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Research article

MATERNAL RISK FACTORS FOR A CHILD'S HEALTH PRIOR TO AND DURING PREGNANCY (RESULTS OF LONG-TERM COHORT MONITORING IN VOLOGDA REGION)

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The work presents the results of the 26-year monitoring with its focus on children's health. Pre-school children living in the Vologda region were selected as a research object. The aim was to assess health risks for children caused by certain maternal factors and conditions. The study was accomplished as an intra-cohort analysis of data on 1454 children from five cohorts (born in 1998, 2001, 2004, 2014 and 2020) by calculating a relative risk rate.

Negative effects produced by sociodemographic, socioeconomic and environmental conditions as well as maternal harmful occupational factors during pregnancy are significant health risk factors for a child. It is true not only for the neonatal period but also during pre-school years. Such health-related factors as stillbirths in case history, complications of a present pregnancy (up-to-date reproductive technologies being applied to achieve it, eclampsia, multiple pregnancy, dangerous fetus position, prematurity, postmaturity, anemia, edemas, protein in urine) and birth (rapid labor, use of vacuum extraction) do the most severe damage to a child's health at birth and their influence persists as a child grows. Other significant risk factors that influence children's health in their pre-school years include diseases of the genitourinary and endocrine systems diagnosed in a mother prior to pregnancy; a mother being single; low incomes; electromagnetic radiation at a place where a family lives; harmful working conditions at a mother's workplace (gases in workplace air, work on a conveyor belt, radiation exposure). A mother's young age is also a health risk factor for a fetus during the prenatal period but its influence reduces as a child grows. In contrast, if a mother is older than 40, this factor protects a child's health during pregnancy but increases likelihood of retarded neuropsychic development by the school age (due to a mother's low health potential).

Overwhelming majority of health risk factors we detected in this study are quite manageable. Our results can be used in creating programs aimed at preserving health of a mother and a child at any level, from individual to national one.

Keywords: *health risks for children, biomedical, sociodemographic, socioeconomic, and environmental factors and conditions, harmful working conditions, a child's health group, prevalence of diseases, dispensary observation and record keeping.*

According to the Global Burden of Disease Study 2019 (GBD 2019), fertility has been declining steadily worldwide over the last two decades whereas life expectancy has been growing in most regions. This leads to a reduction in labor force and in population ageing, which, in their turn, lead to grave socioeconomic and political problems in the contemporary society [1].

Reproductive behavior of the RF population is also changing as families without children or with only one or two children are becoming more widely spread [2]. An outbreak of the new coronavirus infection, among other negative outcomes, has also led to an additional decline in a number of people who want to have children (including those who still do not have them) [3].

The UN predicts that the world population will reach 9.7 billion by 2050. And a share of elderly people will be higher than a share of adolescents and youth (aged from

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15 to 24 years) combined. A share of children younger than 5 years will be lower than a share of people older than 65 years[1].

In Russia, the most substantial loss in children population occurred in 1990–2011 when it decreased by 14 million people; this was followed by a growth in this population group. However, we can well expect another decline in the nearest future. According to average estimates given by Rosstat[2], by 2035 a number of children younger than 14 years will go down by almost 5 million. The most substantial loss is expected in the youngest age group, children aged from 0 to 3 years (by 1.7 million) and those aged from 4 to 6 years (by 1.8 million).

At present, enormous effort is being made in Russia to improve the demographic situation in the country, to support parenthood and childhood, to protect and improve children's health. However, despite all this effort taken both by the state and the society, there is considerable concern about children's health and we should remember that this population group is declining as it is. Health of future generations is a major component in the reproductive and labor potential as well as human potential in general and its preservation has specific economic significance. Given that, it is becoming extremely vital to search for and develop mechanisms able to manage factors that can deteriorate it[3].

Research data indicate that health of a an infant or a preschool child is largely affected by maternal risk factors such as mother's health, biomedical factors including course of a pregnancy, the ordinal number of a birth and abortions in case history, occupational hazards, and mother's age. Obstetric and extragenital pathologies result in complications during the antenatal period and various fetal pathologies; they also create risks of pathologies developing in a child in the neonatal period or at an older age [4].

Our research goal was to assess health risks for a child during the prenatal and preschool period created by exposure to variable maternal factors and conditions prior to and during pregnancy.

To achieve that, the following tasks were set:

1. To analyze studies on maternal health risk factors for a child.

2. To assess a relative health risk for a child caused by certain maternal factors in the prenatal period.

3. To assess a relative health risk for a child caused by certain maternal factors in the preschool period.

4. To suggest targeted recommendations how to develop activities aimed at health preservation and neutralization of adverse health risk factors for preschool children, which we identified in this study.

Our research object was health of children living in the Vologda region. The study focused on examining risk factors for newborns as well as children aged 1–2, 3–4 and 6–7 years.

The research methodology. The study relied on data obtained by five waves of the cohort medical and social monitoring accomplished by the Vologda Research Center of the Russian Academy of Sciences. The monitoring was accomplished within the scientific research project entitled "The study on conditions for raising a healthy generation" [5]. We applied several criteria to include a child into each cohort. First, a child should be born in a specific period (in 1995, May 15–21; 1998, March 01–07; 2001, March 01–25; 2004, March 01–25; 2014, March 01–21; 2020, March 16–April 10)[4]; a maternity

[1] Shifting Demographics. *The UN*. Available at: https://www.un.org/en/un75/shifting-demographics (April 04, 2022).

[2] Edinaya mezhvedomstvennaya informatsionno–statisticheskaya sistema [The Unified interdepartmental information and statistical system]. Available at: https://fedstat.ru (April 04, 2022) (in Russian); Predpolozhitel'naya chislennost' naseleniya Rossiiskoi Federatsii: stat. sb. [Expected population of the Russian Federation: statistical data collection]. *Federal State Statistics Service*. Available at: https://rosstat.gov.ru/compendium/document/13285 (April 04, 2022) (in Russian).

