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- XI НАЦИОНАЛЬНЫЙ КОНГРЕСС С МЕЖДУНАРОДНЫМ УЧАСТИЕМ «РАЗВИТИЕ ФАРМАКОЭКОНОМИКИ И ФАРМАКОЭПИДЕМИОЛОГИИ В РОССИЙСКОЙ ФЕДЕРАЦИИ» – «ФАРМАКОЭКОНОМИКА 2017» 27-28 МАРТА 2017г., ЕКАТЕРИНБУРГ

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PHARMACOECONOMIC ANALYSIS OF LONG-TERM EFFECTS OF MORE WIDESPREAD USE OF IN VITRO FERTILIZATION IN INFERTILITY TREATMENT AT THE REGIONAL AND FEDERAL LEVEL FROM THE STANDPOINT OF SOCIETY AT LARGE IN THE RUSSIAN FEDERATION

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Summary: *pharmacoeconomic analysis of long-term effects of more widespread use of in vitro fertilization (IVF) in infertility treatment at the regional and federal level from the standpoint of society in the Russian Federation was carried out in this research. The research was performed by means of forecasting of future monetary flows produced by a human born with the aid of in vitro fertilization throughout life. The methods of cost analysis, discounted monetary flows, age shifting and model building were used in the research. The result is that net present value (NPV) of tax payments produced within anticipated life period by the human born with of IVF in the Russian Federation was equal to 822,258 rubles. Return on investments (ROI) was 27%. Net present value (NPV) of GDP produced within the state per one human born with the aid of IVF in the Russian Federation was equal to 34.9 million rubles. Return on investments (ROI) was 985%. Additional carrying out of 24,450 IVF cycles on the basis of OMI CMI (Obligatory Medical Insurance) (the level of 2013) results in increase of total growth of population of the Russian Federation by 22.5%, annual additional carrying out of IVF procedure in the quantity carried out in 2013 will allow to produce additional population growth by 2075 estimated at 319 thousand people in productive age, and 222 thousand people aged up to 20 years.*

Key words: *in vitro fertilization (IVF), assisted reproductive technologies (ART), infertility, cost analysis, net present value, discounting, monetary flows, return on investments (ROI), model building, pharmacoeconomics*

Introduction

Birth rate and average duration of life are key figures in estimation of social policy effectiveness of any state. Provision of high level of birth rate and duration of life is a strategically significant aspect of population policy implementation for many states which is conditioned by the necessity of labor efficiency improvement. Even with a maximum encouragement of the birth rate by a state through the provision of sustainable economic climate, existence of labor market demand, appropriate social assistance and insurance, a hidden and undeveloped potential of birth rate growth exists by virtue of delivery of health care to couples suffering from infertility.

Undeveloped potential of the birth rate in conditions of focused policy of encouragement of the birth rate is able to have not only demographic and social effect but also negative economic effect. Such an effect is characterized by limitation of potential capacity of labor resources in the economy able to result in decrease of economic growth rate and decrease of produced GDP.

Taking into account annual growth of quantity of fertility-challenged couples, low level of implementation of procedures aimed at infertility treatment is able to produce a postponed economic burden for a state which is able to have long-term effect on future production output within the state and tax revenues [1].

About 48.5 million couples around the world suffer from infertility, and this figure is on the rise [1]. Although to a greater degree infertility is specific mainly to couples of middle age and urban population where women give birth to the first child in middle age, main burden of infertility falls on countries with developing and emerging economy [2].

In response to the growth of fertility-challenged couples quantity, rapid progress in reproductive medicine and numerous researches in this area allowed to develop significantly the innovative technologies in treatment of fertility-challenged couples around the world [3]. Due to this, assisted reproductive technologies (ART) were widely recommended as effective treatment methods in most countries. ART include a wide variety of treatment methods which, in their turn, include procedures aimed to achive pregnancy [4].

