STATISTICAL MODELS FOR FORECASTING EMERGENCY SITUATIONS OF A BIOLOGICAL AND SOCIAL CHARACTER

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Abstract

The article considers a statistical model for predicting emergency situations of a biological and social nature. Particular attention is paid to the calculation of indicators of resource provision of the medical care system and mortality rates during the spread of the epidemic.

Keywords: forecasting model; Bayesian classifiers; emergency situations of a biological and social nature; indicators of resource provision of the medical care system; mortality rates during the spread of the epidemic.

I. Introduction

The spread of the new coronavirus infection COVID-19 in the world in three years has led to more than five hundred million infections and more than six million deaths. The high dynamics of growth in morbidity and mortality has led not only to a serious burden on the healthcare system in almost all countries of the world, but also to the development of scientific methods for modeling epidemics and pandemics. In particular, in [1], a statistical model for predicting epidemics using Bayesian classifiers is proposed.

The main input data for the formation of the basic training set of this model are the following groups of parameters: input data characterizing the settlement (hereinafter - NP); input data characterizing the socio-economic indicators of the NP; input data characterizing the composition and size of the population of the NP; input data characterizing the demographic indicators of the NP; input data characterizing the symptoms and course of a respiratory viral disease (hereinafter referred to as RVD); input data characterizing the level of provision of the population with medical care resources in the settlement; input data characterizing the epidemiological situation in the NP (with the development of an epidemic caused by RVD); results of forecasting and modeling of the spread of the epidemic caused by the PR in the NP.

II. Methods

Calculation of indicators of resource provision of the medical care system.

The indicators of the availability of resources for the system of providing medical care in the territory during the spread of the epidemic include [2]: the indicator of the availability of hospitalized infectious patients with beds; indicator of availability of oxygen concentrators; indicator of availability of intensive care beds; the indicator of availability of artificial lung ventilation devices (hereinafter - ALV); indicator of provision of medical institutions with senior medical personnel; indicator of provision of medical institutions with paramedical personnel.

The indicator of bed capacity of hospitalized infectious patients (I_{ib}) is determined by the formula [3]:

$$I_{ib} = \frac{K_{\text{к}.il}}{K_{gi}},$$

Where:

$K_{\text{к}.il}$ - the number of beds for hospitalized infectious patients, units;

K_{gi} - the total number of hospitalized infectious patients, people.

The index of provision with oxygen concentrators ((I_{kk}) is determined by the formula:

$$I_{\text{кк}} = \frac{K_{\text{к.кк}}}{K_{\text{кк}}},$$

Where:

$K_{\text{к.кк}}$ — number of oxygen concentrators, units;

$K_{\text{кк}}$ — the total number of hospitalized, with the need for oxygen supply, pers.

The indicator of provision with an intensive care bed fund (I_{it}) is determined by the formula:

$$I_{it} = \frac{K_{\text{к}.it}}{K_{tb}},$$

Where:

$K_{\text{к}.it}$ — number of beds in the intensive care unit (hereinafter referred to as RIIT), units.;

K_{tb} — total number of hospitalized infectious patients, pers.

The indicator of provision with ventilators (or similar devices) (I_{ivl}) is determined by the formula:

$$I_{ivl} = \frac{K_{\text{a}.ivl}}{K_{ivl}},$$

Where:

$K_{\text{a}.ivl}$ — number of ventilators (or similar devices), units;

K_{ivl} — total number of hospitalized infectious patients with the need to connect to ventilators (or similar devices), people

The indicator of provision of medical institutions with senior medical personnel (I_{stmp}) is determined by the formula:

$$I_{stmp} = \frac{K_{stmp}}{K_{gi}}$$

Where:

K_{stmp} — indicator of senior medical personnel, people;

K_{gi} — total number of hospitalized infectious patients, pers.

The indicator of provision of medical institutions with paramedical personnel (I_{srmp}, units per 1000 people) is determined by the formula:

$$I_{srmp} = \frac{K_{srmp}}{K_{gi}}$$

Where:

K_{srmp} — indicator of the average medical personnel, people;

K_{gi} — total number of hospitalized infectious patients, pers.

Calculation of mortality rates during the spread of the epidemic

The indicators of mortality during the spread of the epidemic and in the conditions of its absence include [2]: the mortality rate due to respiratory diseases during the spread of the epidemic; mortality rate due to diseases of the circulatory system during the spread of the epidemic; mortality rate due to neoplasms during the spread of the epidemic; overall mortality rate due to respiratory diseases, diseases of the circulatory system and neoplasms during the spread of the epidemic (in the absence of it).

The mortality rate due to respiratory diseases ((I_{sod}, units per 1000 people) is determined by the formula [4]:

$$I_{sod} = \frac{K_{sod}}{K_{np}} \cdot 1000,$$

Where:

K_{sod} — the number of deaths due to respiratory diseases per month, people;

K_{np} — population of the settlement, pers.

Mortality rate due to diseases of the circulatory system (I_{sbk}, unit per 1000 people.) is determined by the formula:

$$I_{sbk} = \frac{K_{sbk}}{K_{np}} \cdot 1000,$$

Where:

K_{sbk} — the number of deaths due to diseases of the circulatory system per month, people;

K_{np} — population of the settlement, pers.

The mortality rate due to neoplasms (I_{sn}) is determined by the formula:

$$I_{sn} = \frac{K_{sn}}{K_{np}} \cdot 1000,$$

Where:

K_{sn} — the number of deaths due to neoplasms per month, people;

K_{sp} — population of the settlement, pers.

Then the overall mortality rate due to respiratory diseases, diseases of the circulatory system and neoplasms during the spread of the epidemic is determined by the following relationship:

$$I_{sm} = I_{sod} + I_{sbk} + I_{sn},$$

Where:

I_{sod} — mortality rate due to respiratory diseases, units. per 1000 people;

I_{sbk} — mortality rate due to diseases of the circulatory system, units. per 1000 people;

I_{sn} — mortality rate due to neoplasms, units per 1000 people.

III. Results

Thus, this article considers a statistical model for predicting emergency situations of a biological and social nature. Particular attention is paid to the calculation of indicators of resource provision of the medical care system and mortality rates during the spread of the epidemic.

IV. Discussion

The discussion of the verbal and mathematical foundations of predictive modeling of emergency situations of a biological and social nature during the development of an epidemic caused by EIA is quite active in the scientific literature [5–10].

At the previous conference RISK - 2022, the authors presented reports on the issues of predictive modeling of natural and man-made emergencies [11, 12].

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