Демографическое обозрение / Demographic Review
2023;10(3) 4-20 DOI: https://doi.org/10.17323/demreview.v10i3.17970

Achievements of perinatal reform and the capacity for further reduction of infant mortality in Russia

Alla Makarentseva
(makarentseva-ao@ranepa.ru),
Institute for Social Analysis and Prediction, the Russian Presidential Academy of National Economy and Public Administration, Russia

Abstract: *The article reveals the dynamics of infant mortality in Russia after the so-called perinatal reform of 2012. Despite the achievement of low indicators in general (4.4 ppm in 2022), the proportion of post-neonatal mortality remains unreasonably high in the structure of infant mortality, and the proportion of neonatal mortality is significantly lower than in other developed countries. Analysis of causes of death shows that the contribution of preventable causes remains high. So, despite the fact that over the past decade, the main decrease in mortality occurred in the class "certain conditions arising in the perinatal period" (from 48.1 to 23.4 per 10,000 live births), the share of this class in the number of all deaths in the first year of life decreased slightly, from 56% to 51%. Based on the results of econometric analysis, the author claims that the presence of three-tiered obstetric care organizations makes a significant contribution to the reduction of infant mortality at the regional level. Analysis of the problem of preterm birth demonstrates its significant contribution to infant mortality rates. In conclusion, the author proposes a number of steps at the organizational and medical level, as well as in the expansion of the associated statistical and analytical capabilities in order to further reduce infant mortality in Russia.*

Keywords: *infant mortality, perinatal mortality, neonatal mortality, prematurity, three-tiered obstetric care system, criteria for live birth.*

Funding: *The article was written on the basis of the RANEPA state assignment research program.*

For citation: *Makarentseva A. (2023). Achievements of perinatal reform and the capacity for further reduction of infant mortality in Russia. Demographic Review, 10(3), 62-81. https://doi.org/10.17323/demreview.v10i3.17970*

Introduction

More than 10 years ago (in 2012), in Russia began a so-called “perinatal reform”, consisting of the following components: a transition to new criteria for live birth comparable to international ones; the introduction of a three-level obstetric care system; and a program for the development of perinatal centers.

The new system for organizing obstetric care reflects international principles, according to which medical care should take into account regional features and be multilevel. The concept of regionalization of perinatal care was formulated in the United States in the 1970s and has spread globally (Zeitlin et al. 2016). The first level of hospitals – the district - implies the presence of an obstetric center, which does not provide a round-the-clock presence of an obstetrician-gynecologist. The second is maternity hospitals (wards), including those specialized by type of pathology, with intensive care wards for women and newborns. The third level of hospitals is divided into two categories: a) hospitals with an anesthesiology and resuscitation department for women, a resuscitation and intensive care unit for newborns, a pathology department for newborns and premature babies (stage II of nursing), and a remote obstetric consultation center with mobile anesthesiology and resuscitation teams for emergency medical care; b) hospitals of federal medical organizations providing specialized, including high-tech, medical care to women during pregnancy, childbirth and the postpartum period and to newborns. It is precisely third-level organizations that have begun to play a significant role in the further reduction of infant mortality. The construction of perinatal centers began in Russia back in the 1990s, but in 2013 the Perinatal Centers Development Program[1] was launched, which significantly accelerated the pace of construction.

As of 2020, there were 141 third-level obstetric care organizations operating in Russia (Alexandrova et al. 2021). There are few regions of the Russian Federation that do not have such perinatal centers (PCs): in 2020 these were the Kostroma region, the Nenets Autonomous Okrug, the city of Sevastopol as a separate entity (there is a PC in Simferopol), the Kamchatka Territory, the Jewish Autonomous Region and the Chukotka Autonomous Region.

In addition, since 2012, Russia has switched to international criteria for determining live births[2] (see (Alexandrova et al. 2013) for more details). In 2019, an addition to the Order clarified the medical criteria for live births at the borderline gestational age – 22 weeks (Table 1). The improvement of the criteria is due to difficulties in unambiguously determining the gestational age of the fetus; according to the updated criteria, its role is reduced, which better corresponds to the international approach. Discrepancies with WHO methodology remain[3], but their impact on infant mortality indicators is small.

[1] Decree number 2302-r of the Government of the Russian Federation dated December 9, 2013 "On approval of the Program of development of perinatal centers in the Russian Federation (with amendments and additions)". http://government.ru/docs/8816/

[2] Order number 1687n of the Ministry of Health of the Russian Federation of 27 December 2011 (with amendments of 13 September 2019) "On medical criteria of birth, the form of the birth document and the procedure for its issuance".

[3] According to WHO criteria, the gestation period is irrelevant.

Table 1. Criteria for live birth according to Order No. 1687n and its 2019 version

Order 1687n, 2019 version	Order 1687n of 27.12.2011
1. gestation period of 22 weeks or more for a child with a birth weight of 500 grams or more (or less than 500 grams in multiple births) or, if the birth weight of the child is unknown, at birth length of 25 cm or more; 2. pregnancy less than 22 weeks or birth weight less than 500 grams, or if the birth weight of the child is unknown, the child's body length at birth is less than 25 cm - with a life expectancy of more than 168 hours after birth (7 days).	1. period of pregnancy 22 weeks or more; 2. birth weight 500 g or more (or less than 500 g in multiple births); 3. child's body length at birth 25 cm or more (if the child's body mass at birth is unknown); 4. pregnancy less than 22 weeks or birth weight less than 500 grams, or if the birth weight is unknown, the child's body length is less than 25 cm - with a life expectancy of more than 168 hours after birth (7 days).

The consequences of the 2012 transition, reflected in the statistics of infant mortality and its structure, have been analyzed in detail in previous studies (Sukhanova 2013; Kvasha 2014), etc.). In addition to the main reduction in the requirements for fetal weight at birth, according to the new criteria, termination of pregnancy at 22-27 weeks, treated until 2011 as a "late abortion," began to be counted as a premature birth. The reform led to a restructuring of pregnancy, childbirth and abortion outcomes, as well as the number of births and deaths of children by weight category. Experts then pointed out the possibility of administrative distortion of mortality rates for newborns with extremely low body weight (ELBW, less than 1000 grams): *"the main mechanism for "reducing" perinatal mortality [4] today is the "transfer" of deceased and stillborn babies from the ELBW category to the unaccounted for weight group weighing less than 500 g*" (Sukhanova 2013); "*We are talking about a redistribution of the number of completed pregnancies at up to 27 weeks towards abortions at less than 22 weeks"* (Alexandrova et al. 2013). However, the share of such births in the total number of low birthweight births is small (2% of all live births weighing less than 2.5 kg in 2020), and the possibilities of administrative influence on the aggregate indicators of perinatal losses are not so extensive.

In subsequent years, infant mortality in Russia has continued its steady decline, entering the cluster of countries with the best indicators[5]. The main goal of this article is to determine the reserves for further reduction of this indicator, taking into account the dynamics of its structure, regional differentiation and analysis of the contribution of the problem of prematurity. A detailed analysis of infant mortality for real generations can be found in the work of E.M. Andreev "Inequality in infant mortality among the population of modern Russia" (Andreev 2020). This paper shows how social inequality, expressed primarily in features of the mother's education, slows down the decline in infant mortality primarily due to preventable causes of death.