In vitro fertilization (IVF) and intracytoplasmic sperm injection (ICSI) are the most common ART in the world.

More than 500,000 IVF cycles are carried out in European countries annually which subsequently lead to 100,000 additional births [3, 5, 6].

More than 5 million children around the world were born with o IVF and ICSI in 2012 [7].

Taking into account the international recognition and growth of demand for ART, there is a necessity of implementation of these technologies in developing countries. A great number of researches related to ART effectiveness are concentrated among highly developed countries while in developing countries there is a necessity in evaluation and widespread use of these technologies.

Research performed in the Zabaikalye Territory revealed that occurrence of infertility in this region was 24.9% (11.4% - primary infertility, 13.5 - secondary infertility). The data obtained show quite wide occurrence of infertility problem in certain regions of the Russian Federation [18]. Though within 2013, only 24,450 IVF cycles on the basis of OMI were carried out in the Russian Federation furthered to 5,827 births . Such an unimposing statistics is caused by the cost of this procedure which is the main limiting factor for couples suffering from infertility [8].

Due to critical social need in ART, a number of researches were carried out in many countries related to estimation of long-term effects of IVF use in infertility treatment. Similar researches were carried out in developed

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countries (Great Britain, USA, Brazil, Denmark, Sweden, etc.), as well as in countries with emerging economy (Ukraine, Belarus, Kazakhstan). The results of researches show positive dynamics of net present value, tax payment flows and (or) produced GDP for the society in case of more widespread use of ART. The results obtained in researches indicated that future monetary flows which would be produced by every human, particularly, tax revenues modified to current date (taking into account time value of money) will significantly exceed current and future expenses on procedures for birth and social support for a child till he (she) would achieve productive age. However, the result of estimation of net present value depends to a high degree on the level of labor productivity in a country, level of incomes, tax policy, and the state policy in the area of health care [9, 10, 11].

Carrying out of the above researches related to evaluation of long-term economic effects of more widespread use of in vitro fertilization allowed people making decisions in the health care area to obtain assessment of extent of economic burden bearing by the state in case of "unbirth" of every new child in a family suffering from infertility. On the other hand, the results obtained may be interpreted as probable positive economic effect of investments to assisted reproductive technologies in case of provision by the state of availability thereof for such infertile families.

In reference with the above, it is necessary to analyze long-term effects of more widespread use of IVF procedure from the standpoint of economic and demographic influence in the Russian Federation.

Materials and methods

In the frame of this research an analytical model of decision making was built. Calculation of economic efficiency of more widespread use of IVF in the Russian Federation is carried out by calculation of net present value of monetary flow produced by a human born with IVF.

Calculation of net present value was carried out using the following formula:

$$NPV = \sum_{n=1}^{N} \frac{C(1+g)^n}{(1+r)^n} - C_{n0}$$

in which:
NPV – net present value;
C – monetary flow produced within n period;
C_{n0} – expenses on IVF procedure;
g – stable growth rate;
r – discounting rate;
n – period.

Calculation of economic effect of activity of citizens born with IVF was carried out according two main indicators - net present value on tax payments and on produced GDP .

Descriptive model was built dividing the anticipated life period in several basic periods. The first period is growth of unborn child within which a negative monetary flow is produced by the state: expenses on medical procedures and drugs in the frame of IVF cycle(s), pregnancy rate and pregnancy care, expenses on medical services and drugs during labors . The next period is a period of life until achievement of productive age, when negative monetary flows are also produced by means of government transfers (allowances, expenses on education, healthcare, etc.). The following period is productive age. Within this period the human generates positive monetary flow producing GDP and paying taxes to the government. The final period is achievement of retirement age when the human generates negative monetary flows again receiving pensions from the government.

Upon achievement of positive net present value the investment is considered to be profitable. After that the possibility to estimate the return on investments emerges. This estimation was carried out by calculation of return on investments using the following formula:

$$ROI = \frac{NPV}{\sum_{n=0}^{n} C_{neg}} * 100$$

in which:
ROI – return on investments;
NPV – net present value;
C_{neg} – negative monetary flow.

