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Mini Review

Constructing a Mathematical Model of the COVID-19 Epidemic Taking into Account Medical Vaccination

Davron Ziyadullaey[1]*, Dilnoz T Mukhamedieva[1], Mukhammadyahyo G Teshaboyev[2], Yu Sh Bakhramova[3], Dilshod E Eshmuradov[3] and Gulchiroy E Ziyodullaeva[3]

[1]*Tashkent Institute of Irrigation and Agricultural Mechanization Engineers National Research University, Uzbekistan*

[2]*Andijan State Medical Institute, Uzbekistan*

[3]*Tashkent University of Information Technologies, Uzbekistan*

***Corresponding author:** Davron Ziyadullaey, Tashkent Institute of Irrigation and Agricultural Mechanization Engineers National Research University, Uzbekistan.

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Abstract

The article describes and analyzes mathematical models of the spread of infectious diseases, builds a mathematical model of the spread of the COVID-19 epidemic based on the model in question, and examines the effect of medical vaccination on the spread of infectious diseases during an epidemic. It is shown that the considered model makes a significant contribution to reducing the duration of the epidemic by medical vaccination.

Keywords: Model, COVID-19, Epidemic, Medical vaccination, Mathematical modeling, Adequacy, Numerical modeling

Introduction

Mathematical disease modeling is a powerful tool for studying disease transmission mechanisms. Epidemiological models serve as a basis for predicting and evaluating the dynamics of disease spread. This is now a feasible task due to advances in mathematical modeling [1]. There are various mathematical models of epidemics. This article mainly discusses the SIR model, its modifications and additions. Statistical data provided by the Ministry of Health of the Republic of Uzbekistan are used to parameterize the mathematical model of the COVID-19 epidemic. It takes an average of 5-6 days from the time a person is infected with the virus to develop symptoms, but it can take up to 14 days. WHO is committed to maintaining momentum in increasing access to COVID-19 vaccines and will continue to support countries to accelerate vaccine delivery, save lives and prevent people from becoming seriously ill [2]. Various mathematical models of epidemic development have been developed and used in the analysis of the spread of various diseases (typhoid, cholera, ebola, etc.). In addition, these models have also been used to model the development of the COVID-19 epidemic. Since the beginning of the COVID-19 epidemic, more than 11,000 articles on various aspects of the disease, including statistical data and analysis of its spread, have been published in scientific journals and specialized websites. Many models are based on the SIR model (S-healthy, I-sick, R-recovered) and its modifications [3].

The model considered in the article is also considered a modification of the SIR model, in which the state of medical vaccination is additionally considered. The considered period includes from August 1 to October 31, 2021. As of August 1, the total population of Uzbekistan is 35 million, of which the number of infected persons is 131,079, and the number of recovered is 124,728. According to statistics, we can see the increase in the number of infected persons in Uzbekistan in Figure 1 [4].

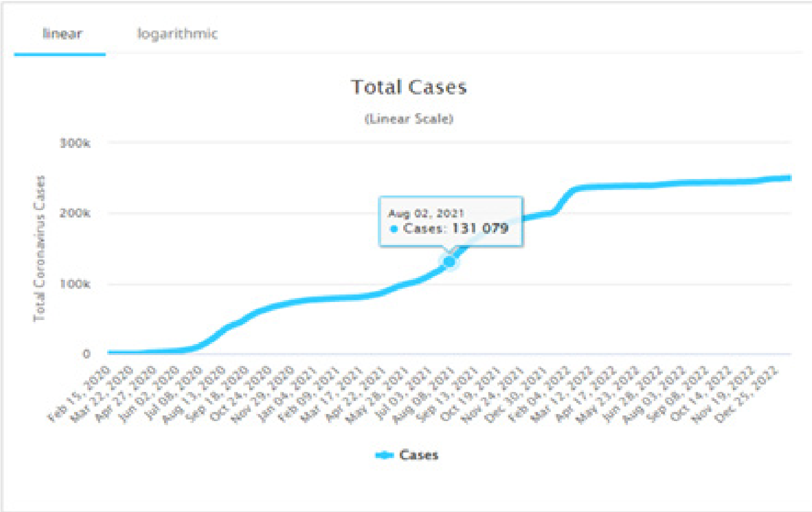


Figure 1: Increase in the number of infected persons in Uzbekistan.