The article is structured as follows. First, the dynamics of infant mortality in Russia in the period after 2012 are compared with those of countries that are doing well in this regard. Next, the dynamics of the structure of infant mortality is analyzed, comparative international estimates are given, and "gaps in the system" in Russia are identified. After this, we move down from the international to the regional level, assessing interregional differences in infant mortality indicators, as well as the role of tertiary level hospitals. The last sections of the article are devoted

[4] Perinatal mortality: All perinatal deaths (with a gestation period of 22 weeks and more or a fetal weight of 500 grams or more), stillbirths and deaths under 7 days of age (calculated for 1,000 live and stillbirths).
[5] See https://childmortality.org/

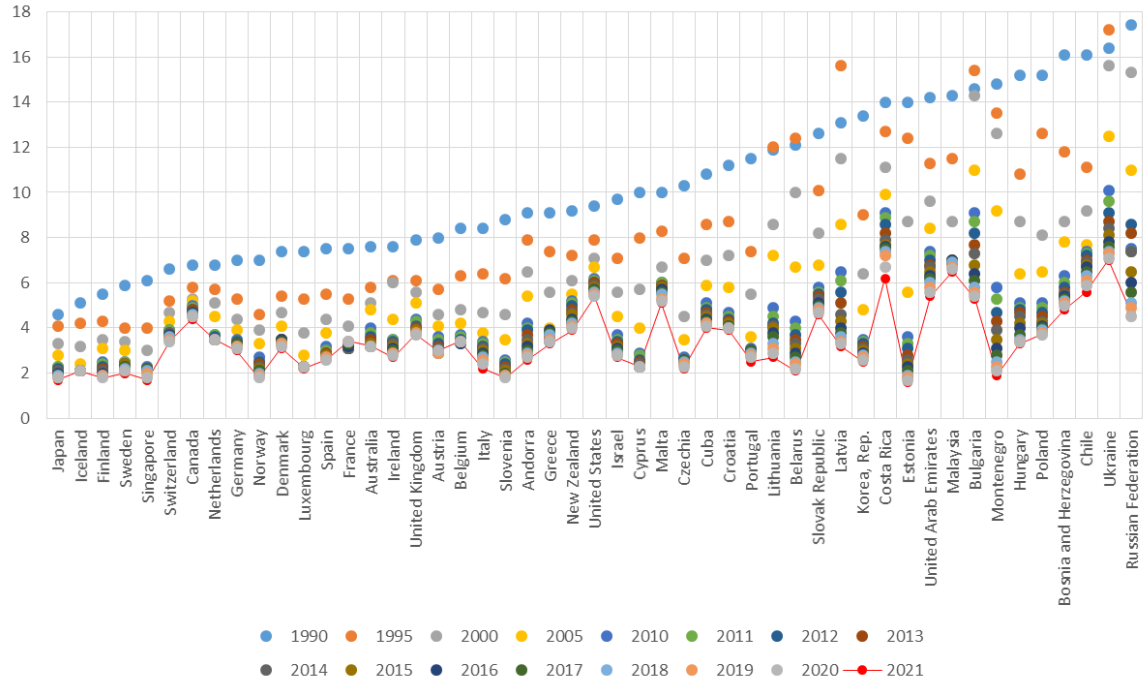
to a brief analysis of the dynamics of the distribution of infant mortality by cause of death, by body weight at birth and taking into account prematurity. The findings provide recommendations for the socio-organizational component of health policy to further reduce infant mortality rates.

The main source of data is statistics from the Federal State Statistics Service, collected from publications, the EMISS database and vital statistics sheets. For international comparisons, we rely on data from the World Bank, namely the Health Nutrition and Population Statistics database. In addition to these sources, data on the number of obstetric care organizations and the proportion of live births in hospitals of different levels from publications of the Russian Ministry of Health were used.

A comparative assessment of the dynamics of infant mortality and its structure

Over the past three decades, Russia has made a big leap in reducing infant mortality and the gap in this indicator with developed countries. In 2022, infant mortality was 4.4 ppm. In 2021, there was a slight increase in the infant mortality rate (from 4.5 in 2020 to 4.6 ppm). This is an indirect effect of the spread of a new type of coronavirus infection and its role in increasing the number of premature births (Bantieva 2023).

Figure 1. Dynamics of infant mortality in selected countries, ppm



Sources: All countries except Russia: https://databank.worldbank.org/; Health Nutrition and Population Statistics database (Access date: 06/01/2023). Russia: https://gks.ru, since 2014, taking into account the Republic of Crimea and the city of Sevastopol.

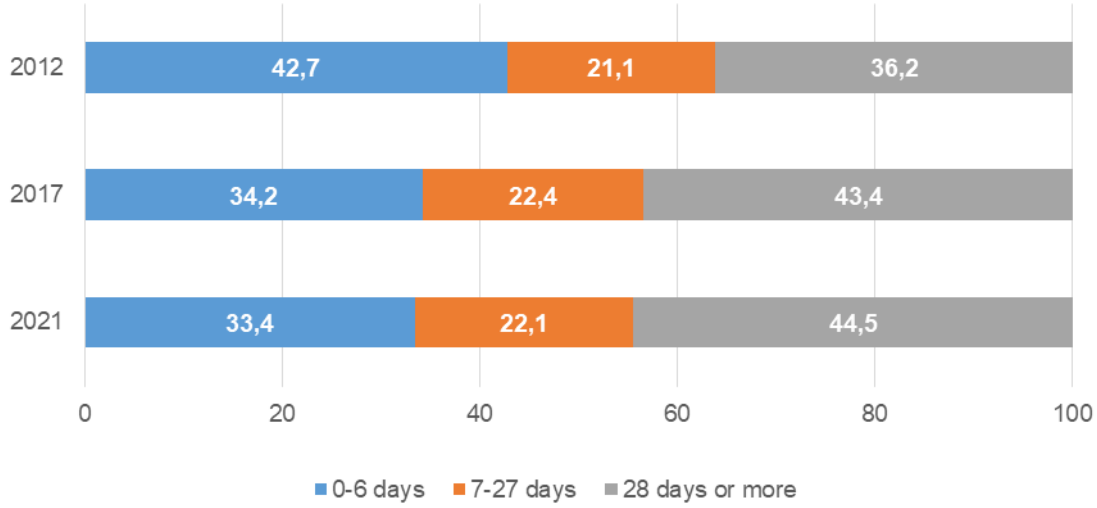
Note: The World Bank estimates infant mortality in Russia to be lower than given by Rosstat.

Figure 1 shows the dynamics of infant mortality in selected countries beginning in 1990, including those in which it was then no higher than in Russia. The decline in this indicator in Russia occurred both before and after the perinatal reform, and its pace in the last decade was the highest among the presented sample of countries. However, even in those countries that have

long achieved very low levels of infant mortality, its slow decline continues. This suggests that the reserves for further reduction of reproductive losses have not been exhausted even in the leading countries.