[3] Shabunova A.A., Korolenko A.V., Natsun L.N., Razvarina I.N. Preserving children's health: search for the ways of solving relevant issues. *Economic and Social Changes: Facts, Trends, Forecast*, 2021, vol. 14, no. 2, pp. 125–144. DOI: 10.15838/esc.2021.2.74.8

[4] Each stage was accomplished in 5 settlements in the Vologda region, namely Vologda, Cherepovets, Velikii Ustyug, Kirillov and Vozhega. These settlements were selected randomly.

patient gave her consent to fill in the questionnaire and to participate in further stages of the prospective study; health workers at a maternity hospital had all the necessary documents on a peculiar course of a given pregnancy and respondent's health. Families with children who took part in at least one stage in the monitoring until a child reached 7 years (n = 1037) were selected from the overall data array (n = 1464) to be analyzed in this study (Table 1).

We applied a relative risk (*RR*) as an indicator to estimate influence that was exerted by the analyzed risk factors on a child's health[5].

We identified and classified several maternal risk factors based on the analyzed literature sources (the results of this analysis are given below) and available biomedical and sociological monitoring data. Use of this exact classification allows correcting the existing system for mother and child protection and supplementing it with targeted activities that have solid scientific basis.

(1) medical and demographic factors: age, marital status of a mother, relationships between spouses;

(2) socioeconomic factors: financial conditions, a possibility to satisfy family needs given the total available family income; estimation of living conditions including absence of own housing;

(3) environmental conditions on a territory where a mother lived: poor quality of water, ambient air pollution, soil pollution (dump, wastes), elevated noise levels, no green spaces or parks, and electromagnetic radiation.

(4) harmful working conditions at a mother's workplace: chemicals and toxicants, dustiness, gas pollution, vibration, noise, humidity, radiation and effects produced by SHF, substantial physical loads, working on a conveyor, working in 2 or 3 shifts, exposure to high and low temperatures, biological hazards, mental strain, night shifts.

(5) biomedical factors: a mother suffering from diabetes mellitus (chronic and gestational); gynecological diseases (chronic noncommunicable ones) and diseases of the urinary tracts (pyelonephritis); hazardous infections (venereal, tuberculosis, hepatitis B/C, HIV, toxoplasmosis); hyper- or hypofunction

Table 1

The profile of the analyzed sampling

Sampling volume	1998 cohort	2001 cohort	2004 cohort	2014 cohort	2020 cohort	Total	
						abs.	%
Initial number of maternity patients	199	250	265	370	380	1464	100.0
Took part in at least one stage in the monitoring (newborns excluded) until a child reached 7 years (inclusively),	166	211	190	243	227	1037	70.8
% of the initial volume	83.4	84.4	71.7	65.7	59.7		
Data base for the study:							
Children aged: younger than 1 year	166	211	190	243	227	1037	100.0
1–2 years	162	196	176	236	227	997	96.1
3–4 years	135	166	160	186	–	647	62.4 (79.9)*
6–7 years	109	144	140	134	–	527	50.8 (65.0)*

N o t e : * analysis for the age periods 3–4 years and 6–7 years was performed as per data obtained by monitoring of the cohorts that included children born in 1998, 2001, 2004 and 2014; % of the initial volume was calculated without considering the 2020 cohort (n = 810).

[5] *RR* was calculated as a ratio of a risk that a disease would developed in an "exposed" group (influenced by a given risk factor) to a risk that a disease would develop (health would deteriorate or an incidence rate would grow) in an "unexposed" group. In this study, we considered only those *RR* values with the lower limit of their confidence interval (CI) being higher than 1.10. Statistical significance of a relative risk was estimated in each case with its value being 95 %.

of the thyroid gland; obesity. We considered a number and outcomes of previous pregnancies and peculiarities of the current one (toxicosis, anemia, edemas, protein in urine, risk of preeclampsia or eclampsia); birth complications (prolonged or rapid labor, cesarean delivery, forceps operation, vacuum extraction, weak birth activity, abnormal (breech) fetus presentation, or multiple pregnancy). A mother's smoking status prior to and during pregnancy was also accounted for.

The estimation was performed in 2 stages:

I. Changes in a child's health during the prenatal period. The estimation criteria included intrauterine growth retardation (IUGR) in a fetus and health disorders (pathologies, diseases, and congenital malformations) in a newborn.

II. Changes in a child's health at an age of 1–2, 3–4 and 6–7 years. These age periods were selected in accordance with the dates of regular medical check-ups that involved examination performed by the greatest number of specialists.

At the second stage, we estimated whether a child was assigned into the health group 2 or higher[6], how frequently a child fell sick, whether a child had any chronic diseases that required mandatory regular medical check-ups. In addition, we estimated RR of specific diseases.

We analyzed biomedical and sociological data by using SPSS statistical software package.

This study makes it possible to identify and classify maternal health risk factors for a child, and to estimate levels and duration of exposure to each of them during the whole preschool period.

Our results and recommendations following them can be used by regional and federal authorities in developing complex programs for providing economic, psychological, pedagogical and medical support to women in their reproductive age. Such support is especially vital during pregnancy. Another important aspect is to ensure additional specific support to risk groups in order to preserve human, intellectual and reproductive potential of children as future generations. Achieving this means that national security of the country has been reinforced.

Analysis of studies and research articles on the subject. Let us consider maternal health risk factors for children, which, in our opinion, are the most significant ones.

A mother's age, an age of marriage and education describe socioeconomic maturity of potential parents and allow judging whether they are ready to take on responsibility to raise a child and to change their life in a drastic way

[6] According to the Order by the RF Pubic Healthcare Ministry dated August 10, 2017 No. 514n "On the procedure for performing regular medical check-ups of minors":

Health group 1 includes minors with proper physical and mental development, without any anatomic defects, functional and morphofucntional disorders;

Health group 2 includes minors who have no chronic diseases (conditions) but have certain functional and morphofucntional disorders; reconvalescents, especially those who have had severe communicable diseases; minors with overall physical retardation without any diseases of the endocrine system (low height, delayed biological development), with body mass deficiency or overweight; minors who often fall sick with respiratory diseases and are sick for a long time; minors with physical malformations, consequences of injuries or operations with functions and systems of the body remaining intact.

