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# CHANGING THE STRUCTURE OF THE WORKING-AGE POPULATION PROJECTED BY THE COHORT COMPONENT METHOD (on the example of a megacity)[1]

**Abstract.** The article deals with the calculations of the population of the Chelyabinsk city for 2018-2035 years. Much attention was paid to the cohort component method whitch is described as a way of predicting demographic processes. Changes in the structure of the working-age population due to changes in the Russian pension legislation are also considered. The author of the article draw conclusions regarding the future of the Chelyabinsk city in the context of its spatial development.

**Keywords:** population projection; spatial development; cohort component method; working-age population; local territories.

## INTRODUCTION

The basis of strategic planning for the development of any territory is its population. When building management strategies, it is important to take into account the criteria and parameters of the object of management and the environment. The decision-making process is determined by the results of development alternatives and forecasts of socio-territorial development. To this end, the generation of forecast information is one of the main factors of effective management in the local territories [1]. The growth of instability of the Russian economy observed in recent years, accompanied by the emergence and simultaneous development of many mutually overlapping crisis processes and structural changes, that has a systemic nature [2]. In these circumstances, the most stable and predictable are demographic processes, as the laws and trends identified in this area decades ago, remain unchanged and relevant to this day. In general, the issues of forecasting socially significant indicators of small areas (cities) and social development of the population in cities were researched by Vishnevskiy A., Iontsev V., Pivovarov Y.,

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Rybakovskiy L., Rodzinskaya I., Medkov V., Demidenko E., Khorev B., Percick E., Yankova Z. and others.

## RESEARCH METHODOLOGY

To date, there are several methods of forecasting the main demographic indicators for the medium term: interpolation method, analytical method, cohort component method and methods based on the theory of cyclic ethnogenesis[3]. The most reliable and relevant at the moment is the cohort component method. It was developed by the american demographer Whelpton P.K. in the second half of the XX century [4]. The essence of the cohort component method is the mathematical modeling of the processes of population movement. The database is based on statistical information on the existing population for the last known period (year), with distribution by age group and by sex. Each year the number goes through the influence of the given variables (demographic factors) and changes. Each person taken as a unit, as it "moves" in the age group (to his age is added one year for each next projected year), and with a certain specified probability he dies, produces offspring, or leaves the territory (arrives at it).

Mathematically, it looks like the formula (1), where $\mathbf{P}_x$is the number of the age group "$x$", $\mathbf{P}_{x+1}$ is the number of the age group "$x$+1" (next year), $\frac{\mathbf{L}_{x+1}}{\mathbf{L}_x}$ is the coefficient of movement to the next age (the probability of living at the age of "$x$+1"), $\mathbf{MC}$ is the migration balance [5].

$$\mathbf{P}_{x+1} = \mathbf{P}_x \frac{\mathbf{L}_{x+1}}{\mathbf{L}_x} + \mathbf{MC} \qquad (1)$$

The above formula is the shortest of its options. The age shift method is a multifactorial demographic prediction. The exact number of such factors is not defined in the scientific literature and may vary depending on the quality of the statistical source and the completeness of the available information about the object of forecasting. Required factors are: life expectancy at birth, migration balance, total fertility rate, total mortality rate. With an increase in the number of factors, the accuracy of the demographic forecast increases, but the complexity of the calculations also greatly increases.

The Chelyabinsk city was chosen for the research, as a territorial entity in need of a population projection for the subsequent strategic planning and creation of a spatial development strategy. To this end, a forecast of the population and the main demographic indicators of the Chelyabinsk city was carried out by means of the latest version of the program DemProj [6] at the time of writing (v5,7). The projection was carried out on the basis of seven indicators: population, life expectancy at birth, total fertility rate, total mortality rate, distribution of births by age groups of women, the ratio of men and women at birth, migration balance that have been adjusted or calculated for each year manually, and then loaded into the program. The data of Rosstat on 01.01.2018 were taken as a basis. The basis data was rounded to one digit in the period 2018-2025 years and two mark in the period 2026-2035 years.

## RESULTS OF THE POPULATION PROJECTION

The result of the population projection of the Chelyabinsk city with the distribution by sex is shown in Figure 1.

