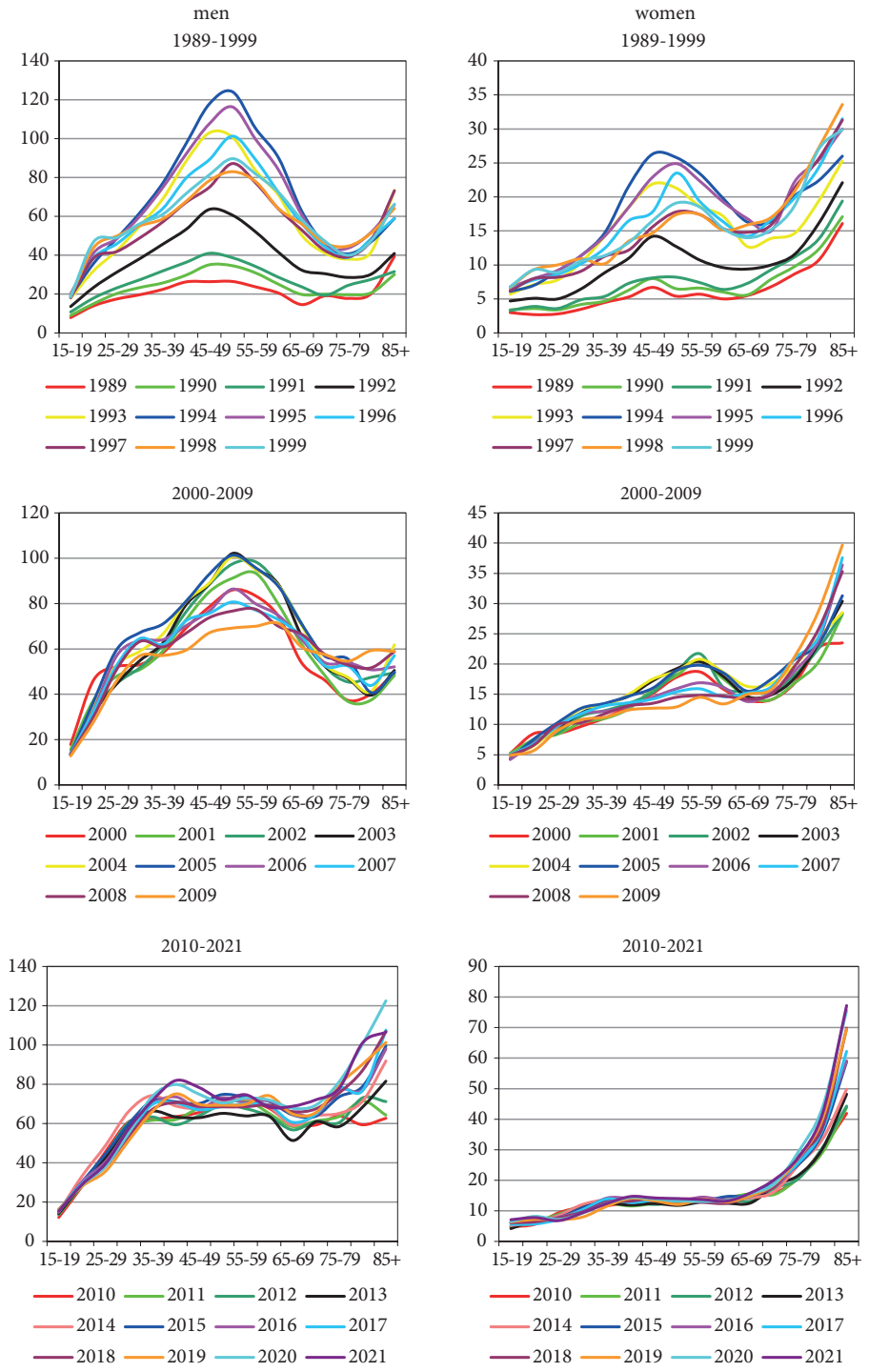

Figure 4. Age profile evolution of adult mortality from injuries with undetermined intent in Russia in 1989-2021 (age-specific mortality rates per 100,000). *Source*: Rosstat data

The 1992 age curve is in an intermediate position, and the age distribution of Russian male mortality from injuries with undetermined intent (according to ICD-9, "unspecified injuries") for 1992-1999 is characterised by a sharp increase in the rate to a maximum at age 50-54, then a decline to a local minimum at age 75-79, and then an increase in the age-specific rates at the oldest ages.