Mathematical Model of an Epidemic

In the immune epidemic model based on the SIR model ("Susceptible-Infected-Recovered"), the population is divided into three classes.

S(t)+I(t)+R(t)=N=const,

S(t)-healthy persons prone to disease.

I(t)-infected, disease-spreading persons.

R(t) persons who have recovered from infection, have immunity, or died, who do not spread the disease.

N-total population, unchanged.

$$u_1(t)=\frac{S(t)}{N}, u_2(t)=\frac{I(t)}{N}, u_3(t)=\frac{R(t)}{N}$$

we introduce a notation like [5-8].

A mathematical model of an epidemic taking into account medical vaccination:

$$\begin{cases} \frac{du_1}{dt}=-au_1u_2 \\ \frac{du_2}{dt}=au_1u_2-bu_2 \quad (1) \\ \frac{du_3}{dt}=bu_2+cu_2 \end{cases}$$

At t=0 with initial conditions at:

$$u_1(0)=u_{10}\geq 0, u_2(0)=u_{20}\geq 0, u_3(0)=u_{30}\geq 0 \quad (2)$$

Here, *a, b*-positive coefficients usually have a size of 1/day.

$a=\frac{1}{T_k}-$ probability of contracting the disease of a susceptible person in contact with an infected person,

the coefficient of the rate of infection, T_k -disease period.

$b=\frac{1}{T_{td}}-$ speed of recovery without taking into account medical vaccination, T_{td} - period of recovery from illness.

$c=\frac{1}{T_v}-$ recovery rate after medical vaccination, T_v - vaccination period.

Analysis of Results

Incoming data:

a. N=35 000 000 kishi

b. t = 0 with initial conditions at:

$$u_1(0)=33530000, u_2(0)=131079, u_3(0)=1336633$$

c. probability of contracting the disease of a susceptible person who is in contact with a sick person, coefficient of morbidity rate

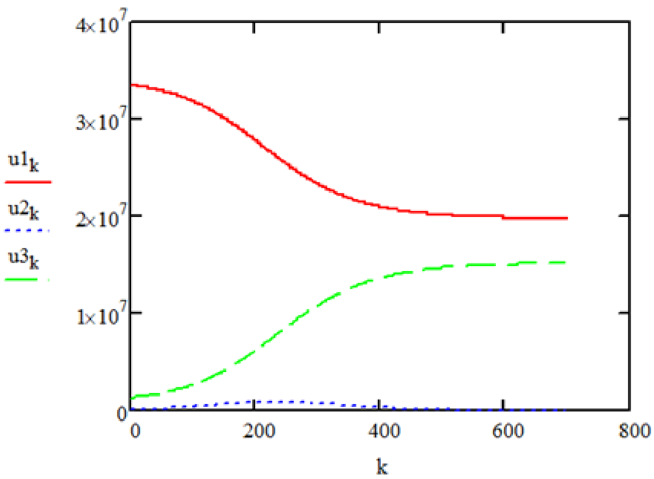
d. speed of recovery without taking into account medical vaccination

e. Time days

The rate of recovery after medical inoculation due to the fact that the vaccine was not originally developed is equal . Therefore, the value of R(t) increases very slowly (Table 1). Recovery rate after medical vaccination graph of the calculation experience is as follows: Figure 2.

Table 1: The rate of recovery after medical inoculation due to the fact that the vaccine was not originally developed is equal c=0. Therefore, the value of R(t) increases very slowly.