To understand what reserves there are for reducing infant mortality in Russia, it is necessary to evaluate in more detail the changes in its structure. As obstetric care modernizes, we should expect an increase in the proportion of deaths in the early neonatal period[6], and a reduction in the proportion of deaths after the first 7 days of life. In other words, mortality should shift towards the cases most difficult to prevent. The change in the structure of infant mortality over the past 10 years in Russia indicates continuing problems in the organization of healthcare. With a reduction in the early neonatal mortality rate from 3.64 ppm in 2012 to 2.59 ppm in 2021 (EMISS), its share in the structure of infant mortality fell (from 42.7 to 33.4%; Figure 2). Against the background of an almost unchanged share of late neonatal mortality[7], the share of postneonatal mortality[8] increased (from 36.2 to 44.5%).

Figure 2. Structure of infant mortality in Russia, 2012, 2017 and 2021, %



Source: Author's calculations based on unpublished data from Rosstat.

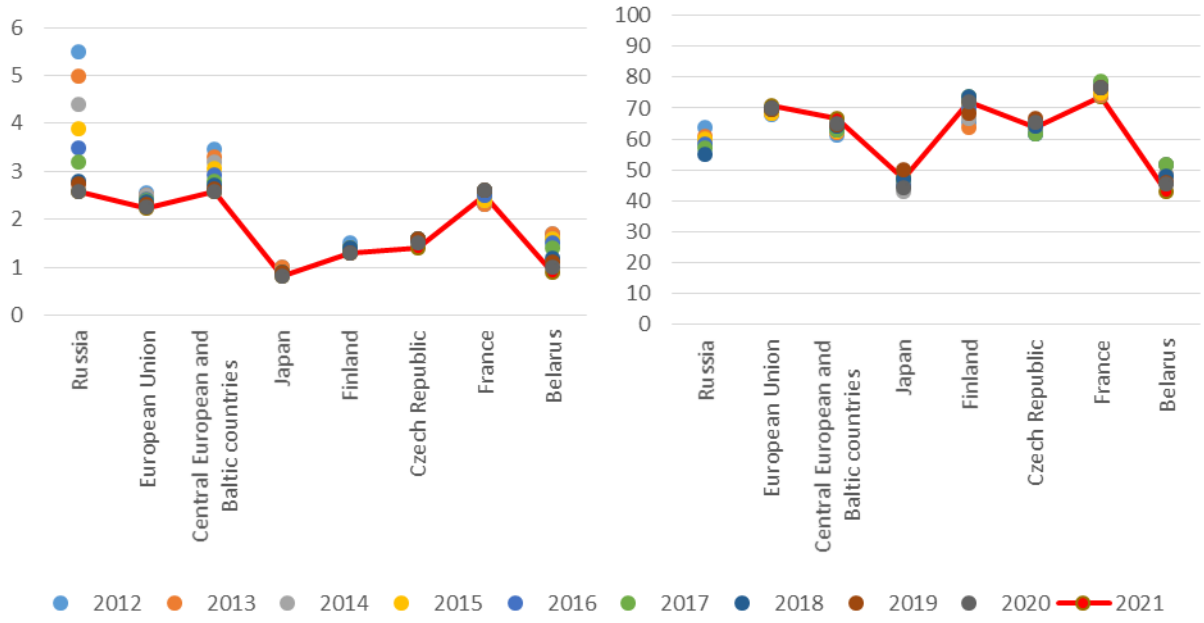
There are several reasons for the increase in the proportion of newborn mortality after 28 days of life, but a significant contribution is made by the delay in modernizing the care of newborns. By this time, most newborns from the high-risk group have left the first stage of nursing - the NICU (resuscitation and intensive care) wards, which are the best equipped and have the largest number of staff - and are transferred to the second stage of nursing. This takes place in the departments of pathology of newborns and nursing of premature babies. The three-tier system assumes the presence of these departments only in third-level organizations or outside the obstetrics system, in children's hospitals. Thus, the transition to the second stage is often accompanied by a move to another medical institution, and, as a rule, it is less well equipped, has less nursing staff, and usually the qualifications of medical workers are lower than

[6] Early neonatal mortality: deaths under 7 days of age (calculated per 1,000 live births).
[7] Mortality between 7 and 27 days
[8] Mortality between 28 days of life and 1 year of age

in the wards of the NICU or PC. Retrofitting and modernizing the second stage of nursing is one of the most pressing tasks in this area (Petrukhin et al. 2021).

Neonatal mortality (NM)[9] is the most important element in the structure of infant mortality. Along with infant mortality (IM), it is one of the most important indicators that evaluate the development of healthcare, economics, and social and demographic policy at the regional or national level. Neonatal mortality is closely associated with preterm birth[10] and complications from it. European reports indicate that a significant proportion of deaths in the neonatal period are unpreventable or difficult to prevent (Zeitlin et al. 2016). However, in Russia this indicator is used less often than others. Thus, Rosstat publications do not contain data on it starting from 2019. Meanwhile, this mortality characteristic is widely used for international comparisons. Thus, while NM coefficients in Russia are already at the level of developed countries, its share in the structure of infant mortality lags behind them (Figure 3), in other words, remains too low. Comparably low shares of NM are observed in leading countries, for example, in Japan, but with much lower NM coefficients.

Figure 3. Neonatal mortality rate (per 1000 live births, left) and the share of neonatal mortality in infant mortality (%, right), Russia and some countries, 2012-2021



Sources: All countries except Russia: https://databank.worldbank.org/; Health Nutrition and Population Statistics database (Access date: 06/01/2023). Russia: https://gks.ru,, since 2014 including the Republic of Crimea and the city of Sevastopol.

Note: The World Bank estimates infant mortality in Russia to be lower than given by Rosstat.

NM coefficients are also used in comparative analysis with stillbirth rates: the logic of modernization of obstetric care is such that NM is decreasing faster than stillbirths. In other words, there is a shift in deaths towards those that are most difficult to prevent. This trend was noted in perinatal monitoring of European countries (Zeitlin et al. 2016), and it is also typical for

[9] All mortality between 0 and 27 days of life per 1,000 live births
[10] At gestational age earlier than 37 weeks

Russia. The stillbirth rate decreased from 6.34 in 2012 to 5.67 in 2021 (per 1000 live and stillborn births), i.e., by 11%. At the same time, the number of deaths in the first 168 hours per 1,000 live and stillbirths fell by 56% (from 3.64 to 1.59 over the same period). Thus, the dynamics of the structure of infant mortality in Russia and against the background of other countries indicates the preservation of significant reserves in its reduction.

Let's look briefly at gender differences. Male fetuses and infants always have higher mortality risks compared to female infants (DiPietro, Voegtline 2017). The differences are associated with both male vulnerability to specific neonatal diseases (see for example (Townsel et al. 2017)), a higher prevalence of congenital anomalies among boys (Ingemarsson 2003), and lower survival of male infants in general. In 2021, infant mortality for boys was 5.25 ppm and 3.99 ppm for girls, while neonatal mortality of boys was 2.96 ppm and 2.10 ppm for girls (see Table A of the Appendix). The excess of neonatal mortality rates for boys compared to girls was 1.35; for comparison, similar estimates for the United States in the second half of the twentieth century are comparable and amounted to 1.28 (Naeye 1971).