Therefore, the increase in mortality of Russian men from injuries with undetermined intent in 1989-1999 was driven by all age groups: the minimum growth of mortality (while reaching nearly 70%) was shown by age 85 and above, and the maximum growth (four-fold), by the 65-69-year-olds.

In 2000s, the curve of mortality from injuries with undetermined intent was generally characterised by the patterns developed after 1993, while the peak in the 50-54 age group gradually flattened out, so that a plateau similar to the 1989 trajectory developed across the middle age groups by the end of the 2000s. However, unlike the 1989 profile, the maximum values of age-specific coefficients were observed among the 55–64-year-olds rather than the oldest-age men.

The gradual transformation of the mortality curve went along with a decline in the rates for men aged under 65 (from nearly 40% among the 20-24-year-olds to 2.2% among the 35-59-year-olds) as the mortality rates among older men grew, nearly 1.5-times among the 75-84-year-olds.

Post-2020, the trends emerging in the 2000s finally took shape: a mortality rate rises up to age 40, then a plateau is reached and a decline to a local minimum among the 65-69-year-olds, with a further growth of indicators to a maximum in older ages. Therefore, the age profile of Russian male mortality from injuries with undetermined intent differs from the suicide mortality curve by a 5-year time shift: while the plateauing of the suicide mortality curve during the most recent period of research was observed among men aged 30-44 and the local minimum, among the 60-64-year-olds, whereas the same for mortality from injuries with undetermined intent, at ages 40-44 and 65-69, respectively.

It should be noted that all age groups contributed to the growth in Russian male mortality from injuries with undetermined intent in 2010-2021, except for the 25-29- and the 30-34-year-olds, whose mortality rates declined by 13.5% and 5.4%, respectively. The maximum growth rate in age-specific indicators, which amounted to 70%, was observed among men aged over 80.

Among women, the development patterns of the age profile of mortality from injuries with undetermined intent in 1989-1999 are characterised by a marked similarity to those among men: thus, the age-specific indices during the last three Soviet years are characterised by significantly lower levels across the entire age range and the absence of a mortality peak in the middle-age groups.

The post-Soviet period saw the development of a peak among the 45-54-year-olds, with a decline to a local minimum among the 65-69-year-olds and a further mortality growth to a maximum in older ages.

Therefore, in the 1990s, as the curve trajectories remained generally similar to one another, the main gender difference in the age profiles of the Russian population was that women reached their maximum at older ages rather than middle age in case of men.

Such transformations resulted in a multiple growth of the Russian female mortality rate from injuries with undetermined intent at all ages, except for ages 85 and above, among whom the rates grew by 86%.

In the early 21st century, an age profile transformation of the Russian female mortality took place, which can be viewed as the opposite of what had been observed in the 1990s: while the trend of growing suicide mortality rates with age persisted, the peak in the middle age gradually flattened out. As a result of these shifts, there was a decline in mortality in two

age groups in 2000-2009, young people (15-24-year-olds) and people of older working age and early retirement age (40-64-year-olds). As the above took place, there was a growth in mortality among young women (aged 25-39) and older women, with the maximum growth, nearing 70 per cent, observed in the oldest age group.

In 2010-2021, the age curve of Russian female mortality from injuries with undetermined intent became undoubtedly similar to the age profile of suicide mortality, with the plateauing by age 30 and a marked growth of age-specific indicators above age 75.

This transformation resulted in a situation where the only age group with a marked (over 20%) decline in the indicators was young women (aged 25-34), as a significant mortality growth took place among women aged above 65. During this period, the mortality rate of older women grew by almost three quarters to reach the maximum. At the same time, the fact should not be ignored that young women (aged 15-19) were the second fastest growing age group, with their mortality rate growing by 43.3%.