This indicator shows the profitability of the government investments.

Since the forecasting period for monetary flows equaled to several decades, this produced the need to take into account time value of money and stable economy growth. For this reason, the rates of stable growth and discounting were included in calculation. Average annual rate of growth of GDP of the Russian Federation for the last 20 years equaled to 3.877% was taken for the discounting rate (weighed average capital cost). Stable growth rate was used for accumulation of all money payments in view of the future growth of Russian, as well as global economy. Stable growth rate was determined as average annual rate of growth of the global economy for the last 60 years and equaled to 3.499% [12, 15].

Analysis of demographic effect of more widespread use of IVF in the Russian Federation was also carried out by determination of additional population growth. The analysis was performed under condition of increase of quantity of IVF cycles implemented by quantity of cycles implemented in 2013, i.e. carrying out of additional 24,450 cycles on the basis of OMI .

Quantity of additionally born children was calculated using the following formula:

$$Q_f = q_c * k_f$$

in which:
Q_f – quantity of children born with IVF;
q_c – number of IVF cycles
k_f– birth rate.

Expenses on achievement of one childbearing were carried out using the following formula:

$$C_b = \frac{q_c * p_c}{Q_f}$$

in which:
C_b – expenses on achievement of one birth;
p_c – cost of one IVF cycle.

In addition, estimation of influence of IVF use on the structure of population of Russia by 2075 was also made. The method of age shifting was used for this. Forecasting with the use of such method is carried out using the following formula:

$$P_{x+n} = P_n * \frac{L_{x+n}}{L_x}$$

in which:
P_{x+n} – forecasted population size in the age of "x+n";
P_x – baseline population size in the age "*x*";
n - length of age interval (and at the same time — length of forecasting interval);
L_x L_{x+n} — numbers of the living from mortality tables for two adjacent age groups;

Data on demographic indicators, wage level for age groups, produced GDP , size of government allowances, unemployment level, and etc. used in this research were obtained from official sources of information [13, 14, 15].

Results

At the first stage the expenses on birth of one child were estimated. This monetary flow was considered to be primary, and was not discounted. Data on the cost of one IVF course were obtained from a tariff agreement on payment for medical assistance rendered on the basis of territorial programme of complete medical insurance for Moscow on 2016 dated 25.12.2015. Average expenses on achievement of one birth were calculated on the basis of number of IVF cycles - 24,450 (according to ART Register – 2013 Report) and number of live birth - 6,602. Thus, expenses on achievement of one birth equaled to 418,922 rubles ($C_b = \frac{24450 * 113109}{6602} = 418\ 922$ rub.) [8].

After determination of the first monetary flow, negative monetary flows were estimated which grew annually by the stable growth rate and were discounted taking into account the discounting rate. Negative monetary flows include as follows: allowances (one-time child birth allowance, maternity allowance, child care allowance, monthly allowance for a child, etc.), expenses on healthcare, education, etc.

The following stage of the research was the estimation of life period of the human when he (she) generates positive monetary flow - reproductive age. Assumption was made in the model that a human in the Russian Federation

begins to work at 20 years old at the average. For greater accuracy of the calculation the data on salary level according to age categories were used which were applied to incomes of the human on achievement of the relevant age category. Then, the tax burden rate in the Russian Federation fixed at the level of 33.3% for the whole analysis period was applied to the salary wage of each period [17].

The final considerated stage was the retirement age. In estimation the assumption was made that average human in the Russian Federation retires on a pension at the age of 58 years old. Taking into account the fact that average duration of life for children born in 2015 equaled to 72 years, in a human's life between 58 and 72 years the negative monetary flow is produced due to retirement benefits and expenses on healthcare [15].