Health group 3 are minors who suffer from chronic diseases (conditions) and are in clinical remission, with rare exacerbations, with intact or compensated functions of organs and systems, without any complications of the major diseases (conditions); minors with physical malformations, consequences of injuries or operations provided that functions of organs and systems are compensated and their state does not impose any limitations on minors' abilities to learn or work.

Health group 4 are minors who suffer from chronic diseases (conditions) in their active phase or are in unstable clinical remission with frequent exacerbations, with intact or compensated functions of organs and systems or incomplete functional compensation; minors with chronic diseases (conditions) in remission, with functional disorders of organs and systems that require supporting therapy; minors with physical malformations, consequences of injuries or operations with incomplete compensation of functions performed by organs and systems and resulting limitations imposed on their ability to learn or work.

Health group 5 are minors who suffer from severe chronic diseases (conditions) with rare clinical remissions, frequent exacerbations, continuous recurrent clinical course, apparent functional decompensation of organs and systems, complications that require permanent therapy; minors with physical malformations, consequences of injuries or operations with apparent functional disorders of organs and systems and significant limitations imposed on their ability to learn or to work; minors with chronic diseases and decompensation.

[6]. All over the world, the existing trends indicate that women get pregnant at an older age more and more often. A mother's age that exceeds 40 years has a positive correlation with preterm birth [7], which, in its turn, produces negative effects on a newborn's health. In particular, children born by mothers who are older than 40 years have congenital heart diseases by two times more frequently [8]. However, this correlation between prematurity and a mother's age remains rather disputable since there is a possibility that negative health outcomes in a newborn result from combined exposure to other harmful factors (primary hypertension, obesity, diabetes mellitus, varicose veins, gynecological diseases, complications during labor and use of artificial reproductive technologies).

Acute and chronic diseases of a mother, threat of miscarriage, and alcohol consumption during pregnancy are well-known maternal perinatal risk factors of developmental disorders during the preschool period [9]. Polycystic ovary syndrome (PCOS) is proven to create an elevated risk of certain mental disorders for a child including sleeping disorders, attention deficit hyperactivity disorder (ADHD), autistic disorders, behavioral, tick and anxiety disorders, intellectual disability, and eating disorders. It should be added that a risk of any neuropsychic disorders is significantly higher for offspring of mothers who have both PCOS and class III obesity; when other factors (a mother suffering from gestational diabetes, cesarean delivery, or infertility) were excluded, it did not change the results [10].

Iron deficiency *anemia* is widely spread among women, especially pregnant ones. It leads to negative outcomes for their physical and emotional health. The disease creates elevated risks of a fetus death, preterm birth, and low birthweight[7].

Diabetes mellitus is among the most widely spread chronic diseases diagnosed in fertile women all over the world and its prevalence is only growing [11]. Women who suffer from gestational diabetes have an elevated risk of complications during pregnancy and birth. Such women and their children are exposed to an elevated risk of developing type II diabetes[8]. Epidemiological studies revealed that a pregnancy complicated with a mother having diabetes could result in development disorders of offspring (for example, autistic disorders [12, 13] and ADHD [14, 15]) due to oxidative stress and fetal hypoxia [1, 16]. Data obtained by a study on a children cohort indicated that children born by mothers with any type of diabetes diagnosed during pregnancy had an elevated lifetime risk of schizophrenia, anxiety disorders, intellectual disability, and behavioral disorders [17].

According to data provided by the WHO, approximately 80 % of people who have type II diabetes mellitus are obese. Diabetes develops by seven times more frequently in people with overweight than in those with normal body weight. *A mother being overweight* is a risk factor that can cause obesity in a child, as shown by the data of multiple regression analysis [18]. And this risk is practically proven manageable. Offspring born by obese mothers who were treated for gestational diabetes mellitus (GDM) had better outcomes regarding their BMI than offspring born by mothers who were not treated for the diseases in the last trimester and suffered from developing dysglycemia [19].

Several latest studies disprove any relationship between a mother *smoking* and developing diseases in future offspring. Thus, according to a prospective cohort study accomplished in Japan, active smoking of a mother prior to and during pregnancy as well as living with a smoking person in a family in the postnatal period did not have any relationship with a risk of asthma for a child. In contrast, if mothers who had never smoked were exposed to "passive smoking" at work and/or at home during pregnancy, their children had elevated risks of developing asthma

[7] De Jesús Montoya Romero J., Castelazo Morales E., Castro E.V., Velázquez Cornejo G., Nava Muñoz D.A., Escárcega Preciado J.A., Montoya Cossío J., Pichardo Villalón G.M. [et al.]. Review by expert group in the diagnosis and treatment of anemia in pregnant women. Federación Mexicana de Colegios de Obstetricia y Ginecología. *Ginecol. Obstet. Mex.*, 2012, vol. 80, no. 9, pp. 563–580 (in Spanish).

[8] Diabetes. *WHO*, 2021. Available at: https://www.who.int/news-room/fact-sheets/detail/diabetes (April 07, 2022).

[20, 21]. It is noteworthy that, according to data obtained by some Norwegian researchers, if a mother smoked during pregnancy, it produced negative effects on health of her grandchildren. Thus, each fourth mother with a child suffering from asthma stated that her mother smoked during her pregnancy [22].

A child's health is especially dependent on exposure to *environmental factors*, such as ambient air pollution, harmful chemicals, climate change, and poor quality of water [23]. One third of the total child disease burden is caused by exposure to harmful environmental factors [24]. According to our research, adverse environmental conditions on a territory where a family lives produce negative effects on labor activity (primarily due to an elevated risk of cesarean delivery as obstetric aid) and on health of newborns [25] and preschool children [26].