Such changes from decade to decade in the age profile of losses from injuries with undetermined intent among both men and women, given the differences in the respective causes – which, as a reminder, include suicide, homicide, and accidents – are evidence of fundamental differences in the nosological range of the causes. The general direction of the transformations suggests that, judging by the similarity of mortality curves, the losses from injuries with undetermined intent increasingly include latent suicides.

Unfortunately, this hypothesis can only be tested from 2011 onwards, when significant amendments were made to the brief classification system of causes of death, as adopted in Russia.

Earlier studies showed that, judging by the similarity of the incident mechanics, hanging and jumping/falling from heights (Y20, Y30) occur most often among incidents that should be re-classified as latent [suicide] [Semyonova et al. 2020b].

Tellingly, the patterns of age-specific configuration of the curve of mortality from incidents classified as latent suicides are almost identical to those for the age profile of suicide mortality: a plateau at working age (among men, the plateauing comes along with a growth in age-specific coefficients up to age 30-39) with a local minimum of indicators at age 60-64, followed by a mortality growth to a maximum in the oldest age group (see Figs. 3 and 5).

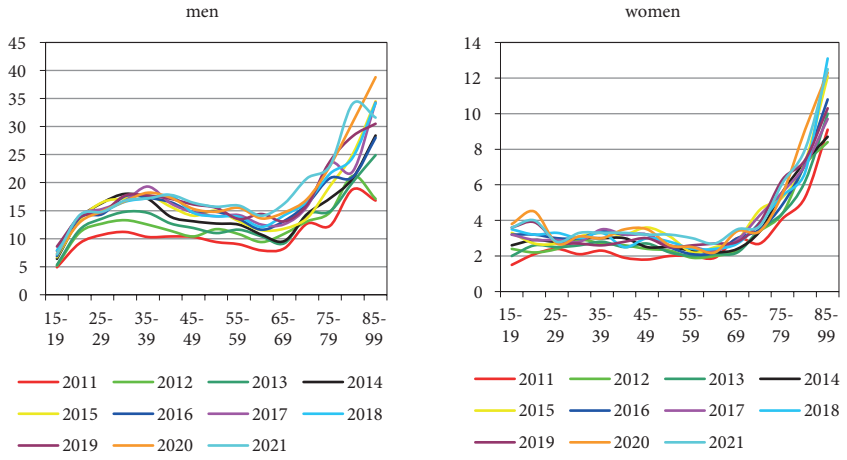

Figure 5. Age profile evolution of cumulative adult mortality from hanging or jumping from heights with undetermined intent in Russia in 2011-2021 (age-specific mortality rates per 100,000). *Source*: Rosstat data

It should be noted that the external similarity of the age-specific profiles of mortality from latent or officially reported suicides is corroborated by such objective indicators as rank correlation coefficients: their minimum values, from 2011 onwards, amounted to 0.94, but, as a rule, did not fall below 0.97-0.98.

Therefore, the hypothesis of suicidal nature of falls or hangings with undetermined intent is corroborated not only in the nosological but also in the age-specific context.

A legitimate question now is the estimation of real losses from suicides, i.e. suicide mortality including its latent component. We emphasise once again that we are talking here not about established indicators, but rather the estimated potential reservoir of latent suicide mortality.

Table 1. Excess of the estimated real suicide mortality rates of Russia's adult population over the official indicators in 2011-2021 (in %)