Net present value (NPV) of tax payments produced during the whole life by a human born with IVF in the Russian Federation equaled to 822,258 rubles. Return on investments equaled to 27%. Graphic representation of cumulating net present value of tax payments is presented in Figure 1. It should be noticed that such calculations for people born without IVF would differ by absence of initial expenses on IVF procedure (in the reference axis beginning "0 years" in Fig. 1).

According to the diagram, breakeven point (payback) of investments is achieved on the 32nd year of the human's life. Data of the diagram also show the decrease of cumulating net present value from 58th year of life at the average that is caused by negative monetary flows from the government aimed at pension benefits. However, as the final result, the indicator has positive value at the end of life which is illustrative of obvious economic advantages of investments for birth rate increase with the aid of IVF.

Then, it was necessary to determine the impact made by every human's activity on economy at large. For this reason, the estimation of net present value of monetary flow produced by a human for economy of the state at large was carried out at the next stage. In order to implement this, positive monetary flow presented by the human was not expressed in wage but in GDP per employed person. Other calculations and assumptions complied with the above methods.

Net present value (NPV) of produced GDP pwithin the state per one human born with the aid of IVF in the Russian Federation equaled to 34.9 million rubles. Return on investments (ROI) equaled to 985%. Graphic representation of cumulating NPV of produced GDP is presented in Figure 2.

Data of the diagram show that payback period for expenses is 21 years. In other words, within the first year of employment the effect for economy at large compensates for all expenses incurred by the state till achievement by the human of productive age. The obtained data is indicated of high economic expediency of stimulationon birth with the aid of IVF technology in infertility couples.

The next stage of the research included the analysis of population growth in the Russian Federation by of more widespread use of IVF. This analysis took into account additional birth rate increased upon additional increase the number of IVF cycles by the level of 2013 (24,450 cycles). Thus, for our purpose, the situations of coverage of requirement in this technology at the governmental level or current situation were modeled (status quo).

Taking into account the data on birth and death rates in the Russian Federation equal to 13.3 and 13.1 per 1,000 people respectively [15]. Calculated population growth in 2015 equaled to 29,304 people. Quantity of people born additionally with the aid of IVF equaled to 6,602 (see Fig. 3).

Data presented at the diagram show that additional performing of 24,450 IVF cycles (the level of 2013) will lead to increase of total population growth in the Russian Federation by 22.5%.

