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SOME ASPECTS OF METHODOLOGICAL SOLUTIONS IN ASSESSING THE LEVEL OF MATERNAL MORTALITY AT THE REGIONAL LEVEL

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ABSTRACT. The purpose of the work is to consider some aspects of the application of the methodology for calculating and comparative analysis of maternal mortality in Smolensk region in comparison with that at the federal level. Statistical and analytical methods were applied, two methods were used to "align" the dynamic series in the study of maternal mortality rates for 25 years, from 1995 to 2019. Sufficiency of calculating a moving average over 3 points to equalize maternal mortality rates at the federal level is demonstrated. For indicators at the regional level, where the absolute values of maternal deaths vary from 1 to 7 per year, alignment over at least 5 years is required using an informed moving average calculation. Specific examples to approve efficiency of application of the ICD-10 recommendations for the publication of maternal mortality rates in order to improve their analysis are applied.

KEY WORDS: maternal mortality; the method of «leveling the dynamic series».

НЕКОТОРЫЕ АСПЕКТЫ МЕТОДОЛОГИЧЕСКИХ РЕШЕНИЙ ПРИ ОЦЕНКЕ УРОВНЯ МАТЕРИНСКОЙ СМЕРТНОСТИ НА РЕГИОНАЛЬНОМ УРОВНЕ

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РЕЗЮМЕ. Цель работы — рассмотреть некоторые аспекты применения методологии расчета и сравнительного анализа показателей материнской смертности в Смоленской области в сопоставлении с федеральным уровнем. Применены статистический и аналитический методы, две методики «выравнивания» динамического ряда при изучении показателей материнской смертности за 25 лет, с 1995 по 2019 гг. Показана достаточность расчета скользящей средней по трем точкам для выравнивания показателей материнской смертности на федеральном уровне. Для показателей регионального уровня, когда абсолютные значения случаев материнской смерти варьируют от 1 до 7 за год, требуется выравнивание не менее чем за 5 лет с помощью расчета взвешенной скользящей средней. На конкретных примерах рассмотрено применение рекомендаций МКБ-10 по опубликованию показателей материнской смертности с целью улучшения их анализа.

КЛЮЧЕВЫЕ СЛОВА: материнская смертность; методика «выравнивания» динамического ряда.

INTRODUCTION

The merger of the maternity hospital and antenatal clinic in the Soviet Union in 1949 made it possible to ensure continuity in the provision of obstetric and gynecological care for pregnant women, women in labor and postpartum women. The obligatory nature of work for the working-age population that existed in the Soviet period (criminal liability was provided for parasitism), the need for pregnant women to obtain a certificate of incapacity for work at the antenatal clinic in a timely manner, patronage health care of pregnant women and a number of other features made it possible to provide almost complete coverage of pregnant women, women in labor and postpartum with medical supervision and provision of medical care. In this established system, the demographic of maternal mortality (MM) ratio largely served as a criterion for the quality of obstetric services. It was calculated based on summary reports of medical institutions of administrative territories and the country as a whole [3]. At the same time, the MM indicator was included in the section of the main ones characterizing the work of the obstetric and gynecologic services. There was no annual open publication of statistical information on the state of health care and population health. Until the mid-80s of the 20th century, MM was calculated as the ratio of maternal deaths per 1000 births [3]. With the formation of the Federal State Statistics Service (Rosstat) in 1991, changes were adopted in the methodology for calculating the indicator per 100,000 live births. Information has become publicly available, traditionally describing the work of the obstetric and gynecologic services. In the Smolensk region, MM rates have been published annually in the statistical collections “State of healthcare and health of the population of the Smolensk region” in the section “obstetric and gynecologic services” since 1995, and since 2000 the information has been presented on the website of the Smolensk Regional Medical Information and Analytical Center (SOMIAC). In 1999, “International Statistical Classification of Diseases and Related Health Problems, 10th Revision” (ICD-10) was introduced into healthcare practice throughout the country by order of the Ministry of Health of the Russian Federation dated May 27, 1997 No. 170. The second volume of ICD-10 provides not only a definition of maternal mortality, but also recommendations on the methodology for calculating MM indicators, presenting statistical data, and analyzing rates. As for the definition and methodology for calculating the MM indicator, they began to be used in Russia before the introduction of ICD-10, ensuring data comparability starting in 1991. At the same time, by 2019, in more than a third of Russian regions (32), no cases of MM were registered, and in a number of regions the rate was several times higher than the Russian level ($9{,}0^0/_{0000}$), including in the Smolensk Region ($28{,}2^0/_{0000}$) — 3 times [10].