	2011	2012	2013	2014	2015	2016	2017	2018	2019	2020	2021
men											
15-19	20.5	24.1	28.4	38.1	46.3	53.6	63.3	71.6	80.3	80.6	80.2
20-24	21.3	25.7	29.5	38.1	42.0	50.2	59.4	69.3	70.3	73.6	82.3
25-29	20.8	27.2	29.3	39.8	44.9	40.7	53.3	60.8	64.0	69.6	77.8
30-34	21.5	26.3	29.4	39.3	39.0	45.4	50.3	58.7	66.0	65.9	72.7
35-39	21.1	26.4	29.5	36.9	39.1	41.8	54.7	56.7	62.8	67.3	69.3
40-44	23.1	25.6	29.4	34.0	39.8	45.6	47.8	56.2	58.8	65.7	70.7
45-49	20.3	24.0	26.9	32.5	37.3	41.9	47.0	54.2	63.4	60.3	67.4
50-54	19.9	26.8	25.2	31.9	39.3	40.3	46.8	49.0	60.0	56.9	67.3
55-59	20.5	25.8	28.5	32.6	35.3	39.8	47.9	49.0	49.2	58.4	65.3
60-64	21.8	26.4	32.4	31.7	34.5	38.8	46.6	46.6	61.0	55.8	59.9
65-69	20.8	29.4	26.9	28.1	35.3	42.8	44.0	50.5	45.9	55.5	57.5
70-74	24.1	24.3	25.4	29.4	34.1	43.4	46.6	57.3	51.7	56.0	67.2
75-79	18.4	25.2	25.3	30.0	36.3	43.2	48.1	49.8	54.4	57.9	63.0
80-84	24.5	26.1	26.4	28.8	39.7	36.6	46.0	53.8	63.5	62.9	72.6
>85	24.1	25.0	35.1	35.5	50.4	38.6	53.3	55.7	57.9	67.6	53.4
women											
15-19	19.0	33.9	34.5	43.2	56.9	63.7	75.1	77.9	90.0	122.3	108.6
20-24	28.5	32.4	41.7	50.0	63.4	78.3	73.4	97.6	133.6	127.6	130.3
25-29	34.5	32.4	37.6	51.9	51.3	69.4	76.4	86.8	90.2	82.2	105.9
30-34	27.3	40.6	37.7	46.1	47.1	57.6	62.4	78.9	69.0	97.7	95.8
35-39	32.9	33.8	42.7	47.1	48.9	63.4	74.1	78.3	74.3	82.0	97.3
40-44	28.2	33.2	35.0	51.3	51.4	54.8	72.5	57.5	72.4	95.8	84.3
45-49	24.7	37.3	38.3	36.1	49.0	63.6	62.3	65.3	73.8	91.7	87.7
50-54	30.0	32.3	33.3	47.5	53.4	45.5	55.1	70.8	65.5	66.8	112.8
55-59	31.0	30.1	42.2	40.4	46.9	46.4	59.0	68.3	79.1	72.7	94.2
60-64	27.9	33.5	33.1	42.9	43.5	46.3	57.2	68.0	89.0	55.9	71.6
65-69	36.3	32.4	34.4	39.0	50.0	60.1	62.7	62.6	79.6	93.2	94.5
70-74	27.9	35.2	35.3	34.4	53.9	52.4	84.6	71.7	80.8	74.0	91.1
75-79	28.6	32.2	39.2	46.6	47.9	48.1	60.9	76.9	75.4	74.7	98.4
80-84	27.9	36.3	36.2	48.4	54.1	55.7	69.5	68.3	81.3	95.8	95.6
>85	32.3	33.6	42.6	37.6	61.3	60.5	57.0	87.6	63.1	99.2	96.4

Table 1 shows that, starting from 2011 onwards, the excess of estimated mortality rates over the officially established ones has been steadily increasing in all age groups among both men and women. Therefore, for men in 2011, the estimated suicide mortality rate in all age groups exceeded the official rate by 20%, with the maximum excess (about 24%) reached at the very old age. However, by 2021, the excess of estimated over official rates ranged from 82.3% for the 20–24-year-olds to 1.5 times for men aged 85 and above.

The situation among women was similar to that: in 2011, the excess of estimated mortality rates over the official ones grew from 19% for the 15-19-year-olds to 32.3% for women aged 85 and above. By 2021, the excess in all age groups was close to two-fold, however, a slight decline with age is observed in the respective rate, from 2.3 times for the 20-24-year-olds to two-fold for women of very old age.

Therefore, not only has the latent component significantly increased over the past 11 years, but its age vector has also changed: whereas in the early 2010s the excess was growing, in the early 2020s it was declining with age.

Discussion

The first thing that should be noted is the most unexpected result of all obtained, i.e. the change in the configuration of the age profile of suicide mortality during different periods of Russia's recent history.