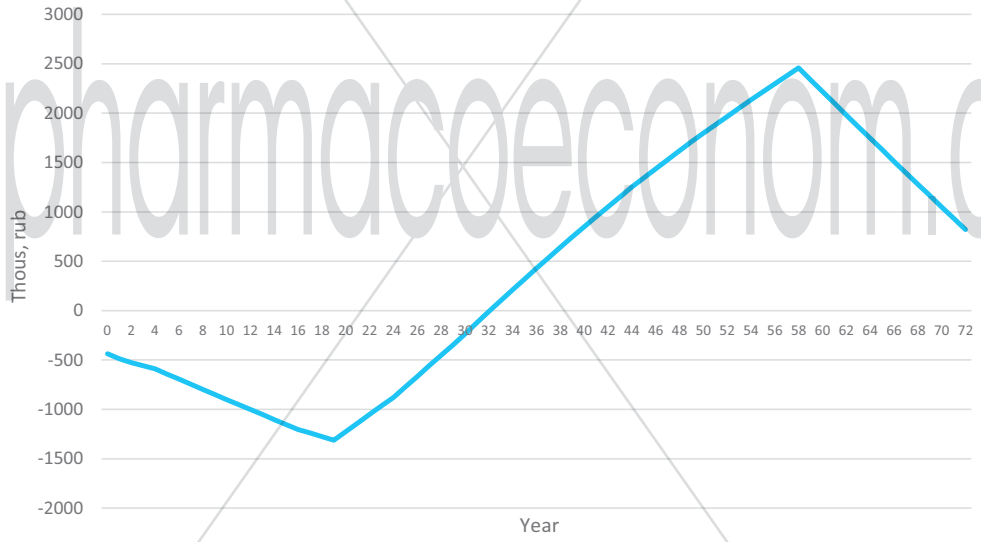

Figure 1. Cumulating NPV of tax payments

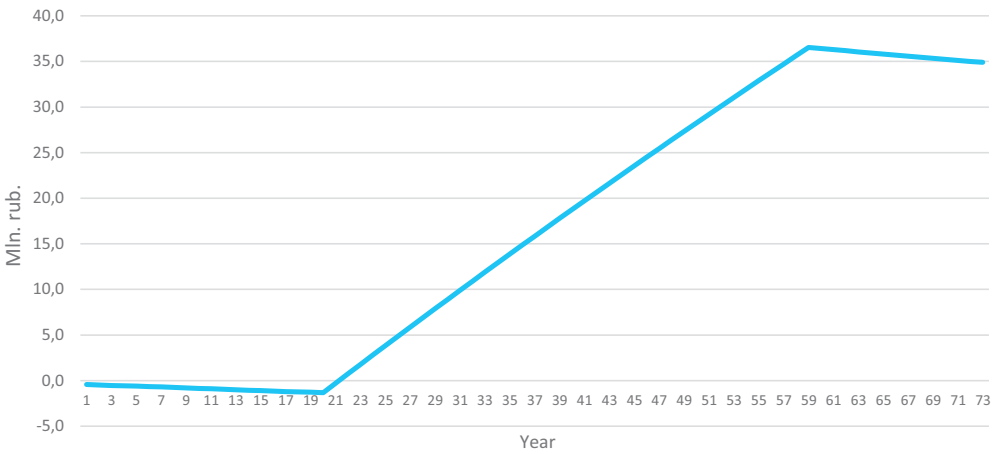

Figure 2. Cumulating NPV of GDP produced

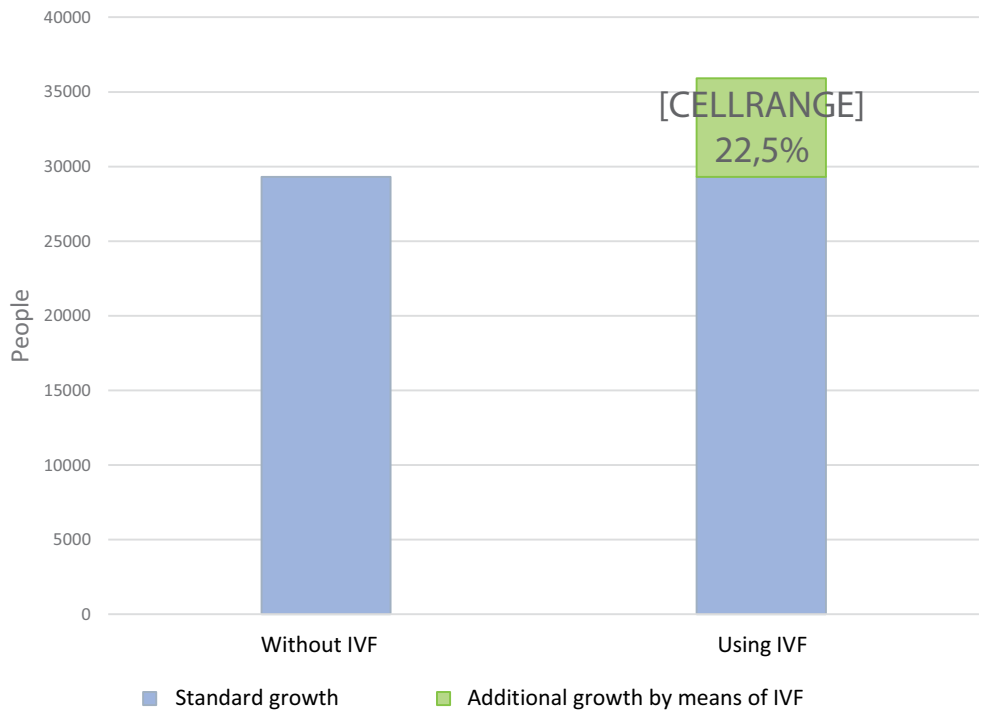

Figure 3. Indicators of total population growth with and without IVF.