Harmful working conditions at a woman's workplace can also affect her reproductive health and make for pathologies developing in children during the first year of their life. Chemical pollution was established to produce negative effects on health and reproductive functions of female workers employed at metallurgic plants, textile productions, gas and oil processing enterprises; female model makers and controllers employed in civil engineering; female laboratory workers dealing with chemical analysis; female engineers in chemical industry; female surgeons, gynecologists, obstetricians, and nurses at in-patient surgical hospitals [27]. These female workers are more frequently exposed to threats of abortions, spontaneous miscarriages, complications during pregnancy and birth, and offspring's congenital malformations. These pathological states were shown to have a relationship with elevated contents of sulfur dioxide, phosphor anhydride, lead, nickel, and iron in ambient air. We should remember that pregnancy makes a woman's body more sensitive to harmful environmental factors [28]. As shown in our earlier studies, harmful working conditions at a future mother's workplace are also a risk factor that can cause complications during birth and lead to weak labor activity, necessity to use stimulation or cesarean delivery; or, on the contrary, this factor can cause rapid labor thereby increasing a risk of negative health outcomes in a newborn (pathological states, diseases or congenital malformations) [25].

Pregnancy maintenance and, consequently, fetus development are highly vulnerable and sensitive to any disorders caused by *prenatal stress*. Prevalence of any clinically diagnosed anxiety disorders during pregnancy equals 15 % (reaching 18 % during the first month after birth) [29]. Five percent of mothers in high-income countries suffer from clinical depression in the perinatal period; the share reaches 15–50 % in low- and middle-income countries [30].

Anxiety, depression and stress during pregnancy are risk factors that can have negative outcomes such as threat of miscarriage [31], preterm birth, and necessity to use premedication or cesarean delivery [32]. There are several delayed outcomes, such as an elevated clinically significant level of generalized anxiety (even after the prenatal one has been put under control) half a year after birth [33] and a shorter breastfeeding period [34]. This, in its turn, produces negative effects on a child's health.

It should be noted that an unwanted pregnancy and stress before birth are risk factors that can cause stillbirth [35], fetal hypotrophy [31], developing endocrine and immune reactions during pregnancy. Consequently, a child has an elevated risk of chronic diseases, such as allergy and asthma [36], recurrent respiratory infections [37], more frequent hospital admissions due to all types of communicable diseases (typically among boys) [38]. Maternal stress factors have a remote outcome which is earlier menarche in girls; this is highly undesirable regarding their mental, social and reproductive health and a reason for weaker immunity and overweight [39]. As for boys, this factor is associated with weaker reproductive functions in adulthood [38].

If a mother experiences negative emotions, this has significant influence on formation of a child's mental health [40, 41]. Depression and anxiety during pregnancy can induce emotional disorders in a child, create certain difficulties in mastering pro-social behavior, facilitate disorders of motor (in a child

younger than 2 years), cognitive and speech development [30]. They can also create elevated risks of oppositional defiant disorder (ODD) [42], behavioral disorders, and attention deficit hyperactivity disorder in a child, as well as raise a level of anxiety and dependence on psychoactive drugs [43].

Abortions produce the greatest effects on a woman's reproductive potential. A risk of dangerous infections grows drastically after *surgical abortion* (they account for one third of deaths associated with abortions, predominantly due to infection with Clostridia [44]). Women with artificial abortions in their case history, even after potential distorting factors had been corrected, still had significant risks of preterm birth (prior to the 37th week of pregnancy) and low birthweight (less than 2500 grams). Perinatal outcomes were worse in case of surgical abortion against medical one [45]. In addition, previous abortions create elevated risks of developing placenta previa in future [46], depression, breast neoplasia and cancer [47].

At present, issues related to influence exerted by *cesarean delivery* on a child are becoming especially vital since more and more children are born by this operation (the share reaches 25–30 % across the RF). Cesarean delivery results in elevated risks of negative effects on a child's physical health and neural and cognitive development as opposed to natural birth. The risks persist even after all maternal and obstetric factors have been corrected [48]. Besides, scientists established that women became pregnant less frequently after cesarean delivery. Studies indicate that cesarean delivery can be associated with smaller gestational age at birth and a reduced opportunity to breastfeed a baby, elevated risks of respiratory diseases in the neonatal period, developing asthma [49], type I diabetes and attention deficit hyperactivity disorder [50], autism [51], epilepsy [52], eczema [53], obstructive sleep apnea [54], elevated risks of lower respiratory tract infections [55] and higher body mass index in six month time (but without obesity in future) [56]. A type of delivery was shown to influence development of cognitive abilities in 5-year old children. Children who were born by cesarean delivery turned out to be less successful in doing cognitive tests than their counterparts who were born naturally [57].

Therefore, research articles describe a wide range of harmful maternal risk factors for a child's health. Next, we are making an effort to assess their relative risk within our long-term cohort study.

Results and discussion. ***I stage. Assessment of health risk factors for a child in the prenatal period.*** A young age of a mother during pregnancy creates by 2.2 times higher risk of intrauterine growth retardation (*RR* = 2.22, 95 % CI: 1.23–3.98) and by 70 % higher risks of severe health disorders in a newborn (*RR* = 1.69, 95 % CI: 1.24–2.28). This might be due to the fact that this factor often aggravates a clinical course of a pregnancy by creating an elevated risk of anemia (on average by 48 %) and edemas (by 2.2 times) for a mother thereby producing extremely negative effects on a child's health.

According to our calculations, a more mature age of a mother does not create an elevated health risks for a child in the prenatal period. However, it increases a risk of cesarean delivery (as a mother becomes older: the risk is by 35 % higher among women older than 35 years and by 88 % higher among those older than 40 years). This, in its turn, may have certain negative influence on a child's health in future.