AIM

The aim of the work is to consider some aspects of the application of the methodology for calculating and comparative analysis of maternal mortality rates in the Smolensk Region in comparison with that at the federal level.

MATERIALS AND METHODS

MM indicators in the Smolensk Region were analyzed in comparison with the federal

level for 25 years: from 1995 (the appearance of annual open regional reporting) to 2019 (before the start of the COVID-19 pandemic). The source of statistical information is Rosstat (https://rosstat.gov.ru), SOMIAC (https://somiac.ru/s_medstat.htm) and printed and electronic publications of statistical collections "State of healthcare and health of the population of the Smolensk Region" [4–8, 11–17].

Two methods of "leveling" ("smoothing") the time series were used: calculating a moving average over three points and calculating a weighted moving average (over five points) [9]. Counting a three-point moving average ($\tilde{y}_i$) allows you to replace each level (y_i) with the average value of this level and two adjacent ones (y_{i-1} и y_{i+1}), i.e. the system 123 234 345 is used, etc.:

$$\tilde{y}_i\,(3) = (y_{i-1} + y_i + y_{i+1}) : 3 \quad \text{(formula 1)}.$$

Using formula 1, a moving average of the MM indicator in Russia for 1996 was calculated $\tilde{y}_2 = (y_1 + y_2 + y_3) : 3 = (53{,}3 + 48{,}9 + 50{,}2) : 3 = 50{,}8$. By the same formula, rates for subsequent years up to and including 2018 were computed. Formula 1 is not suitable for calculating the aligned values of the first ($\tilde{y}_1$) and last levels ($\tilde{y}_{25}$). To count them, another formula was used:

$$\tilde{y}_1 = (7 \cdot y_1 + 4 \cdot y_2 - 2 \cdot y_3) : 9 \quad \text{(formula 2)}.$$

When computing the first level (1995), we received:

$$\tilde{y}_1 = (7 \cdot y_1 + 4 \cdot y_2 - 2 \cdot y_3) : 9 = (7 \cdot 53{,}3 + 4 \cdot 48{,}9 - 2 \cdot 50{,}2) : 9 = 52{,}0^*.$$

Using formula 2, the last level is also calculated (in our study, 2019 is $\tilde{y}_{25}$), while the points of the series are counted from the end:

$$\tilde{y}_{25} = (7 \cdot y_{25} + 4 \cdot y_{24} - 2 \cdot y_{23}) : 9 = (7 \cdot 9{,}0 + 4 \cdot 9{,}1 - 2 \cdot 8{,}8) : 9 = 9{,}1^*.$$

The method of calculating a weighted moving average using five points is recommended with strong fluctuations of indicators. It includes three formulas: for calculating a five-point moving average, the first and last levels of the indicator (y_1, y_{25}), the second and penultimate levels (y_2, y_{24}).

The formula used to calculate the moving average is:

$$\tilde{y}_i = (y_{i-2} + 2 \cdot y_{i-1} + 4 \cdot y_i + 2 \cdot y_{i+1} + y_{i+2}) : 10 \quad \text{(formula 3)}.$$

Using formula 3, we compute the MM in the Smolensk Region for 1997 ($\tilde{y}_3$):

$$\tilde{y}_3 = (y_1 + 2 \cdot y_2 + 4 \cdot y_3 + 2 \cdot y_4 + y_5) : 10 = (63{,}7 + 2 \cdot 56{,}2 + 4 \cdot 24{,}3 + 2 \cdot 24{,}7 + 67{,}3) : 10 = 39{,}0.$$

According to the same formula, indicators in the Smolensk Region were calculated for subsequent years up to 2017 inclusive.