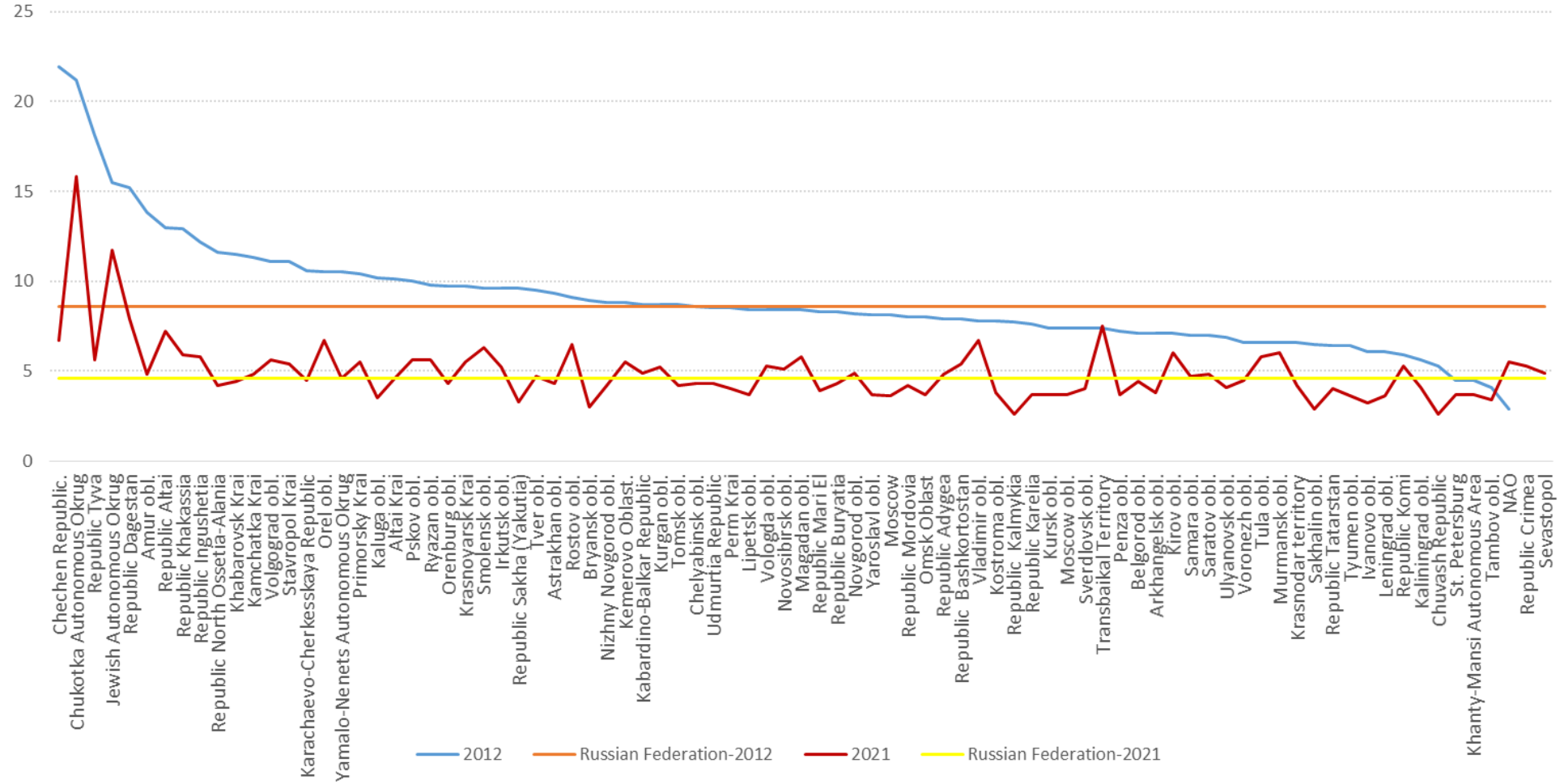
Let us recall that in Russia there remain differences in infant mortality depending on the order of birth: *"Second children die less often than others, but when the mother is under 30 years of age, the mortality rate of firstborns is lower than that of second children. The most likely to die are the fourth and subsequent children. This happens in all age groups of the mother"* (Andreev 2020). It seems that these differences are partly explained by the difference in the risks of complications in pregnancies of different orders, and partly by the social characteristics of mothers, not only their level of education (lifestyle), but also their place of residence and access to obstetric care organizations.

Regional differentiation and the contribution of three-level organization of obstetric care

In the last decade, positive dynamics of infant mortality have been observed in all constituent entities of the Russian Federation, except for the Trans-Baikal Territory (7.4 ppm in 2012 and 7.5 ppm in 2021; Figure 4). Low rates (less than 20%) of the reduction in infant mortality during this period are also characteristic of the Komi Republic, Tula, Vladimir, Kirov, Tambov regions and St. Petersburg. However, the dynamics in the latter are not evidence of the low quality of obstetric services, but reflect the concentration of complex pregnancy cases in its medical institutions. The largest reduction (more than 60%) was achieved by the Khabarovsk Krai, the Republic of North Ossetia, the Amur Oblast, the Republic of Sakha, the Kaluga Oblast, the Republic of Kalmykia, the Bryansk Oblast, the Republic of Tyva and the Chechen Republic. However, the last two subjects of the Russian Federation had a very high level of infant mortality in 2012, and in addition, the collection of statistics in them is considered imperfect. In particular, E.M. Andreev shows that regional dynamics of infant mortality do not always behave plausibly (Andreev 2020). By 2021, regional differentiation in infant mortality remained (Figure 4, right).

The level of infant mortality in the regions is also influenced by the nature of the settlement: in rural areas, the territorial accessibility of obstetric services is lower, and infant mortality rates are higher (5.3 ppm versus 4.4 in the urban population in 2021 on average in the Russian Federation). Russia, following many developed countries, closed small obstetric services in rural areas in the process of reorganizing the entire system (Grzybowski, Stoll, Kornelsen 2011). This has increased social inequalities in access to obstetric services, as rural populations and economically vulnerable women have difficulty finding timely transportation.

Figure 4. Infant mortality rates in Russian regions, 2012 and 2021



Source: EMISS.

To understand the impact of the three-tier delivery system on regional estimates of infant mortality, we conducted regression analysis. In previous studies, models included various healthcare indicators as independent variables: availability of beds, number of medical personnel, abortions, morbidity, and so on (Zelinskaya, Terletskaya 2013; Ivanova 2014). Due to the focus of this work on the progress of perinatal reform, we use the cumulative indicator "distribution of live births by hospital level" (data taken from: (Kotova et al. 2021)). It is worth noting that we cannot use indicators with two-way dependence, such as, for example, the proportion of normal births, mortality by hospital level, and so on. Perinatal centers take the most complex cases, so in regions with a small number or total lack of them, such indicators give an incorrectly optimistic picture[11]. At the same time, morbidity indicators for pregnant women better reflect detection than the epidemiological picture.

In the process of testing, regression models included independent demographic (population density, share of the urban population), economic (GRP per capita, share of the population below the poverty line), and healthcare (number of births by hospital level, number of abortions per 1000 women of fertile age) regional indicators. In the model with infant mortality, two variables remained statistically significant: the proportion of live births in third-level hospitals and the proportion of the urban population[12] (Table 2). The lack of significance of the abortion intensity variable (up to 22 weeks) indirectly confirms the small role of the administrative component in infant mortality rates.