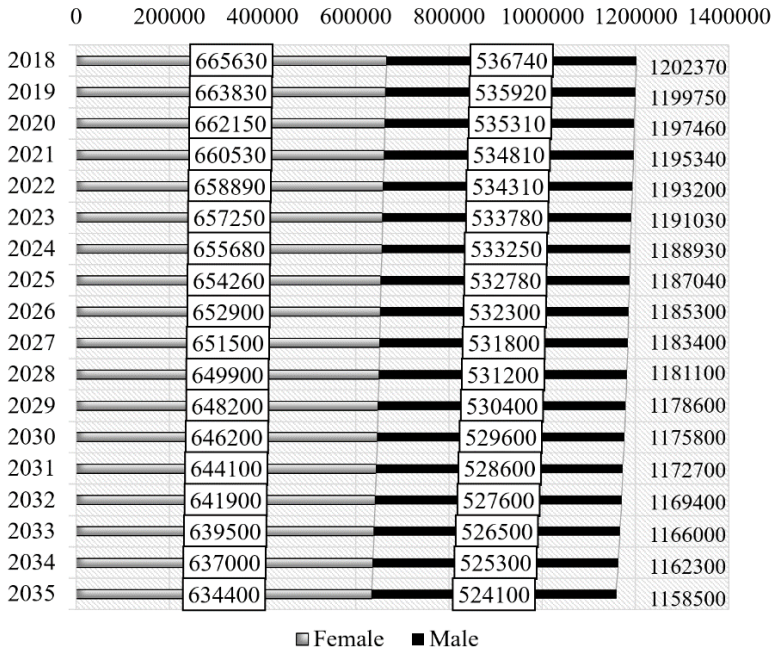


*Fig. 1. The results of population projection*

From these data it is clear that the population of the Chelyabinsk city in the coming years will decline, but this decline is quite small and ranges from 0.2%-0.3%

per year. In the process, the city will lose about 3.6% of its population in 17 years. The population decline is more evident in Figure 2.

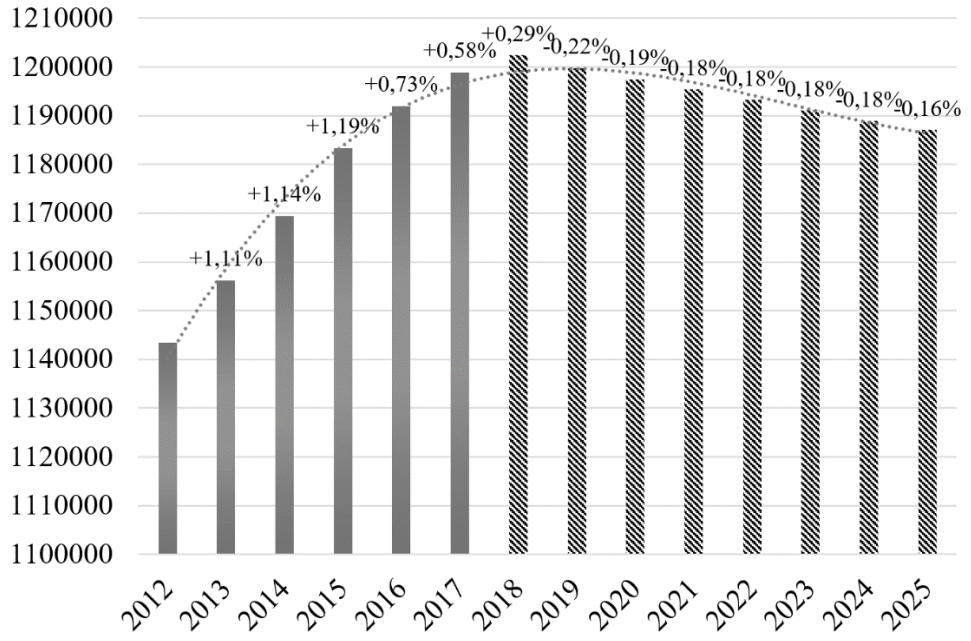


*Fig. 2. The population decline of the Chelyabinsk city*

The difference between the male and female population will be slightly reduced, but will remain almost unchanged. Figure 3 shows the projected sex ratio of the Chelyabinsk city by year (men per 100 women).