To calculate the first and last levels, the formula is used:

$$\tilde{y}_1 = (7 \cdot y_1 + 5 \cdot y_2 - y_3 - y_4) : 10 \quad \text{(formula 4)}.$$

In our study, the first level is 1995 ($\tilde{y}_1$), the last level is 2019 ($\tilde{y}_{25}$). Using formula 4, we compute:

$$\tilde{y}_1 = (7 \cdot y_1 + 5 \cdot y_2 - y_3 - y_4) : 10 = (7 \cdot 63{,}7 + 5 \cdot 56{,}2 - 24{,}3 - 24{,}7) : 10 = 67{,}8^{**};$$

$$\tilde{y}_{25} = (7 \cdot y_{25} + 5 \cdot y_{24} - y_{23} - y_{22}) : 10 = (7 \cdot 28{,}2 + 5 \cdot 12{,}9 - 11{,}6 - 10{,}3) : 10 = 24{,}0^{**}.$$

To calculate the second and penultimate levels we use the formula:

$$\tilde{y}_2 = (3 \cdot y_1 + 5 \cdot y_2 + y_3 + y_4) : 10 \quad \text{(formula 5)}.$$

In our work, the second level is 1996 ($\tilde{y}_2$), the penultimate level is 2018 ($\tilde{y}_{24}$). Using formula 5, we compute:

$$\tilde{y}_2 = (3 \cdot y_1 + 5 \cdot y_2 + y_3 + y_4) : 10 = (3 \cdot 63{,}7 + 5 \cdot 56{,}2 + 24{,}3 + 24{,}7) : 10 = 52{,}1^{***};$$

$$\tilde{y}_{24} = (3 \cdot y_{25} + 5 \cdot y_{24} + y_{23} + y_{22}) : 10 = (3 \cdot 28{,}2 + 5 \cdot 12{,}9 + 11{,}6 + 10{,}3) : 10 = 17{,}1^{***}.$$

To assess the reliability of the difference between the compared indicators, the Student's t-test was calculated.

Table 1

Maternal mortality in the Russian Federation for 1995–2019 (per 100,000 live births, in $^{0}/_{0000}$)

Таблица 1

Материнская смертность в Российской Федерации за 1995–2019 годы (на 100 000 живорожденных, в $^{0}/_{0000}$)

Год / Year	Материнская смертность / Maternal mortality		Скользящая средняя (3 точки) — $\tilde{y}_i$ (3) / Moving average (3 points) — $\tilde{y}_i$ (3)	Год / Year	Материнская смертность / Maternal mortality		Скользящая средняя (3 точки) — $\tilde{y}_i$ (3) / Moving average (3 points) — $\tilde{y}_i$ (3)
	$^{0}/_{0000}$	порядковый уровень (y) / ordinal level (y)			$^{0}/_{0000}$	порядковый уровень (y) / ordinal level (y)	
1	2	3	4	5	6	7	8
1995	53,3	$У_1$	***52,0****	2008	20,7	$У_{14}$	21,6
1996	48,9	$У_2$	50,8	2009	22,0	$У_{15}$	19,7
1997	50,2	$У_3$	47,7	2010	16,5	$У_{16}$	18,2
1998	44,0	$У_4$	46,1	2011	16,2	$У_{17}$	14,7
1999	44,2	$У_5$	42,6	2012	11,5	$У_{18}$	13,0
2000	39,7	$У_6$	40,1	2013	11,3	$У_{19}$	11,2
2001	36,5	$У_7$	36,6	2014	10,8	$У_{20}$	10,7
2002	33,5	$У_8$	34,0	2015	10,1	$У_{21}$	10,3
2003	31,9	$У_9$	29,6	2016	10,0	$У_{22}$	9,6
2004	23,4	$У_{10}$	26,9	2017	8,8	$У_{23}$	9,3
2005	25,4	$У_{11}$	24,3	2018	9,1	$У_{24}$	9,0
2006	23,7	$У_{12}$	23,7	2019	9,0	$У_{25}$	***9,1****
2007	22,0	$У_{13}$	22,1				

RESULTS

Table 1 presents MM rates in the Russian Federation for the period from 1995 to 2019.