Table 2. Results of linear regression analysis of the relationship between mortality rates in Russian regions and the share of those born in third-level organizations, 2020.

	Dependent variable: infant mortality per 1,000 live births		Dependent variable: early neonatal mortality per 1,000 live births	
	Standardized coefficients	significance	Standardized coefficients	significance
Share of births in third-level hospitals [13]	-.419	.000	-.406	.000
Share of urban population	-.368	.001	-.210	.051
Constant		9.209		4.429

In the regression analysis of infant mortality, only the variable of the proportion of births in third-level level hospitals was significant, while the (separate) inclusion of indicators for the first and second levels showed no significance. However, in the analysis of early neonatal mortality, the variable "proportion of births in second-level hospitals" turned out to be significant: it increases the rates of early neonatal mortality at the regional level (Table 3).

[11] "The obligation to report to the civil registry office the birth of a stillborn child or the birth and death of a child who died in the first week of life is vested in... the head of the medical organization in which the child was delivered or died" (Federal Act number 143-FZ of 15 November 1997 (24.07.2023 version) "On civil status acts"), from which we conclude that the child will be registered as deceased in the region of his birth. In the event of the death of a child after 7 days of life, a medical death certificate is issued and the death is registered by the parents at the registry office, from which we conclude that such cases will be registered in the region of registration of the child's mother.

[12] In the absence of a variable of the share of the urban population, the proportion of the population with incomes below the poverty line was significant.

[13] Regions without third-level hospitals are assigned a value of "0".

If a perinatal center is unavailable or if a prenatal diagnosis is incorrect, complicated pregnancies are delivered in second-level organizations, which still need modernization and retrofitting.

Table 3. Results of linear regression analysis of the relationship between mortality rates in Russian regions and the share of those born in second-level organizations, 2020.

	Dependent variable: early neonatal mortality, per 1,000 live births	
	Standardized coefficients	significance
Share of urban population	-.225	.039
Share of live births in second-level hospitals	.412	.000
Constant	2.18	

Thus, the presence and territorial accessibility of third-level obstetric care organizations make a significant contribution to the reduction of infant mortality at the regional level.

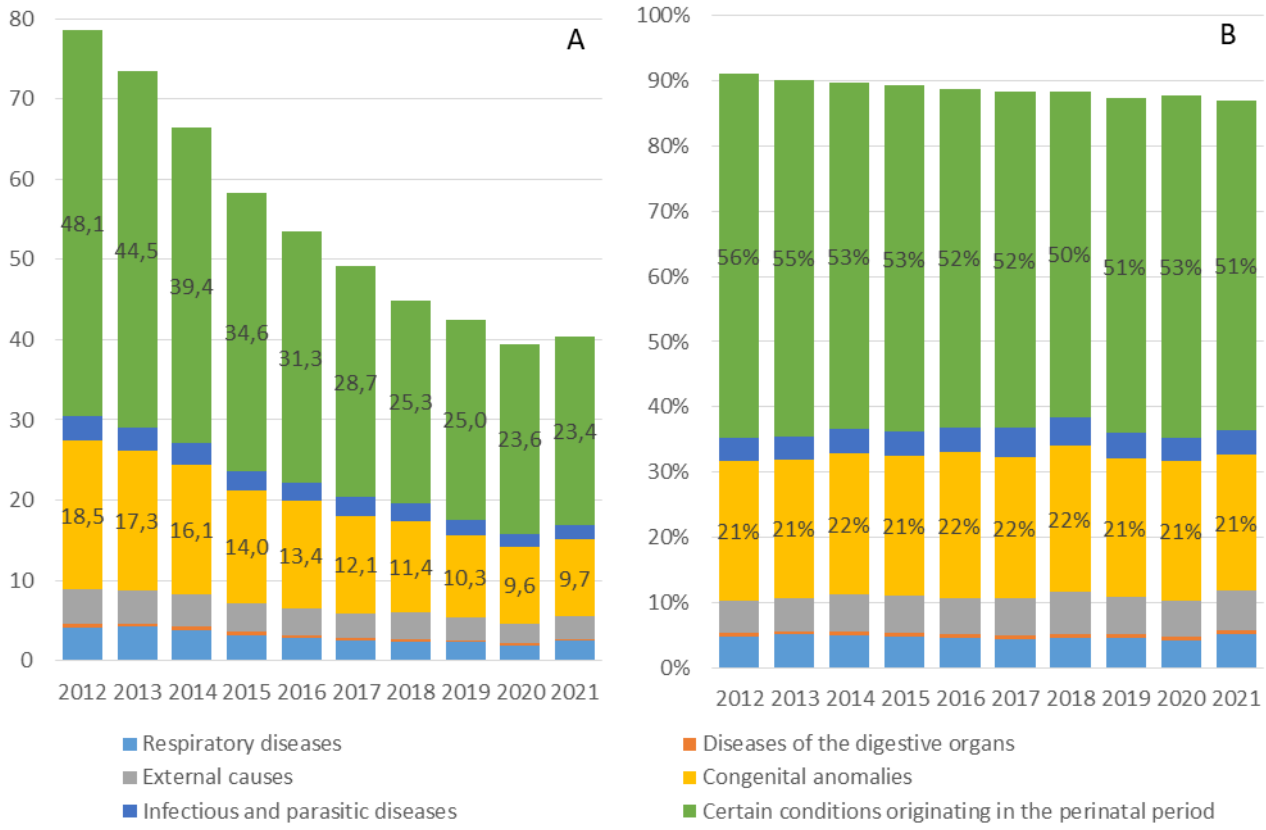
Causes of infant mortality and the prematurity factor

The causes of perinatal and neonatal mortality and stillbirth vary according to the gestational age of the fetus. The main causative factors that lead to pregnancy complications, perinatal morbidity and mortality in developed countries are congenital anomalies (CA), preterm birth and intrauterine hypoxia (Al-shehri et al. 2022). The class of congenital malformations accounts for 21% of all infant deaths in Russia (Figure 5b). It is very heterogeneous in terms of life-threatening risks and the extent of required treatment and rehabilitation. The most common types are: congenital defects of the circulatory system (mainly heart defects), anomalies of the musculoskeletal system and digestive organs, chromosomal abnormalities (primarily Down syndrome) and others. Reducing mortality from CA is achieved by improving and disseminating prenatal diagnosis and correcting CA in utero or after birth. Infant mortality from CA decreased in Russia from 18.5 in 2012 to 9.7 in 2021 (per 10,000 live births) (Figure 5A).

The largest class of causes of infant mortality, “Certain conditions originating in the perinatal period,” is largely composed of preventable causes of death. In this regard, it shows the most positive dynamics: over the last decade, the main decrease in mortality occurred in the “certain conditions” class (from 48.1 to 23.4 per 10,000). However, its share of all deaths in the first year of life decreased slightly: from 56 to 51% (Figure 5B).

Premature births are a leading cause of infant mortality and morbidity in both developed as well as developing countries (Keller et al. 2010). In high-income countries, their prevalence and outcome depend on the quality of obstetric practice, as well as on a wide range of population characteristics, including multiple pregnancies, maternal age, body mass index, smoking, pregnancy spacing and outcome of previous pregnancies, induced abortions, and so on (Delnord, Blondel, Zeitlin 2015). Measuring all these characteristics in mass studies is difficult. An increase in the proportion of mothers of older reproductive ages does not lead to an increase in premature births (VanderWeele, Lantos, Lauderdale 2012). Nor was a clear connection with the socioeconomic status of the mother found; different studies give different results.