During the systemic crisis (now acute, now sluggish) that undoubtedly marked the 1990s, the age profile of male suicide mortality was characterised by a certain similarity to the age-specific homicide mortality curve, with the maximum of age-specific indicators at middle age, a subsequent decline and then some growth in oldest ages.

It is particularly relevant for that period that the WHO combines deaths from homicide and deaths from suicide into a single category of "violent mortality" [Borges et al. 2010].

Crucially, it is in times of crisis that this specificity of age configuration of suicide mortality develops, and we emphasise that in the last relatively stable year of 1989, the age profile of suicide mortality had no distinct peaks, and relatively low levels of suicide mortality, as well as its age patterns, persisted up until 1993.

At the beginning of the 21st century, the age curve in the working-age population, characterised by the recovery from the socio-economic crisis of the previous decade, gradually flattens out due to the elimination of the middle-age peak which passes into a descending plateau with a local minimum at age 60-64 (its nature is not quite clear), and a further growth of indicators with age, reaching their maximum values at very old ages.

During the 2010s, the modern suicide mortality curve took its final shape, with an increase in age-specific indicators up to age 35-39, plateauing and then showing an exponential growth at older ages. Interestingly, the local minimum at age 60-64 is gradually flattening out during the same period.

It is more than revealing that the suicide mortality curve for Russian women was characterised by a sharply pronounced age specificity precisely during the crisis years of the 1990s: as male mortality followed a sigmoidal curve, female suicide mortality steadily grew with age, from age 25 onwards. At the same time, during the crisis years of 1993-1996, women, too, developed a local maximum among the 50-54-year-olds.

In the 2000s, women still showed a fairly pronounced mortality growth with age, but it gradually flattened out towards the end of the decade.

In the 2010s, a plateau of suicide mortality in working age groups finally took shape. At the same time, among women, a specific feature was the final development of a local minimum among the 55-64-year-olds, which began to emerge in the mid-2000s.

Therefore, we can state that the variation of the suicide mortality rates of the Russian population came along with a significant transformation of the age curve, while the working-age groups largely determined the age curve both during the 1990s crisis and at present (post-2010): they demonstrate the highest rates of both negative and positive trends.

However, both the above-mentioned levels, rather low as they are, especially for women, and suicide mortality trends of the Russian population with their very high rates of decline, unfortunately, raise well-founded doubts as evidenced by data on mortality from injuries with undetermined intent (Y10-Y34). As we remember, the losses from this section of causes, which is stipulated to include a latent suicide component, did not show any pronounced positive trends while being characterised by abnormally high mortality rates throughout the period under study [Semenova & Antonova 2007].

Furthermore, a minimum of two incident types which are part of this section are the ones that largely determine the ways of committing suicide in Russia: hanging, in the first place, and, to a great extent, jumping from heights [Kvasha et al. 2014].

This study was supposed to verify the above hypothesis by analysing the age-specific aspects of mortality: indeed, if the age profile of mortality from these incidents falling under the category of "undetermined intent" differed in any significant way from the suicide mortality curve, then that would refute the proposed hypothesis.

Unfortunately, it was only possible to test this hypothesis after the amendment was made to the brief classification of causes of death adopted in Russia in 2011, whereby incidents of losses from injuries with undetermined intent were separated into specific headings, and, as a result, it was possible now to estimate mortality from hanging/suffocation (Y20) and jumping/falling from heights (Y30) with undetermined intent as a potential reservoir of latent suicide.

The hypothesis has been reliably corroborated, at least at the statistical level: this is evidenced by the general patterns of the age profile of officially reported or latent suicides, and by the correlation coefficient between the age distribution of mortality from these incidents, which has never fallen below 0.94 and in some years amounted to 0.98-0.99.

Therefore, we can state that, with due account of the latent component, the real level of losses from suicide in Russia can currently exceed the official figures by 80% to 50% among men, though decreasing with age, and approximately two times among women, regardless of age.