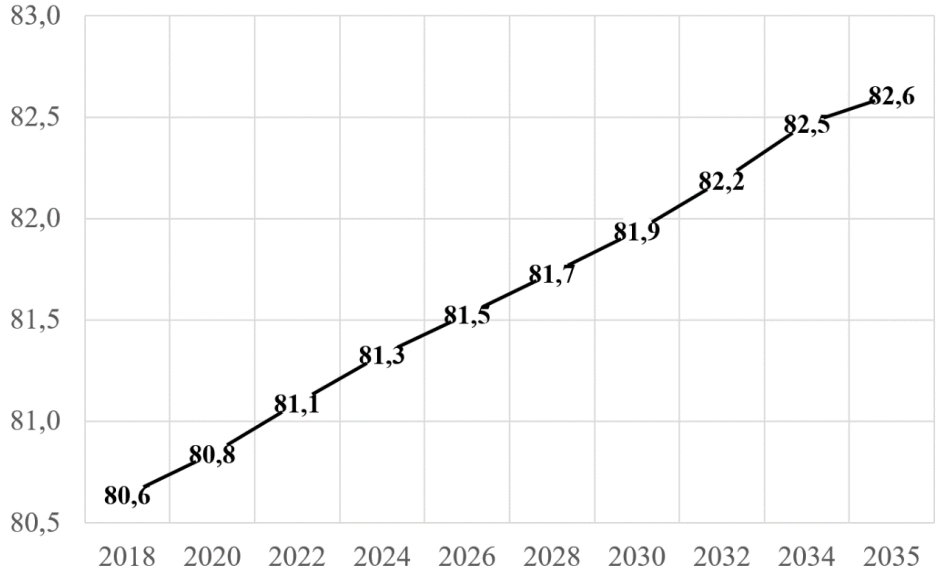


*Fig. 3. The projected sex ratio of the population of the Chelyabinsk city in years (men per 100 women)*

The greatest interest from the point of view of spatial development is the change in the structure of the working-age population. Such is considered to be the

male population in the age group 18-59 years and female in the age group 18-54 years in accordance with the current at the time of writing pension legislation. It should be noted that now the development and approval of the pension reform is actively taking place, most of the stages for the adoption of which have already passed. In accordance with it, starting from January 1, 2019, the working age in Russia will be 18-65 years for males and 18-60 years for females. Such innovations will lead to an increase in the number of working-age population. Figure 4 shows its projected size for the Chelyabinsk city and the percentage increase since the adoption of the pension reform.

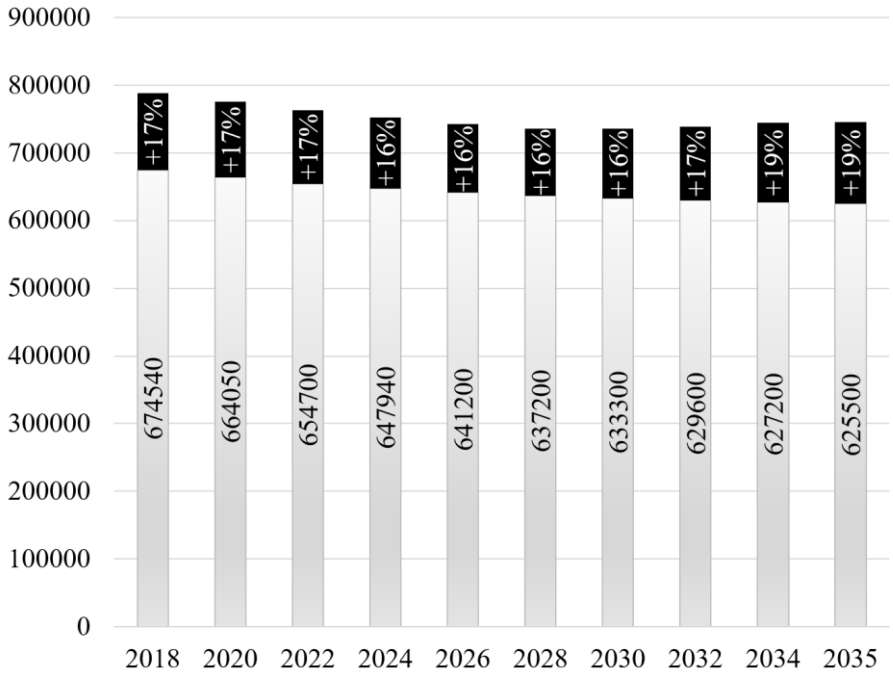


*Fig. 4. The projected increase in the number of working-age population for the Chelyabinsk city and the percentage increase since the adoption of the pension reform*

It is planned to gradually increase the retirement age. Men over the age of 60 years in 2018 (or more years) retire at 60. If the man at the moment 55 years and less, he retires at 65. Similarly, for women: those who turn 55 in 2018 retire at 55, and all those women who are 50 years old and younger retire at 60. There are also intermediate stages, which, however, are not so important, but provide even greater smoothness of the transition.