Marital status of a mother produces indirect effects on a child's health, according to our data. Lone mothers (single, divorced or widowed) have by 3 times higher risks of intrauterine growth retardation (*RR* = 2.22, 95 % CI: 1.27–3.68) and consequently giving birth to a child with health disorders (by 1.7 times, *RR* = 1.66, 95 % CI: 1.24–2.21). Probably, lacking support and help provided by a man becomes a long-term stress factor for a pregnant woman who has to rely only on herself during this difficult period in life, financial issues included. Therefore, our study confirms that perinatal stress produces extremely negative effects on a child's health, starting from the embryonic period.

Financial position of a family expecting a child primarily influences health of a fu-

ture mother and if it is poor, a pregnancy is likely to have complications. Thus, low purchasing capacity made for developing anemia and edemas in the respondents (the risk grew by 33 % and 80 % accordingly) and the same was true for living conditions estimated as unsatisfactory by the respondents themselves (by 43 % and by 2 times accordingly). This was probably due to diets not being rich in all the necessary nutrients and not being variable enough, overcrowding, too much stuffiness and humidity in a place of living. We did not establish any effects produced by these factors on fetal development but they still can become apparent later, as children grow.

Pregnant women who live on territories with an *unsatisfactory ecological situation* have greater risks of edemas during pregnancy, especially if water quality (a 58 % increase in the risk) and ambient air quality (a 75 % increase) do not conform to the existing hygienic standards. Polluted ambient air correlates also with likelihood of cesarean delivery (this risk grows by 60 %).

When future parents live under exposure to electromagnetic radiation, this creates higher risks (by 2.7 times) that their newborns will have developmental deviations, congenital malformations and diseases (*RR* = 2.72, 95 % CI: 1.53–4.85).

Harmful occupational factors create health risks for a mother and a child. Women who work under exposure to chemicals and toxicants as well as to biological hazards have higher risks of cesarean delivery (by 76 % and 90 % accordingly).

Such a harmful factor as “dustiness” increases a risk of congenital malformations in future offspring on average by 60 % (*RR* = 1.59, 95 % CI: 1.17–2.16).

A future mother’s health and chronic diseases in her case history is also a health risk factor during pregnancy. Thus, we confirmed that diseases of the urinary tracts naturally increased a risk of edemas during pregnancy (*RR* = 2.64, 95 % CI: 1.85–3.77) and obesity created an elevated risk of cesarean delivery (*RR* = 2.18, 95 % CI: 1.41–3.38). We did not detect any negative effects produced by specific diseases of a mother on intrauterine development.

Another significant risk factor is obstetric complications during previous pregnancies. In particular, preterm birth and stillbirth in case history increase a risk of cesarean delivery in future by 2.4 and 4.3 times accordingly.

We should pay special attention to *peculiarities and complications of a pregnancy* as health risk factors for children. Thus, edemas, protein in urine, eclampsia, abnormal (breech) presentation, prematurity or postmaturity (the latter prevailed in our study), rapid labor and a multiple pregnancy create elevated risks of a newborn having pathologies, congenital malformations, or developmental disorders (Table 2). According to our monitoring data, out of all the biomedical obstetric factors, the greatest harm to a newborn’s health (by 2.9 times higher risks) is done by use of reproductive technologies (occurred exclusively in the 2020 cohort).

Table 2

Obstetric case history as a risk factor during pregnancy and for a child’s health in the prenatal period (relative risk)

Complications during pregnancy	Health disorders in a newborn
Edemas	1.72 (1.32–2.25)
Protein in urine	1.61 (1.24–2.08)
Eclampsia	2.08 (1.37–3.15)
Abnormal (breech) presentation	1.75 (1.19–2.59)
Prematurity / postmaturity	1.41 (1.10–1.79)
Rapid labor	1.73 (1.18–2.53)
Multiple pregnancy	2.07 (1.34–3.20)
IVF (only for the 2020 cohort)	2.87 (1.35–6.08)

Eclampsia, in its turn, increases risks of intrauterine growth retardation by 3.4 times (*RR* = 3.39, 95 % CI: 1.51–7.61)[9].

[9] According to obstetric case histories, eclampsia tended to be diagnosed less and less frequently up to 2014 (it was detected in 6 % of the respondents in 1998; 4 %, in 2001; 2 %, in 2004; and 1.2 %, in 2014). Starting from 2020, there was an increase in the indicator up to 2.2 %, and deaths due to the diagnosis happened in each analyzed year (one stillbirth), 2020 excluded.

II stage. Effects produced by risk factors on children's health in the preschool period. The analysis of socio-demographic factors revealed that *a mother's age* exceeding 40 years created elevated risks of: need in regular medical check-ups already during infancy (*RR* = 2.14, 95 % CI: 1.47–3.11); underweight (*RR* = 4.23, 95 % CI: 1.10–16.23) and anemia (*RR* = 2.43, 95 % CI: 1.17–4.29) in a child aged 1–2 years; diseases of the ENT at the age of 3–4 years (*RR* = 1.77, 95 % CI: 1.13–2.76) and delayed neuropsychic development (NPD) by the age of 6–7 years (*RR* = 7.24, 95 % CI: 2.58–20.30). A mother's rather young age (younger than 20 years) increased risks of intrauterine growth retardation but did not turn out to be a health risk factor for children in future. Its influence was eliminated. This might be associated with high health potential of a younger mother and since this potential gradually declines with age, an impact on a child's health is obvious.