At the following stage of the research estimation of additional economic effect in situation of natural total population growth and total population growth by means of IVF technology was calculated.

It should be noticed that in this analysis estimation of net present value of produced GDP was carried out. The following indicators were taken into account in calculation: male and female born ratio, unemployment level, different retirement age (55 and 60 for women and men respectively), and different life duration depending on gender

Table 1 presents the analysis of economic efficiency of produced GDP .

Table 1. Demographic and economic effect of additional use of IVF.

Indicator	*Without IVF*	*With IVF*	*Change (total)*	*Change (relative)*
Population growth (people)	29,304	35,906	6,602	22.53%
NPV (billion rubles)	956.2	1,169	+213	22.24%
ROI	1,024%	1,001%		

Graphic representation of the data is shown in Figure 4.

According to the diagram, additional population growth by means of IVF results in significant positive effect expressed in additional growth of GDP of the state in whole.

The next stage of the research included forecast of population structure of the Russian Federation by 2075 taking into account maintenance of the current birth and death rates. The analysis was aimed at determination of additional population growth according to age groups by means of additional annual use of IVF at the level of 2013 (24,450 cycles).

Forecasting values of population structure in Russian Federation are presented in Table 2.

Graphic representation of additional population growth according to age groups by means of additional use of IVF is presented in Figure 5.

Data of the diagram show additional growth by 2075 estimated at 319 thousand people - this is population in reproductive age, as well as 222 thousand people aged up to 20 years. Thiswill allow increasing significantly the economic effect from additional birth by means of IVF.

Conclusions

The results of pharmacoeconomic analysis of long-term effects of more widespread use of in vitro fertilization in infertility treatment in the Russian Federation revealed:

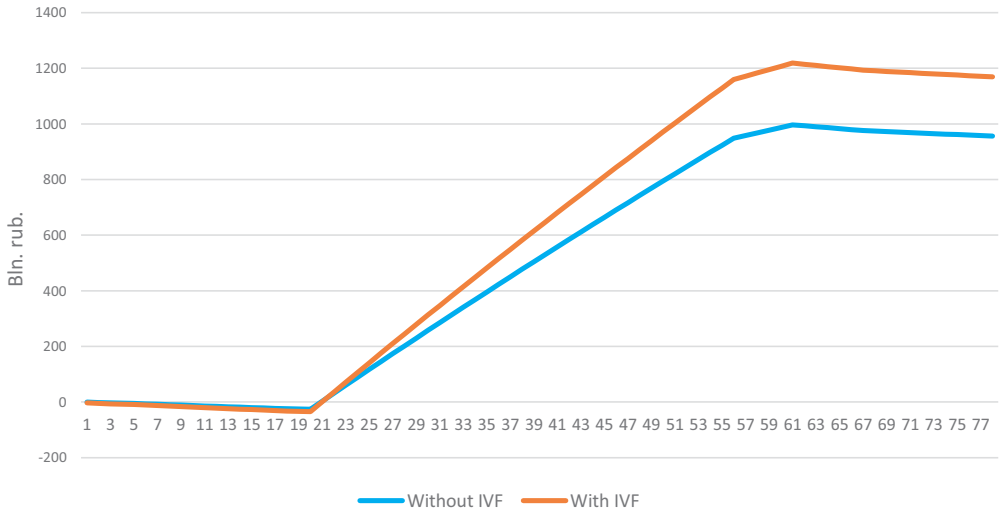

Figure 4. Cumulating NPV for population growth without IVF and with additional use of IVF