## DISCUSSION

The number of working-population in Chelyabinsk city will increase from 99 thousand per year to 120 thousand people per year. This is very important for a city with a population of 1.2 million people. This difference for the Chelyabinsk city is about 8% of the population, which will remove some burden from the budgets of all levels. In addition to the obvious advantages, such a sharp increase can be express as an equally sharp increase in the unemployment rate in the case of unprepared city. If you do not create jobs in advance for so many citizens, it can cause a "social explosion".

It is interesting to compare the dynamics of the working-age population of the Chelyabinsk city after the adoption of pension reform and under the current legislation, shown in Figure 5.

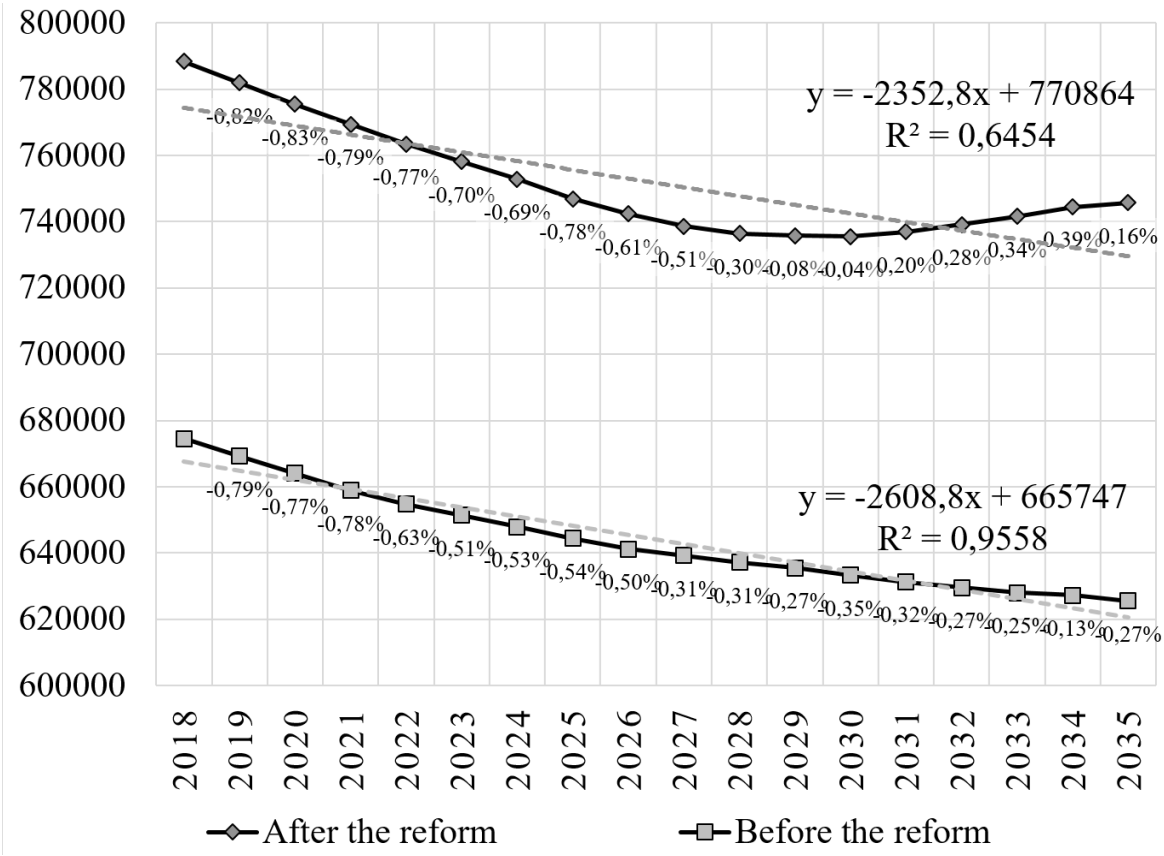


*Fig. 5. Comparison of the dynamics of the working-age population of the Chelyabinsk city in the case of approval of the pension reform and under the current legislation*