This magnitude of undercounting may seem exaggerated, but it appears that it may further include a suicide component from falls from heights classified as accidental (W13), first, among the symptoms, signs or misclassified conditions; second, those reported under the heading "cause of death unknown" (R99); and thirdly, those reported under drug poisoning, both accidental and with undetermined intent, the vast majority of those deaths being attributable to the use of sleeping pills, sedatives, or psychotropic substances (X41, Y11).

The reasons for the above are analysed in detail in a 2020 study [Semyonova et al. 2020a, 2020b; Karaush et al. 2020; Bokhan et al. 2020]. Let us just point out that specialised comprehensive research is required, including that of the methods used by statistical services, law enforcement agencies, and forensic departments, with a view to developing measures towards normalisation of the counting of suicide mortality.

Within the framework of the present study, we can state that presently the estimates of the Russian population's losses from suicide with due account of the latent component are much closer to the real suicide mortality situation than the official figures.

Conclusions

In summarising the results of the study, we note as follows. The age profile of suicide mortality of the Russian population over the 30 years of Russia's recent history has undergone significant transformations due to socio-economic developments.

During the 1990s crisis, men developed a sigmoidal mortality curve peaking at middle age, with the 50-54-year-olds showing the highest levels of age-specific mortality at the height of the crisis in the mid-1990s.

In the 2000s, a gradual flattening-out of the mortality peak at middle age took place, with the peak at the oldest age. Post-2010, the age profile of suicide mortality acquired a present-day configuration characterised by the shaping of a plateau in the working-age groups, into which the peaks of previously observed indicators transformed.

The systemic crisis of the 1990s was marked by fundamental gender differences: as Russian men developed a sigmoidal suicide mortality curve, the age-specific mortality profile among Russian women was characterised by a steady increase in age-specific indicators starting from age 25-29, while in the mid-1990s, women also experienced a mortality peak among the 50-54-year-olds. In the 2000s, a gradual transformation of the women's suicide mortality curve took place, which only ended after 2010. In recent years, the age profile of suicide mortality acquired a maximum gender similarity, as evidenced by the rank correlation coefficients amounting to 0.9.

The analysis of the age profile of suicide mortality and mortality from injuries with undetermined intent has corroborated the hypothesis that a substantial proportion of suicides are latent on account of hanging and jumping/falling from heights with undetermined intent.

In 2011-2021, the excess of the estimated real suicides over their official level sharply increased across all ages, amounting to 20% vs. 80% among the 15-25-year-old men, and 25% vs. 1.5 times in older individuals. Among women in 2021, there was a two-fold excess of real rates over the official ones in all age groups, compared to an increase with age of the same excess from 19% to 32% in 2011.

Judging by the level and trends of variation in mortality from injuries with undetermined intent, a systematic undercounting of suicide mortality by its transformation into the latent form has taken place throughout the post-Soviet period.

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Information about the authors

- Victoria Georgievna Semyonova – Doctor of Economics; main researcher, Health and Self-Preservation Behaviour Department, Institute for Demographic Research – Branch of the Federal Centre of Theoretical and Applied Sociology of the Russian Academy of Sciences (IDR FCTAS RAS), Moscow, 119333, Russia. Email: vika-home@yandex.ru
- Aleksandr Vladimirovich Zubko – Ph.D. of Medical Sciences; leading researcher Health and Self-Preservation Behaviour Department, Institute for Demographic Research – Branch of the Federal Centre of Theoretical and Applied Sociology of the Russian Academy of Sciences (IDR FCTAS RAS), Moscow, 119333, Russia; leading researcher Department of public health and demography Russian Research Institute of Health (RIH) Moscow, 125206, Russia. Email: zalexandrae@gmail.com
- Tamara Pavlovna Sabgayda – Doctor of Medicine, Professor; main researcher, Health and Self-Preservation Behaviour Department, Institute for Demographic Research – Branch of the Federal Centre of Theoretical and Applied Sociology of the Russian Academy of Sciences (IDR FCTAS RAS) Moscow, 119333, Russia; main researcher Department of public health and demography Russian Research Institute of Health (RIH) Moscow, 125206, Russia. Email: tsabgaida@mail.ru