A mother being single is a significant health risk factor not only in the prenatal period but also in later years since it can cause chronic diseases in a child as early as in infancy (*RR* = 1.50, 95 % CI: 1.18–1.91) and at the age of 3–4 years (*RR* = 1.55, 95 % CI: 1.21–1.99). Children born by single mothers have retarded physical and neuropsychic development at the age of 1–2 years (*RR* = 1.45, 95 % CI: 1.15–1.84) with NPD progressing further at the age of 3–4 years (*RR* = 1.64, 95 % CI: 1.10–2.51) and 6–7 years (*RR* = 3.89, 95 % CI: 2.09–7.23). A risk of cardiovascular diseases (*RR* = 1.95, 95 % CI: 1.40–2.70) and diseases of the ENT (*RR* = 1.68, 95 % CI: 1.11–1.54) almost doubles at the age of 3–4 years; the same goes for risks of neurological pathologies at the age of 6-7 years (*RR* = 1.84, 95 % CI: 1.29–2.62).

Previous studies confirmed that a *poor financial position and low purchasing capacity* of a mother during pregnancy and birth had a remote effect on a child's health that became apparent in the preschool period. This resulted in elevated risks of a child needing regular medical check-ups (*RR* = 1.39, 95 % CI: 1.11–1.74) predominantly due to diseases of the gastrointestinal tract (GIT) (*RR* = 1.87, 95 % CI: 1.13–3.09) and neurological pathologies (*RR* = 1.53, 95 % CI: 1.12–2.11).

Environmental factors on a territory where a family lives undoubtedly affect a child's health. Thus, drinking "low-quality water" during pregnancy creates an elevated risk of developing cardiovascular diseases for a child by the age of 1–2 years (*RR* = 1.63, 95 % CI: 1.17–2.94). Exposure to electromagnetic radiation multiplies a number of diseases a child has had by the senior preschool age (*RR* = 1.25, 95 % CI: 1.19–1.30), makes for more children being assigned into the health groups 3–5 (*RR* = 1.16, 95 % CI: 1.12–1.20), creates elevated risks of the ENT diseases (*RR* = 3.39, 95 % CI: 1.50–7.69) and obesity (*RR* = 9.19, 95 % CI: 1.75–48.35).

Harmful working conditions at a mother's workplace one year prior to childbirth deteriorate a child's health. Thus, if a mother worked on a conveyor production, it elevates a risk of neurological disorders in a child at the age of 1–2 years (*RR* = 2.08, 95 % CI: 1.19–3.60); occupational exposure to high temperatures (*RR* = 2.19, 95 % CI: 1.30–3.67) and work in night shifts (*RR* = 1.75, 95 % CI: 1.15–2.67) increases risks of cardiological diseases; exposure to low temperatures creates elevated risks of underweight (*RR* = 3.71, 95 % CI: 1.19–11.46) and lacrimal duct stenosis (*RR* = 5.77, 95 % CI: 1.35–24.56); exposure to vibration raises risks of allergic reactions (*RR* = 1.94, 95 % CI: 1.14–3.29); exposure to gas pollution at a mother's workplace creates elevated risks of retarded physical and neuropsychic development (*RR* = 2.02, 95 % CI: 1.45–2.83).

Gas pollution (*RR* = 1.71, 95 % CI: 1.33–2.21), exposure to radiation and SHF (RR = 1.48, 95 % CI: 1.10–2.08), working at a conveyor production (*RR* = 1.61, 95 % CI: 1.11–2.34), and exposure to high temperatures (*RR* = 1.47, 95 % CI: 1.15–1.87) increase risks of the ENT diseases by 50–60 % in children aged 3–4 years. We should mention that if a future mother works on a conveyor, this creates by 2.5 times higher risks of such diseases in older children as well (*RR* = 2.57, 95 % CI: 1.26–5.25 at the age of 6-7 years)**.** Exposure to

gas pollution (*RR* = 1.16, 95 % CI: 1.12–1.21) and radiation (*RR* = 1.16, 95 % CI: 1.13–1.20) a year prior to childbirth is a risk factor for a child being assigned into a worse health group by the school age.

According to our monitoring data, *a woman's health* did not impose serious threats for a child's health, hereditary diseases being the only exclusion. Such pathologies as hyper- or hypofunction of the thyroid gland increase a risk of an endocrine pathology in a child developing before it reaches the preschool age by 8 tines (*RR* = 8.18, 95 % CI: 2.04–32.88). And if a future mother has diabetes and obesity in her case history, than a number of diseases a child has is likely to multiply at the age of 1–2 years (*RR* = 1.20, 95 % CI: 1.13–1.29) and a child's health is more likely to deteriorate at the age of 3–4 years (*RR* = 1.18, 95 % CI: 1.14–1.22).

A mother smoking during pregnancy creates elevated risks of delayed physical and neuropsychic development at the age of 1 year (*RR* = 1.57, 95 % CI: 1.23–1.97), diseases of the ENT in infancy (*RR* = 1.57, 95 % CI: 1.14–2.17) and delayed NPD by the age of 2 years (*RR* = 2.73, 95 % CI: 1.35–5.50). If a mother smoked prior to a pregnancy, it increases a risk of obesity in a child by 2.8 times by the age of 6–7 years (*RR* = 2.81, 95 % CI: 1.20–6.61). We did not establish any likelihood that asthma would develop in a preschool child in case a mother smoked. Probably, this factor will show itself later.

Such *pregnancy complications* as edemas and anemia made for developing neurological diseases (*RR* = 1.43 and 1.80 accordingly), diseases of the ENT (*RR* = 1.57 and 1.77 accordingly) and GIT pathologies (*RR* = 1.64 and 1.96 accordingly) as well as anemia (*RR* = 1.44 and 1.58 accordingly) in a child at the age of 1–2 years. Cardiovascular diseases become more frequent by the age of 3–4 years (*RR* = 1.60, 95 % CI: 1.15–2.27). We should remember that a young age of a future mother, her low purchasing capacity, unfavorable environmental factors in a place of living and diseases of the genitourinary system in case history create elevated risks of edemas and anemia during pregnancy. Therefore, they indirectly act as health risk factors for a child in future. Protein in urine increases risks of cardiological diseases by the age of 1–2 years (*RR* = 1.59; at the age of 3-4 years, *RR* = 1.50, 95 % CI: 1.10–2.06), neurological diseases (*RR* = 1.85) and the ENT diseases (*RR* = 1.71; by the age of 3–4 years, *RR* = 1.37, 95 % CI: 1.15–1.63).