Consider each option separately. The graph shows that in case of non-adoption of the pension reform the number of working-age population will decrease in each year by about 0.3% -0.7% per year. At the same time, the total for 17 years, it will decrease by 7.4%. Since this value is greater than the reduction in the total population, it means that the share of the working population in the total population will decrease, and the burden on the budget will increase. In case of adoption of the pension reform, firstly, in each year the working-age population will be noticeable for 100 thousand people more than now. Secondly, the number of working-age population will also decrease in this case, but the rate of this decline will slow down every year. The increase will begin in 2031. The total population will decrease, therefore, the proportion of the working-age population will begin to increase, despite the fact that it will increase due to the reform. This is due to the structure of the population, which is convenient to consider in the projected age-sex pyramid shown in Figure 6, which reflects the data for 2018 and 2031. In the last decade, the birth rate has been relatively high. The population expected to become working-age population in about 12 years. The "pyramid" clearly shows demographic waves, which explains the subsequent increase in the working-age population. After some time (about 10-15 years), the share of the working-age population in the total population would begin to decrease again.

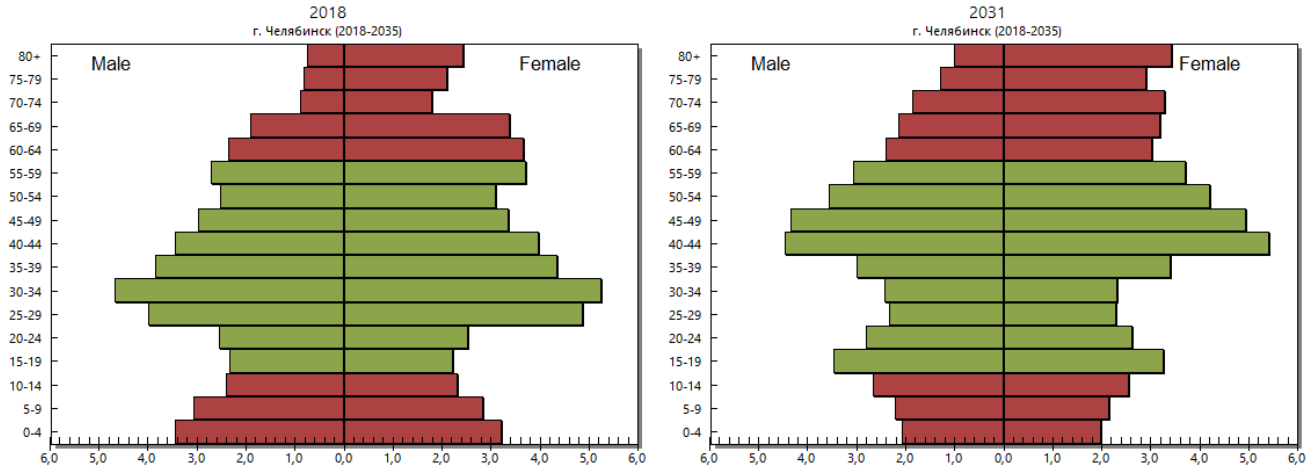


*Fig. 6. The forecasted age-sex pyramid*

In addition to reducing the population, it is necessary to pay attention to the aging of the population, which occurs from year to year and it is natural. It occurs

due to the increase in life expectancy and the total fertility rate, which is insufficient for the natural generational change. Therefore, population ageing is a fact that accompanies natural decline. Figure 7 shows the expected average age of the population of the Chelyabinsk city.