№	VaqtT(kun)	S	I	R
0	1	33500000	131000	1340000
1	50	31900000	453000	2670000
2	100	27900000	925000	6190000
3	150	23400000	794000	10800000
4	200	21000000	347000	13700000
5	250	20200000	114000	14700000
6	300	19900000	33700	15100000
7	350	19800000	9740	15200000



Note*: Red line S(t)-healthy individuals prone to disease; Blue line I(t)-infected, spreading disease; Green line R(t)-persons who have recovered after infection, have immunity or died, do not spread the disease.
Figure 2: Recovery rate after medical vaccination c=0 graph of the calculation experience is as follows.

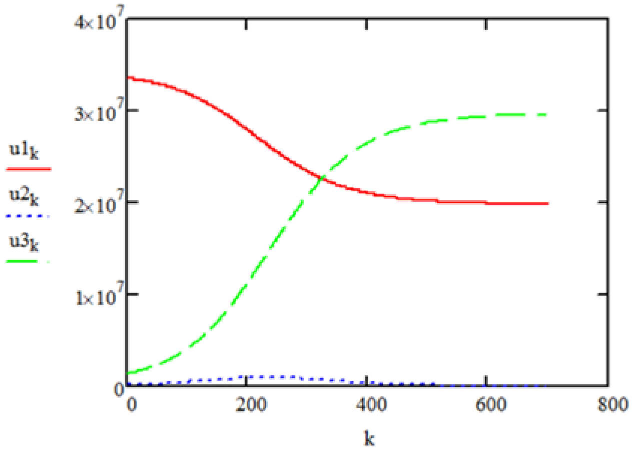
Table 2: Recovery rate after medical vaccination c=0.1 result of calculation experiments would be as follows.

№	Time T (days)	S	I	R
0	1	33500000	131000	1340000
1	50	31900000	453000	4050000
2	100	27900000	925000	11200000
3	150	23400000	794000	20700000
4	200	21000000	347000	26500000
5	250	20200000	114000	28600000
6	300	19900000	33700	29300000
7	350	19800000	9740	29500000

Recovery rate after medical vaccination result of calculation experiments would be as follows: Table 2.

The graph of the calculation experience when there is a recovery rate after medical vaccination is as follows Figure 3.

As you can see, medical vaccination is very important. The higher the number of vaccinated, the faster the number of recoveries. We can see this from Figure 2.



Note*: Red line S(t)-healthy individuals prone to disease; Blue line I(t)-infected, spreading disease; Green line R(t)-persons who have recovered after infection, have immunity or died, do not spread the disease.

Figure 3: The graph of the calculation experience when there is a recovery rate after medical vaccination is as follows.

Acknowledgment

None.

Conflicts of Interest

None.

References

1. Y Chen, J Cheng, Y Jiang, K Liu (2020) A time delay dynamical model for outbreak of 2019-nCoV and the parameter identification. Journal of Inverse and Ill-posed Problems 28(2): 243-250.
2. https://www.who.int/health-topics/coronavirus/.
3. Sokolovsky VL, Furman GB, Polyanskaya DA, Furman EG (2021Spatiotemporal modeling of the COVID-19 epidemic. Health Risk Analysis 1: 23-37.
4. http://www.worldometers.info/coronavirus/.
5. Kabilzhanova FA, Boltaboyeva NI (2022) Mathematical modeling of the spread of the COVID-19 coronavirus epidemic in Uzbekistan "Innovative developments and research in education". International scientific-online conference 132-136.
6. Ziyadullaev D, Muhamediyeva D, Abdullaev Z, Aynaqulov S, Kayumov K (2023) Generalized models of a production system of fuzzy conclusion. E3S Web of Conferences 365: 01019.
7. Ziyadullaev DSh, Mukhamedieva DT, Ziyodullaeva GYe (2018) Development of mathematical model of lesson schedule formation system. Journal of Advanced Research in Dynamical and Control Systems-JARDCS 10(14): 1850-1854
8. Abdullaev Z, Ziyadullaev DSh, Muhamediyeva DT (2022) The task of assessing the risk in the operation of a complex free formal system. Journal of Physics: Conference Seriesthis link is disabled 2176(1): 012071.