Figure 5. Number of children who died in the first year of life by main classes of causes of death:
A) per 10 thousand live births per year, people;
B) % of all deaths per year

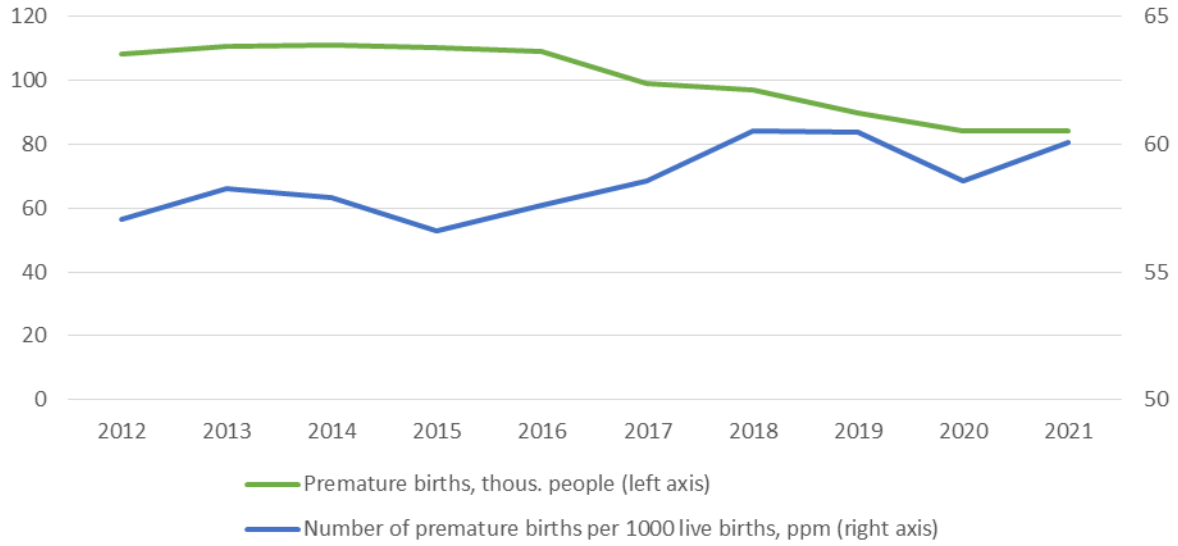


Source: EMISS.

On average, the worldwide proportion of premature births is 11% (Walani 2020), while in economically developed countries it fluctuates around 5% (Nurova, Mirzoeva 2022). In Russia, this indicator is at a comparable level: in 2021, the share of premature babies among the number of live births was 6% (Figure 6). The share of premature births from the number of women who ended their pregnancy with childbirth was 4.8% in 2021, and 4.7% in 2020. A slight increase in the proportion of premature births is associated with the consequences of the spread of a new coronavirus infection (Bantieva 2023).

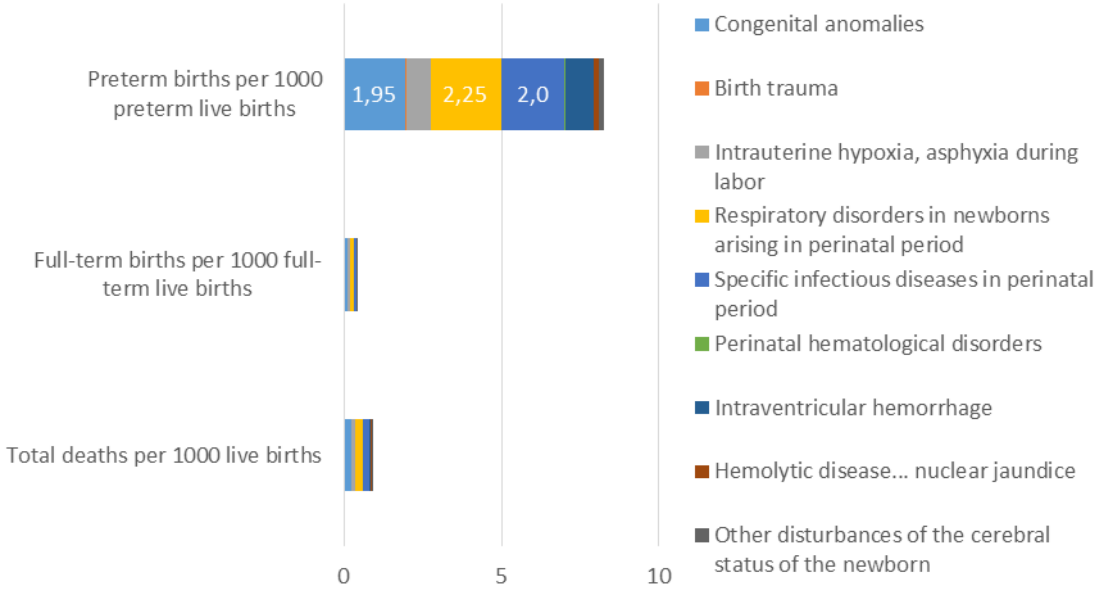
The risks of mortality among full-term and preterm infants are very different (Figure 7). In 2020, according to the Ministry of Health, the number of newborn deaths in maternity institutions per 1000 live births was 0.44 among full-term and 9.2 among premature infants (20 times higher). The greatest contributors to premature mortality were respiratory disorders, infectious diseases and congenital anomalies. Intrauterine infection (IUI), according to some estimates, reaches 70% among premature infants (Nurova, Mirzoeva 2022). The high level of IUI among preterm infants is associated with the fact that both the risks of prematurity and the risks of IUI are influenced by placental insufficiency and disruption of the protective function of the placenta.

Figure 6. Number of premature babies, thousand people and per 1000 live births



Source: Health status of pregnant women, women in labor, postpartum women and newborns. Rosstat, official website. [Electronic resource]. https://rosstat.gov.ru/storage/mediabank/zdr3-2.xls

Figure 7. Number of deaths of newborns in maternity institutions, born with a body weight of 1000 g or more, by cause of death, per 1000 live births of each category, 2020



Source: (Alexandrova et al. 2021: table 28, p. 139).

Unfortunately, neither the Ministry of Health nor Rosstat publishes data on infant mortality and its components by gestational age of the fetus, only by birth weight. This impoverishes the ability to analyze infant mortality taking into account the problem of prematurity. Of course, low birth weight and low fetal weight are associated with higher mortality risks. However, weight closely correlates with gestational age, and - using a single indicator - the choice of gestational age will be more correct. Using body weight alone may give incorrect signals to the researcher, as it does not reflect the presence and degree of intrauterine

growth restriction. For example, a baby weighing 1 kg can be born both at 27-28 weeks and at 32-33 weeks (in the case of IUGR).

According to international data, more than 84% of premature births occur in the 32-36th week of pregnancy, only about 5% are extremely premature (formerly 28 weeks), and about 10% occur in weeks 28–32 (Walani 2020). Gestational age influences the risks of mortality and health consequences of the newborn, as well as the volume and nature of medical care required during nursing and further rehabilitation.