Table 2. Population structure in Russian Federation in 2075

Age group	Population without use of IVF (thous. people)	Population with IVF use (thous. people)	Growth (total)	Growth (relative)
0-4	9,857	9,917	60	0.61%
5-9	9,758	9,814	56	0.57%
10-14	9,737	9,791	54	0.55%
15-19	9,717	9,769	52	0.54%
20-24	9,678	9,728	50	0.52%
25-29	9,612	9,659	47	0.49%
30-34	9,507	9,552	45	0.47%
35-39	9,346	9,388	42	0.45%
40-44	9,157	9,195	38	0.41%
45-49	8,940	8,975	35	0.39%
50-54	8,661	8,694	33	0.38%
55-59	8,295	8,324	29	0.35%
60-64	7,421	7,421	0	0.00%
65-69	5,951	5,951	0	0.00%
70-74	4,771	4,771	0	0.00%
75-79	3,908	3,908	0	0.00%
80-84	4,164	4,164	0	0.00%
85-89	3,826	3,826	0	0.00%
90-94	2,012	2,012	0	0.00%
95-99	709	709	0	0.00%

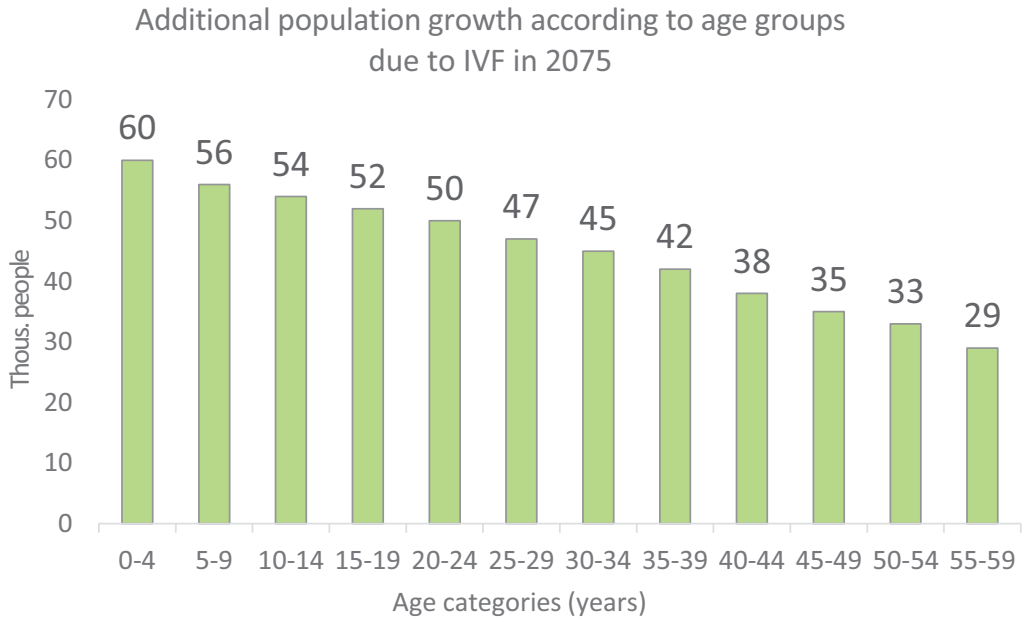

Figure 5. Additional population growth according to age groups in 2075 due to people born with IVF.

- net present value (NPV) of tax payments produced within anticipated life period by the human born with IVF in the Russian Federation equaled to 822,258 rubles. Return on investments (ROI) was 27%.

- net present value (NPV) of GDP within the state per one human born with IVF in the Russian Federation equaled to 34.9 million rubles. Return on investments (ROI) was 985%.

- additional carrying out of 24,450 IVF cycles (the level of 2013) leads to increase of total population growth in the Russian Federation by 22.5%.

- additional annual carrying out of IVF at the level of 2013 will produce additional population growth by 2075 estimated at 319 thousand people in reproductive age, as well as 222 thousand people aged up to 20 years.