Let us examine *peculiarities of previous frequencies* as a potential risk health factor for preschool children. Stillbirths in case history do not disrupt intrauterine development (probably due to more profound medical support and timely prophylaxis); nevertheless, they make a number of diseases in infancy multiply and create elevated risks of a child needing regular medical check-ups already in infancy and early preschool age thereby reducing basic health indicators by the age of 7 years (Table 3). A child also has elevated risks of GIT pathologies during the first year of life (*RR* = 5.54, 95 % CI: 1.36–22.47); underweight (*RR* = 22.85, 95 % CI: 9.51–54.92) and anemia (*RR* = 3.94, 95 % CI: 1.75–8.89) at the age of 1–2 years; and by 15 times higher risks of bronchial asthma at the age of 6–7 years (*RR* = 15.88, 95 % CI: 2.89–87.25). We can assume that a previous tragic experience associated with stillbirth is a significant stress factor for a mother during her whole life and it is especially true for another pregnancy. In addition, this diagnosis indicates that a woman's reproductive system is rather weak, she has serious health issues and her health potential is rather low. All this might trigger weaker health of her future children.

Spontaneous miscarriages in a mother's case history make for chronic diseases developing in a child at the age of 6–7 increasing their risks by 1.5 times against children whose mothers do not have miscarriages in their case history (Table 3).

We can also trace a relationship between ectopic pregnancies in a mother's case history and such chronic pathologies developing by the school age as bronchial asthma (*RR* = 11.89, 95 % CI: 1.97–71.57) and obesity (*RR* = 6.88, 95 % CI: 1.19–39.75).

Table 3

Obstetric case history of previous pregnancies as a health risk factor for a child in the neonatal and preschool period (relative risk)

Risk factor	Health group 2 or higher at the age of 6–7 years	Frequency of diseases		Need in regular medical check-ups	
		1–2 years	6–7 years	1–2 years	6–7 years
Stillbirth	1.16 (1.12–1.20)	1.23 (1.19–1.27)	1.25 (1.19–1.30)	2.56 (2.30–2.84)	-
Miscarriages	-	-	-	-	1.45 (1.13–1.86)
Ectopic pregnancy	1.16 (1.12–1.20)	-	-	-	-

Table 4

Peculiarities of a pregnancy as a health risk factor for a future child in the preschool period (relative risk)

Risk factor	Health group 2 and higher		Frequency of diseases at the age of 6–7 years	Need in regular medical check-ups		
	3–4 years	6–7 years		1–2 years	3–4 years	6–7 years
Rapid labor	-	-	-	-	-	1.59 (1.11–2.29)
Multiple pregnancy	-	1.16 (1.12–1.20)	1.25 (1.20–1.31)	-	1.59 (1.11–2.29)	-
Vacuum extraction	1.18 (1.14–1.22)	1.16 (1.12–1.20)	-	2.54 (2.29–2.82)	-	1.91 (1.26–2.89)

Peculiarities and complications of the current pregnancy produce the greatest effects, first of all, on a newborn's health. Still, their negative outcomes can become apparent also as a child grows up. A multiple pregnancy is the most severe complication and the gravest health risk factor for children. It creates elevated risks for children aged 1-2 years regarding neurological deviations (*RR* = 1.76, 95 % CI: 1.12–2.74) and disorders of the GIT (*RR* = 2.79, 95 % CI: 1.55–5.05); for children aged 3–4 years, allergic reactions (*RR* = 3.48, 95 % CI: 1.77–7.02), neurological diseases (*RR* = 3.05, 95 % CI: 1.69–5.52) and diseases of the ENT (*RR* = 1.67, 95 % CI: 1.19–2.33); as a result, children need regular medical check-ups (Table 4). If a woman carries twins[10], it makes health deterioration more likely in children aged 6–7 years creating elevated risks of diseases of the CNS (*RR* = 3.36, 95 % CI: 2.18–5.61), diseases of the visual organs (*RR* = 4.33, 95 % CI: 1.24–15.09) and bronchial asthma (*RR* = 12.98, 95 % CI: 3.37–49.95).

Rapid labor makes for a child needing regular medical check-ups already at the age of 6–7 years (Table 4) and creates an elevated (by 4.6 times higher) risk of obesity at this age (*RR* = 4.63, 95 % CI: 1.66–12.90).

Vacuum extraction[11] correlates with children needing regular medical check-ups due to chronic diseases already at the age of 1–2 years and with their poorer health in future. After vacuum extraction has been applied during labor, children have by 5 times higher risks of GIT diseases (*RR* = 5.54, 95 % CI: 1.36–22.47) and by 6 times higher risks of cardiovascular diseases (*RR* = 6.05, 95 % CI: 1.49–24.58). Children aged 3-4 years have by 8 times higher risks of allergic reactions (*RR* = 8.08, 95 % CI: 6.58–9.91), and children aged 6–7 years have by 25 % higher risks of diseases of the ENT (*RR* = 1.25, 95 % CI: 1.20–1.30).

We should note that research articles mention multiple facts proving negative influence exerted by cesarean delivery on a child's health.

[10] In our cohort study, all cases of multiple pregnancies were diagnosed exclusively when two newborns were born.
[11] We detected one case of vacuum extraction in the 2014 cohort and one more in the 2020 cohort in our cohort study.

We can confirm growing prevalence of this type of delivery (from 10 % in the 1998 cohort up to 27 % in the 2020 cohort) similarly to the global trends. Still, we did not detect any elevated relative health risks for children who were not born naturally in our study. Partially, this can be due to the fact that cognitive disorders in children are determined more reliably by using cognitive tests and longitudinal observations in primary school, and this was beyond the scope of our research tasks and the sampling analyzed in the present research article.