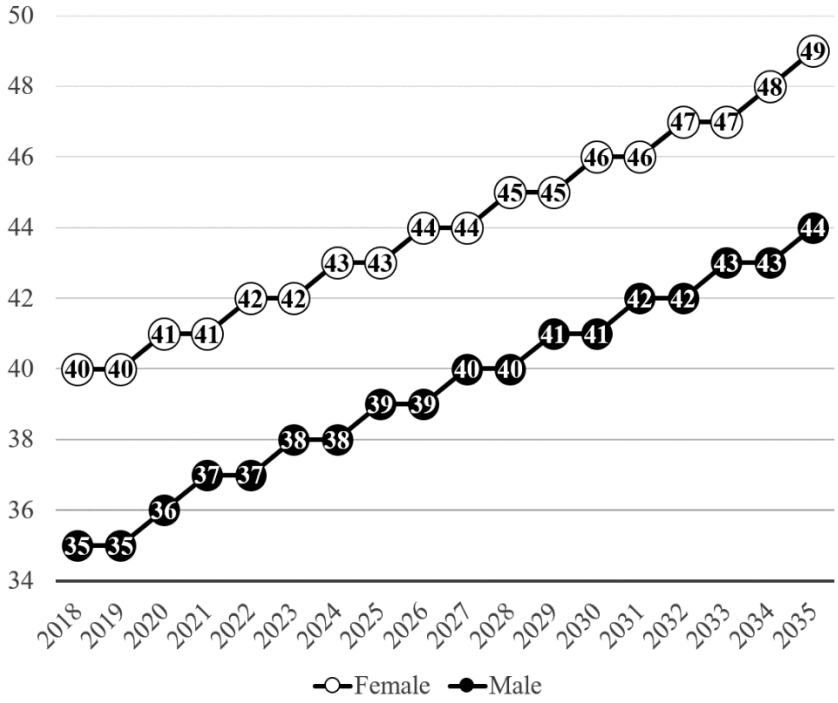


*Fig. 7. Expected average age of the population of the Chelyabinsk city*

The reasons for this include “aging from below”, which is the result of low fertility and “aging from above,” which is the result of an increase in average life expectancy. Both varieties are characteristic of the Chelyabinsk city, but to a greater degree “aging from below”. The average age of males and females is increasing roughly equally and will increase by nine years by 2035. This process can also be traced to the age-sex pyramid (Figure 6). Such indicators are one of the reasons for the adoption of the pension reform, as the average age of a woman will be about 49 years, which is only five years less than the current retirement age. In 2018, this gap is 10 years, if the reform will adopted, by 2035, this gap will also be 10 years.

In general, the aging of the population is bad enough for the economy, as the creation of new industries, especially high-tech, usually focused on young people ready for training and retraining. If we say that the average resident of the

Chelyabinsk city is almost pre-retirement age, it is difficult to plan any large-scale production projects and investment programs. This problem is not unique to the studied object, it is typical for most regions of Russia and advanced world States, but it does not mean that it cannot be solved.

## CONCLUSION

In the context of many structural and crisis changes, the dynamics and proportions of many indicators change. In the long term, the issues of economic development and sustainability are largely related to the socio-economic problems of negative development scenarios, issues of life support and risks [7]. The question of the sustainability of the social system is inextricably linked to the projection and regulation of the population, which follows from the definition itself. The economic ecosystem functions by means of economically active units [8]. The more of these units the more stable the economic system. However, there is a need for an appropriate infrastructure ready to accept them. Lack of schools, hospitals, kindergartens and low wages of social workers not only hinder the increase in the birth rate, but also the economic involvement of citizens. With regard to data on the number and composition of the population of the Chelyabinsk city, it is necessary to conclude the following. The population will decrease. This is primarily due to the indicator of the migration balance, which has been declined the past seven years. Replacement of the population by natural reproduction is unlikely to be possible with this total fertility rate, which is trivial for urban formations. Therefore, it is necessary to pay attention to the creation of economically favorable conditions in the city to prevent the outflow of the population in fertile age and increase immigration flows. The number of working-age population will slightly reduce if the current pension legislation remains unchanged. However, a more likely scenario is the adoption of amendments to the pension legislation in the near future. In this case, the number of working-age population and its share in the total population will increase dramatically. It is necessary to include this information in the development strategy of the Chelyabinsk city and take appropriate measures to build economic

capacity and create new jobs. Otherwise, the "released" population may become an even greater burden on the budgets of all levels than if it were simply considered incapable of work. If current demographic trends continue and worsen, the population will continue to "age". These indicators can have a very bad impact on the investment attractiveness of the Chelyabinsk city and ultimately force to replace the disabled population by working-age by increasing immigration flows. Of course, they should be increased, but this should be done systematically and in accordance with the strategy. Migration substitution should be of timely and thoughtful, but it is better to stimulate natural reproduction in the city by attracting people from rural areas, benefits and payments at the municipal level.

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