Conclusions and recommendations

In the last decade, the system of maternal and child health care has continued to improve in Russia. The result of the steps taken has been a decrease in infant mortality rates. At the same time, there are currently extensive reserves for its further reduction. In the structure of infant mortality, the share of postneonatal mortality remains unreasonably high, and, accordingly, the share of neonatal mortality is significantly lower than in other developed countries.

Improved medical care, the development of resuscitation measures and intensive technologies for caring for newborns, especially for newborns with low and extremely low body weight, play a significant role in reducing infant mortality. After the formation of the modern obstetric care system in developed countries, the main efforts were focused on maximizing the reduction of preventable infant mortality and eliminating all known risks associated with pregnancy and childbirth. Not only the direct development of medical technologies plays a role, but also the improvement of organizational practices, two key components of which are optimizing the routing of pregnant women[14] and reducing the number of consecutive hospitalizations of newborns in institutions at various levels. In particular, the low prevalence of inter-care transfers of newborns has been assessed as an important factor in the survival of preterm infants in Japan (Isayama 2019).

To summarize, we can identify directions for further steps to reduce infant mortality in Russia.

1. The organizational and medical aspect:
    - further develop prenatal diagnostics and increase their accessibility. Diagnostic procedures such as genetic testing, direct fetal tissue biopsy and non-invasive prenatal diagnosis (NIPD) help in the early detection of developmental abnormalities during the first trimester of pregnancy, which allows for early informed decisions about prolongation or termination of pregnancy, and also leads to better postpartum treatment of individual anomalies (for example, congenital heart defects (Dolk, Loane, Garne 2011)). Improve screening programs to detect fetal growth restriction;
    - improve the territorial accessibility of third-level obstetric care organizations, complete the program for the construction of perinatal centers, ensure high quality roads along the route to them;
    - shift the focus to upgrading and improving the qualifications of medical personnel in second-level obstetrics organizations and in medical organizations providing the second stage of nursing for premature newborns;

[14] The principle of “in utero transfer”: high-risk fetuses should be transported to the third level of obstetric care in utero.

- develop centers for remote consultation and monitoring of pregnant women (Zilber, Ankudinov 2019). Telemedicine technologies can reduce social inequalities in pregnancy services.

2. Public awareness:
   - raise awareness about the need for *pregnancy planning* (a set of diagnostic, treatment and preventive measures aimed at preparing a married couple for full conception, pregnancy and the birth of a healthy child), including examination and treatment of infections that are predominantly sexually transmitted, as well as taking folic acid before pregnancy and in the early stages. It is known that timely intake of folic acid is associated with a reduction in the risk of intrauterine anomalies (Spina Bifida, fetal heart disease);
   - improve communication during pregnancy between the doctor and the patient. Currently, the Internet has become one of the most popular sources of information on the topic of medicine, and pregnant women are no exception. A meta-analysis of publications shows that most women do not discuss information obtained from the Internet with their doctor (Sayakhot, Carolan-Olah 2016). This contributes to the massive formation of erroneous beliefs about pregnancy and influences behavioral practices regarding the consumption of medical services during this period.

3. Improving the quality of related statistics and analytical capabilities:

3.1 expansion of published Rosstat statistics:

- annual publication of neonatal mortality rates (0-27 days); publication of the number of live births and deaths by aggregated categories of fetal gestational age, separately and in intersection with body weight for research into the problem of intrauterine growth retardation. The problem of prematurity significantly affects the level of infant mortality, but is poorly reflected in Russian statistics.

3.2 development of information technologies:

- for purposes of analysis, it is necessary to maintain and aggregate the use of state and regional databases on pregnancy outcomes with a wide range of medical, demographic and social indicators;
- registers of pregnant women (including those with critical obstetric conditions) are currently being introduced in Russia; there is a need to expand them and bring them to a unified federal level. These should allow for the analysis of statistics on basic interventions aimed at increasing the survival of preterm infants: the timely administration of maternal antenatal steroids and neonatal surfactant[15]. Monitoring the frequency of maternal antenatal steroid administration provides important information about the potential for reducing infant mortality. Thus, in Western countries, 80-90% of newborns weighing less than 1500 g receive antenatal corticosteroids; in Japan this is 60% (Isayama 2019);
- Many countries have established national registries that measure outcomes for newborns born preterm (Lui et al. 2019). Russia also needs to maintain regional and federal databases on preterm infants (like iNeo (Shah et al. 2019) or the Japanese Newborn Research Network of Japan (NRNJ)). Such a database can be formed on the

[15] These two drug classes appear to be key to reducing premature infant mortality (Zeitlin et.al. 2016).
In particular, a surfactant is a solution that is injected through a tube directly into the lungs of the child. It spreads rapidly through all the airways and increases blood oxygen saturation. In some cases, the child needs a double or even triple dose of surfactant.

basis of registers of pregnant women. The databases are used in international joint research, making it possible to compare the results of nursing premature babies and to introduce best practices. Thus, the use of the iNeo database led researchers to the conclusion that, against the background of a decrease in infant mortality, there is a recession in morbidity rates or even an increase in individual diseases (namely, bronchopulmonary dysplasia (BPD)). The connection between the dynamics of mortality due to respiratory disorders and the dynamics of the number of children diagnosed with BPD must also be monitored in Russia.

Infant mortality is mainly associated with congenital anomalies, premature birth and low birth weight, and pregnancy complications. The shift in fertility to increasingly older ages increases the risks of these conditions and poses new challenges to maternity services in developed countries. Russia is also following the path of aging motherhood, but the prevalence of pregnancies among mothers of late reproductive age in Russia is still not as high as in other countries. In other words, there is time to modernize pregnancy management practices and maternity services to take into account the risks and needs of this category of women.

References

Aleksandrova G.A., Son I.M., Leonov S.A., Ogryzko E.V., Sukhanova L.P., Boguslavsky M.A., Bozhko V.N., Gladkikh T.E., Shcherbakova G.A., Oblomneva A.A. 2013, Grineva A.M. *Main indicators of maternal and child health, activities of the child welfare and obstetric assistance service in the Russian Federation.* Moscow: FGBU "TSNIIIZ" Ministry of Health of the Russian Federation.

Al-shehri H., Dahmash D.T., Rochow N., Alturki B., Alrajhi D., Alayed F., Alhazani F., Alsuhibany H., Naser A.Y. (2022). Hospital admission profile of neonates for conditions originating in the perinatal period in England and Wales between 1999–2020: an ecological study. *International Journal of General Medicine. 15*, 1973-1984. https://doi.org/10.2147/IJGM.S354847

Andreev E.M. (2020). *Inequality in infant mortality among the population of modern Russia. Issues of statistics*, 27(2), 48-62. https://doi.org/10.34023/2313-6383-2020-27-2-48-62

Bantieva M.N. (2023). Trends in the morbidity of pregnant women, women in labor and post-partum women in the Russian Federation. Some aspects of pathology prevention. Report presented at the conference *Topical problems of maternal and child health: priority for prevention* of FSU "TSNIIIZ" Ministry of Health of the Russian Federation.