Thus, the results obtained may be interpreted as positive economic effect of investments to assisted reproductive technologies due to increase of level of labor resources able to result in increase of rate of economic and GDP growth.

Reference list

1. Mascarenhas MN, Flaxman SR, Boerma T, Vanderpoel S, Stevens GA. National, regional, and global trends in infertility prevalence since 1990: a systematic analysis of 277 health surveys.Plos One. 2012;9(12):e1001356. doi: 10.1371/journal.pmed.1001356.
2. World Health O. Preconception Care to Reduce Maternal and Childhood Mortality and Morbidity. Geneva (CH): World Health Organization; 2012.
3. Aleixandre-BenaventR,SimonC,FauserBCJM.Trendsinclinicalreproductive medicine research: 10 years of growth. FertilSteril. 2015;104(1):131–7. doi: 10.1016/j.fertnstert.2015.03.025.
4. Butler P, Khanna J. Assisted reproduction in developing countries-facing up to the issues. Prog Hum Reprod Res. 2003;63:1–8.
5. International Committee for Monitoring Assisted Reproductive Technologies (ICMART) press release.ESHRE Istanbul; Turkey: Jul, 2012.
6. Sullivan E, Zegers-Hochschild F, Mansour R, Ishihara O, de Mouzon J, Nygren K. International Committee for Monitoring Assisted Reproductive Technologies (ICMART) world report: assisted reproductive technology 2004. Hum Reprod.2013;28:1375–90. doi: 10.1093/humrep/det036.
7. European Society of Human Reproduction and Embryology (ESHRE) 5 Million Babies. European Society of Human Reproduction and Embryology (ESHRE); 2012. [updated 2012; cited 2015 31.8]
8. V. S. Korsak, A. A. Smirnova, O. V. Shurygina. ART in Russia. Report for 2013. ART register of RAHR. Saint-Petersburg, 2015.
9. Fragoulakis V., Maniadakis N. Estimating the long-term effects of in vitro fertilization in Greece: an analysis based on a lifetime-investment model. Clinicoecon Outcomes Res. 2013 Jun 20;5:247-55. doi: 10.2147/CEOR.S44784. Print 2013.
10. Mandrik O., Knies S., Severens JL3. Economic value of in vitro fertilization in Ukraine, Belarus, and Kazakhstan. Clinicoecon Outcomes Res. 2015 Jun 12;7:347-56. doi: 10.2147/CEOR.S79513. eCollection 2015.
11. Connolly M.P., Pollard M.S., Long-term economic benefits attributed to IVF-conceived children: a lifetime tax calculation. AmJManagCare. 2008 Sep;14(9):598-604.
12. TheWorldBank[Electronic source]. – Access mode: http://data.worldbank.org/indicator/NY.GDP.MKTP.CD
13. The common portal of the budget system of the Russian Federation [electronic source]. – Access mode: http://budget.gov.ru/.
14. A. E. Kononova, N. B. Shugal. The total cost of education in the Russian Federation. Newsletter. – Moscow : National research University «Higher school of economy», 2014. – 56 S. – (Monitoring the Economics of education; No. 3(77)).
15. Federal state statistics service [Electronic resource]. – Access mode: http://www.gks.ru/.
16. Tariff agreement on payment for medical assistance according to the territorial program of compulsory health insurance of Moscow in 2016 from 25.12.2015
17. The Ministry of Finance of the Russian Federation [Electronic resource]. – Access mode: http://minfin.ru/ru/document/index.php?id_4=22363
18. Frolova N.I., Belokrinitskaya T.E., Anokhova L.I., Kadalova N.V., Lugovskaya O.V., Yakimova Yu.V., Ananina, D.A., Turanova O.V., Assessment of fertility of young women of reproductive age in Zabaykalsky region: an epidemiological study // MiD. 2014. No. 4.