Columns 2 and 6 of this table contain indicators from official sources of statistical information [10]. It should be noted that MM levels fluctuated both upward and downward over 25 years. Thus, in 1995, the MM indicator was $53,3^{0}/_{0000}$, in 1996 it decreased to $48,9^{0}/_{0000}$, in 1997 it increased to $50,2^{0}/_{0000}$, etc. To determine the general trend in the dynamics of maternal mortality rates in Russia, a simple method of "smoothing" the dynamic series was used through a moving average over three numbers (points) [9]. The equalized maternal mortality indicators are recorded in columns 4 and 8 of Table 1.

As data in these columns show, the use of a simple method of "leveling" the dynamic series made it possible to identify a clear annual downward trend in MM indicators in Russia, almost 6 times from 1995 ($52,0^{0}/_{0000}$) to 2019 ($9,1^{0}/_{0000}$).

To establish the trend in maternal mortality in the Smolensk Region, 2 methods of "smoothing" the dynamic series were used: calculating a moving average using three points and calculating a weighted moving average (using five points). Column 4 of Table 2 presents the results obtained by computing the moving average over three points, i.e. for 1996–2018 according to formula 1, for 1995 and 2019 — according to formula 2.

However, when using the "smoothing" technique over three points, a significant variation in maternal mortality remains — the indicator either increases or decreases by 2 times or more. That is why the second method was used — calculating a weighted moving average over five points.

The equalized values of MM rates in the Smolensk Region are recorded in column 5 of Table 2. Thus, when averaging over a five-year period, we obtain fluctuations in the MM indicator within smaller limits. And since 2000, there has been a tendency for the MM rate in the Smolensk Region to decrease almost 3 times, from 68,8 to $24,0^{0}/_{0000}$ by 2019. However, in general, regional indicator levels exceed federal levels.

When assessing the reliability of the actual levels of maternal mortality in Russia by year,

Table 2

Maternal mortality in the Smolensk region for 1995–2019 (per 100,000 live births in $^{0}/_{0000}$)

Таблица 2

Материнская смертность в Смоленской области за 1995–2019 годы (на 100 000 живорожденных в $^{0}/_{0000}$)

Год / Year	Материнская смертность / Maternal mortality		Скользящая средняя (3 точки) — $\tilde{y}_i$ (3) / Moving average (3 points) — $\tilde{y}_i$ (3)	Взвешенная скользящая средняя — $\tilde{y}_i$ / Weighted moving average — $\tilde{y}_i$
	$^{0}/_{0000}$	порядковый уровень (y) / ordinal level		
1	2	3	4	5
1995	63,7	$У_1$	***69,1****	***67,8*****
1996	56,2	$У_2$	48,1	***52,1*****
1997	24,3	$У_3$	35,1	39,0
1998	24,7	$У_4$	38,8	43,1
1999	67,3	$У_5$	61.5	60,1
2000	92,5	$У_6$	77,7	68,8
2001	73,4	$У_7$	59,4	59,3
2002	12,1	$У_8$	36,2	35,7
2003	23,1	$У_9$	19,4	25,9
2004	22,9	$У_{10}$	23,1	21,9
2005	23,3	$У_{11}$	23,0	22,9
2006	22,9	$У_{12}$	22,5	25,4
2007	21,2	$У_{13}$	31,5	28,3
2008	50,3	$У_{14}$	33,4	35,3
2009	28,6	$У_{15}$	36,0	34,3
2010	29,2	$У_{16}$	35,6	34,1
2011	48,8	$У_{17}$	32,5	35,9
2012	19,5	$У_{18}$	35,5	30,0
2013	38,0	$У_{19}$	25,5	29,8
2014	19,1	$У_{20}$	25,7	22,2
2015	20,1	$У_{21}$	16,5	18,9
2016	10,3	$У_{22}$	14,0	13,7
2017	11,6	$У_{23}$	11,6	14,1
2018	12,9	$У_{24}$	17,6	***17,1****
2019	28,2	$У_{25}$	***25,1****	***24,0*****

statistically significant differences ($p < 0,001$) over 25 years were established only for three time periods when the rates decreased significantly: in 2004 ($23,4^{0}/_{0000}$) compared to 2003 ($31,9^{0}/_{0000}$), in 2010 compared to 2009 (16,5 and $22,0^{0}/_{0000}$, respectively) and in 2012 compared to 2011 (11.5 and $16,2^{0}/_{0000}$, respectively).