Delnord M., Blondel B., Zeitlin J. (2015). What contributes to disparities in the preterm birth rate in European countries? *Current opinion in obstetrics & gynecology*. 27(2), 133–142. https://doi.org/10.1097/GCO.0000000000000156

DiPietro J.A., Voegtline K.M. (2017). The gestational foundation of sex differences in development and vulnerability. *Neuroscience*. 342, 4-20. https://doi.org/10.1016/j.neuroscience.2015.07.068

Dolk H., Loane M., Garne E. (2011). Congenital heart defects in Europe: prevalence and perinatal mortality, 2000 to 2005. *European Surveillance of Congenital Anomalies Working G.* 123, 841–849. https://doi.org/10.1161/CIRCULATIONAHA.110.958405

Grzybowski S., Stoll K., Kornelsen J. (2011). Distance matters: a population-based study examining access to maternity services for rural women. *BMC health services research*. 11(1),1-8. https://doi.org/10.1186/1472-6963-11-147

Ingemarsson I. (2003). Gender aspects of preterm birth. *BJOG: an international journal of obstetrics and gynecology*. 110, 34-38. https://doi.org/10.1016/S1470-0328(03)00022-3

Isayama T. (2019). The clinical management and outcomes of extremely preterm infants in Japan: past, present, and future *Translational pediatrics*. 8(3), 199-211. https://doi.org/10.21037/tp.2019.07.10

Ivanova I. A. (2014). Statistical analysis and modelling of infant mortality as one of the indicators of demographic security of the regions of the Russian Federation. *Regional economics: theory and practice*. 9, 50-55.

Keller M., Felderhoff-Mueser U., Lagercrantz H., Dammann O., Marlow N., Hüppi P., Buonocore G., Poets C., Simbruner G., Guimaraes H., Mader S., Merialdi M., Saugstad O.D. (2010). Policy benchmarking report on neonatal health and social policies in 13 European countries *Acta paediatrica*. 99(11), 1624-1629. https://doi.org/10.1111/j.1651-2227.2010.01894.x

Kotova E.G., Kobyakova O.S., Starodubov V.I., Alexandrova G.A., Golubev N.A., Ogryzko E.V., Polykarpov A.V., Shelepova E.A. (2021). *The main indicators of maternal and child health, activities of the child protection and obstetric assistance service in the Russian Federation*. M.: Central Hospital of the Ministry of Health of the Russian Federation.

Kvasha E.A. (2014). Mortality of children under 1 year in Russia: what changed after the transition to new definitions of live birth and stillbirth. *Demographic review*. 1(2), 38-56. https://doi.org/10.17323/demreview.v1i2.1816

Lui K., Lee S.K., Kusuda S., Adams M., Vento M., Reichman B., Darlow B., Lehtonen L., Modi N., Norman M., Håkansson S., Bassler D., Rusconi F., Lodha A., Yang J., Shah (2019). Trends in outcomes for neonates born very preterm and very low birth weight in 11 high-income countries. *The Journal of pediatrics*. 215, 32-40. https://doi.org/10.1016/j.jpeds.2019.08.020

Naeye R.L., Burt L.S., Wright D.L., Blanc W.A., Tatter D. (1971). Neonatal mortality, the male disadvantage. *Pediatrics.* 48(6), 902-906. https://doi.org/10.1542/peds.48.6.902

Nurova A. A., Mirzoeva R. K., Berdysh D. S. (2022). The current situation in perinatal and infant mortality in Russia. *Bulletin of Biomedicine and Sociology*. 7(2), 59-66. https://doi.org/10.26787/nydha-2618-8783-2022-7-2-59-66

Petrukhin V.A., Gridchik A.L., Logunova L.S., Chechnya M.A., Aksenov A.N., Dub N.V., Melnikov A.P. (2021). Modernization of obstetric care - reserve for reduction of perinatal and infant mortality. *Russian obstetrician-gynecologist.* 21(3), 5-10. https://doi.org/10.17116/rosakush2021210315

Sayakhot P., Carolan-Olah M. (2016). Internet use by pregnant women seeking pregnancy-related information: a systematic review. *BMC pregnancy and childbirth*. 16(1), 1-10. https://doi.org/10.1186/s12884-016-0856-5

Shah P.S. Lee S.K., Lui K., Sjörs G., Mori R., Reichman B., Håkansson S., San Feliciano L., Modi N., Adams M., Darlow B., Fujimura M., Kusuda S., Haslam R., Mirea L. (2019). The International Network for Evaluating Outcomes (iNeo) of neonates: evolution, progress and

opportunities. *Translational pediatrics*. 8(3), 170-181. https://doi.org/10.21037/tp.2019.07.06

Sukhanova L.P. (2013). Pregnancy outcomes and perinatal losses under new birth criteria. *Social aspects of health of the population*, 31(3), 7.

Townsel C.D., Emmer S.F., Campbell W.A., Hussain N. (2017). Gender differences in respiratory morbidity and mortality of preterm neonates. *Frontiers in pediatrics*. 5, 6. https://doi.org/10.3389/fped.2017.00006

VanderWeele T.J., Lantos J.D., Lauderdale D.S. (2012). Rising preterm birth rates, 1989–2004: changing demographics or changing obstetric practice? *Social science and medicine*. 74(2), 196-201. https://doi.org/10.1016/j.socscimed.2011.10.031

Walani S.R. (2020). Global burden of preterm birth. *International Journal of Gynecology & Obstetrics.* 150(1), 31-33. https://doi.org/10.1002/ijgo.13195

Zeitlin J., Mortensen L., Cuttini M., Lack N., Nijhuis J., Haidinger G., Blondel B., Hindori-Mohangoo A.D. (2016). Declines in stillbirth and neonatal mortality rates in Europe between 2004 and 2010: results from the Euro-Peristat project. *J Epidemiol Community Health*. 70(6), 609-615. https://doi.org/10.1136/jech-2015-207013

Zelinskaya D.I., Terletskaya R.N. (2013). Regional features of infant mortality from congenital malformations in the Russian Federation. *Children's Hospital*. 1, 10-13. https://rdkb.ru/files/file2033.pdf

Zilber N.A., Ankudinov N.O. (2019). Regional obstetric monitoring: an innovative tool to manage a cluster of obstetric care. *Journal of telemedicine and e-health.* 5(1), 3-7.

Appendix

Table A. Coefficient of infant mortality by life expectancy of boys and girls, 2021, per 1,000 live births

	Boys	Girls
Including: to 1 day	0.36	0.28
1 day	0.44	0.34
2 days	0.33	0.22
3 days	0.23	0.15
4 days	0.17	0.12
5 days	0.11	0.13
6 days	0.12	0.09
7-9 days	0.34	0.21
10-13 days	0.28	0.21
14-19 days	0.28	0.21
20 days	0.04	0.03
21-27 days	0.25	0.20
28 days	0.03	0.03
29 days	0.03	0.03
30 days	0.02	0.01
1 month	0.65	0.48
2 months	0.37	0.29
3 months	0.26	0.20
4 months	0.20	0.20
5 months	0.19	0.16
6 months	0.16	0.10
7 months	0.12	0.08
8 months	0.07	0.08
9 months	0.08	0.06
10 months	0.06	0.05
11 months	0.06	0.04
Unknown	-	-
Total	5.25	3.99

Source: Author's calculations based on unpublished Rosstat data.