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Mathematical modeling of the dynamics of incomes of the population under epidemic process

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Motivation and Aim: The covid-19 epidemic has had an impact not only on the health of the population, but also on the economy of individual settlements and, in general, the whole world. Any significant increase in the incidence, even on a local scale of the city, leads to a significant adjustment in the functioning of the labor market. This paper considers a mathematical model of the impact of the spread of morbidity on the macroeconomic indicators of a particular region, such as the average per capita income of the population and the size of the labor force.

Methods and Algorithms: The paper presents a mathematical model built on ordinary differential equations of the SIR type [1] and the supplemented urban Lotka–Volterra model [2]. Based on the proposed differential model, an optimal control problem has been presented that allows taking into account not only the economic and epidemiological components, but also the social interaction of people within the population. The Pontryagin maximum principle was used to solve the optimal control problem.

Results: As a result, two well-analytically analyzed models of the impact of the spread of the virus on the most important macroeconomic indicators of the region were obtained. Various scenarios of the dynamics of the economic and epidemiological components of the Novosibirsk region are constructed depending on the different social behavior of its inhabitants.

Conclusion: The models obtained in the work can be improved by refining the epidemiological model and expanding the differentiation of the population relative to the epidemiological layers. The results of the analysis of the optimization model show a significant influence of social sentiments on the spread of the virus within the population and the economic situation. Consideration of epidemiological parameters in the form of control functions allows, in a way, to take into account the heterogeneity of the population and consider model parameters that are sensitive to changes within the interval, avoiding determining their exact value.

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