It is noteworthy that in the Smolensk Region, despite pronounced fluctuations in MM indicators, no statistically significant differences were found either when comparing regional indicators by year over 25 years, or when comparing regional with federal levels ($p > 0,001$). The current problem of statistical reliability of the compared indicators, especially at the level of the constituent entity of the Russian Federation, is due to the small size of the researched population.

The methodology for calculating and publishing MM rates in accordance with ICD-10 suggests always indicating the numerator (the

Table 3

Presentation of statistical information necessary for calculation and analysis of maternal mortality rates

Таблица 3

Представление статистической информации, необходимой для расчета и анализа показателей материнской смертности

Год / Year	Число случаев материнской смерти в РФ / The number of cases of maternal death in the Russian Federation	Число родившихся в РФ / The number of people born in the Russian Federation	Показатель МС в РФ, $^0/_{0000}$ / MDR indicator in the Russian Federation, $^0/_{0000}$
2007	354	1 610 122	22,0
2008	354	1 713 947	20,7
2017	149	1 690 307	8,8
2018	146	1 604 344	9,1

number of registered cases of MM), as well as the denominator used to calculate the MM indicator, i.e. number of live births or total number of births [1]. In fact, this presentation of the indicator makes it possible to assess the "contribution" to the level of maternal mortality of a decrease or increase in the absolute value of cases of MM and the absolute number of births (or live births). Thus, in Russia from 1995 to 2019, the number of maternal deaths decreased by 5,4 times, from 727 to 134. At the same time, the number of births increased by 1,54 times in the period from 2000 (1 266 800) to 2014 (1 942 683). And from 2014 to 2019, the number of births decreased by 1,34 times (from 1 942 683 to 1 481 074, respectively). Table 3, as an example, shows selected data for the Russian Federation for the years 2007–2008 and 2017–2018 on presentation of statistical information necessary for calculation and analysis of MM.

It should be noted that with the same absolute number of MM cases in 2007 and 2008 (354 each), the MM indicator level decreased from 22,0 to $20,7^0/_{0000}$ due to an increase in the number of births. And in 2018, the MM rate ($9,1^0/_{0000}$) was higher compared to 2017 ($8,8^0/_{0000}$), although the absolute number of cases of MM decreased from 149 in 2017 to 146 in 2018, which is explained by a decrease in the number of births.

The pronounced fluctuation in MM rates in the Smolensk Region is due to the small number of cases of maternal death against the backdrop of a reduction in the number of births. For the period from 1995 to 2019, the highest level ($92,5^0/_{0000}$) corresponds to 7 cases of MM in 2000. Moreover, when the case of death is 1 (2016–2018), due to a decrease in the number of births in the region, the level of MM indicators is various and is 10,3, 11,6 and $12,9^0/_{0000}$, respectively.

CONCLUSION

Since the moment of public openness, MM indicators have been characterized by upward and downward deviations; particularly pronounced fluctuations in MM levels are observed at the regional level. To identify trends when studying maternal mortality, it is possible to use the technique of "leveling" dynamic series. Moreover, if at the federal level the alignment of indicators is achieved by calculating a moving average over three years, then at the regional level — at least over five points (in 5 years). In general, during the period from 1995 to 2019, some success was made in reducing MM rates at the federal and regional levels.

A comparison of regional indicators by year and against the national level can be supplemented by assessing the reliability of the difference in the compared values and reflecting this information in regional reporting.

When publishing MM indicators, it is advisable to indicate not only the calculated rates, but also the absolute values of the numerator and denominator to identify their "contribution" to the level of the indicator for each year studied.

The development of software with an algorithm for computing the moving average, reliability and presentation of materials on maternal mortality in accordance with the recommendations of ICD-10 will improve the analysis of such a significant social phenomenon as maternal mortality, and present this indicator in statistical collections as a separate table in the demography (population) section.

ADDITIONAL INFORMATION

Author contribution. Thereby, all authors made a substantial contribution to the conception of the study, acquisition, analysis, interpretation of data for the work, drafting and revising the article, final approval of the version to be published and agree to be accountable for all aspects of the study.

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