Conclusion. The accomplished study allows making the following conclusions. Overwhelming majority of socio-demographic, socioeconomic, biomedical and environmental maternal risk factors exert their influence on a child's health not only in the prenatal and postnatal periods but also deteriorate it throughout the whole preschool period.

If a woman younger than 20 gave birth to a child with a risk of intrauterine growth retardation, a child's health improved up to its physiological standards by 7 years. But in case the same happened to women being older than 40 years, deviations in neuropsychic development persisted in their children up to the age of 6–7 years. Such children are a risk group regarding behavioral disorders, failure to master school subjects, and difficulties in adapting to school routines. We can assume that the difference occurs due to a younger mother having a higher health potential, which is genetically transferred to a child.

A mother being single also produces negative effects on a child's health starting from the intrauterine period and aggravating issues related to a child's neuropsychic development by the age of 7 years.

Low financial incomes of a family indirectly influence children's health during the preschool period. They, among other factors, are able to cause diseases of the gastrointestinal tract, neurological diseases and need in regular medical check-ups.

Harmful environmental factors produce the most apparent negative effects on how a child's body develops and functions. In our study, we detected a relationship between a family living under exposure to electromagnetic radiation and fetus pathology in the prenatal period. The outcomes usually persist up to the age of 6–7 years (ENT pathologies, more frequent diseases, and increased body mass index).

Despite the scientific and technical progress and new safe technologies being implemented at productions where future mothers are employed, harmful working conditions deteriorate children's health as pediatricians stated when questioned about it. Regular medical check-ups that are usually accomplished at the age of 1–2 and 3–4 years revealed diseases of the nervous and cardiovascular systems, diseases of the ENT and eye. Outcomes occurring due to exposure to such harmful factors as "dustiness", "high temperature", "low temperature", "work in night shifts", and "vibration" are reduced to their minimum by the time children start school and we can state that children recover. But it is rather alerting that effects produced by gas pollution, work on a conveyor and exposure to radiation and SHF persist up to the age of 6–7 years and become apparent due to a child being assigned into a health group with poorer health in general and diseases of the ENT in particular.

If we consider a mother's health a risk factor for a child, we bear in mind a woman's health both prior to pregnancy and during it including diseases in her case history and her bad habits such as smoking. As revealed by our study, a developing endocrine pathology in a child by the end of the preschool period has the most significant relationship with a mother having hyper- or hypofunction of the thyroid gland in her case history and smoking before pregnancy.

When we assess risk rates created by variable maternal health risk factors, we should note that obstetric case history with complications during previous pregnancies, namely stillbirths and ectopic pregnancy, crates by 10 times higher risks of such an autoimmune disease as bronchial asthma in children predominantly by the age of 6–7 years.

Complications of the current pregnancy and birth, such as anemia, edemas, or protein in urine, make for a pathology developing in a child in the prenatal period, at the age of 1–2 years and 3–4 years. A child usually recovers by the time he or she goes to school.

More severe complications including multiple pregnancy, rapid labor, or vacuum extraction have more serious consequences that persist during the whole preschool period. Typically, they are neurological diseases, diseases of the ENT and visual organs, increased BMI, and bronchial asthma.

Given the research results, we believe that it is necessary to improve activities aimed at preventing and treating diseases of children caused by manageable maternal risk factors. Overwhelming majority of maternal health risk factors for a child, which we established in our study, are manageable and can be neutralized by introducing proper state socioeconomic support to future parents, by improving gynecological and obstetric aid, and by developing perinatal centers.

Children who are born by women aged 40 years and older as well as single mothers are to be assigned into a risk group susceptible to deviations in neuropsychic development. Such children require regular medical check-ups to monitor their neuropsychic development up to the age of 18 years. It is necessary to develop a mechanism and a procedure for this monitoring and medical, psychological and pedagogical support that should involve parents, experts at preschool children facilities and polyclinics for children.

When a pregnant woman with low incomes comes to a gynecological clinic to be observed during her pregnancy, it is necessary to provide her with additional social support. Then, it is necessary to provide her child with the same monitoring regarding neuropsychic development and medical, psychological and pedagogical support that should involve parents, experts at preschool children facilities and polyclinics for children and be provided up to the age of 18 years.

We should try to provide families with children with housing located on territories free from any exposure to electromagnetic radiation. It is necessary to provide sanatorium-resort treatment for children who have diseases of the ENT and live on a territory exposed to electromagnetic radiation as well as children born by mothers who have to work under harmful working conditions. We also believe it is necessary to improve the regulatory and legislative base concerning health protection provided for women who work under harmful or hazardous working conditions.

We should communicate the results of scientific studies focusing on negative influences produced by smoking prior to pregnancy on a child's health to mothers, parents and children and motivate them to pursue a healthy lifestyle.

We understand that residual and hardly measurable combinations of all the external and internal risk factors require further investigation. In particular, some attention should be given to impacts exerted on a child's physical and neuropsychic development by a father's age, bad habits among older generations in a family, and cesarean delivery. We also realize the necessity to provide scientific substantiation for targeted recommendations on how to improve strategies aimed at preserving both parents' and children's health in order to increase health potential of next generations.

Limitations of the study. (1) Our study sampling was made of obstetric patients with an initially favorable medical and social situation who gave their consent to participate in the study. It did not include all the women who gave birth to their children during the specific periods when our cohort was sampled. (2) It is rather difficult to keep the same number of participants in the monitoring over the long-term study period. Our sampling reduces every year. (3) Residual and hardly measurable combinations of all the external and internal factors require further investigation.

Prospects of the study. In future, we plan to examine maternal risk factors for a child's health not only in the preschool period but at older ages as well. We realize the necessity to provide scientific substantiation and to develop targeted recommendations on how to improve strategies aimed at preserving both parents' and children's health in order to increase health potential of next generations.

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