Factor Temporal Prognosis
of Tick-Borne Encephalitis Foci Functioning on the
South of Russian Far East

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Abstract

A method of temporal factor prognosis of TE (tick-borne encephalitis) infection has been developed. The high precision of the prognosis results for a number of geographical regions of Primorsky Krai has been achieved. The method can be applied not only to epidemiological research but also to others.

1. Introduction

While studying various complex systems the examination of their functioning both in the past and in the future is of great importance. The most informative index of natural pest foci is the changing of human infection rate. Epidemic temporal rows of infection integral expression of influence of a number of factors. They comprise prognosis data which can be used to study this or that phenomenon in future [1].

Prognosis approach in scientific research, including the development of methodological base of natural - foci infection rate prognosis, is the main research and practical goal. It is of great importance nowadays because the epidemic situation has become worse not only in Russia, but also in many regions and countries of the world.

There exist two ways of temporal prognosis. The first one is extrapolation prognosis. It is based on the analysis of temporal rows of infection for the past several years and on their direct extrapolation.

The second approach to temporal prognosis is a factor one and it has several stages. Possibilities and advantages of temporal factor prognosis are the following.

● First, a researcher, using extrapolation prognosis, deals with average characteristics which reflect general trend of phenomenon development. This trend is an artificial line where the most important for prognosis of critical level conditions of the analysed system are graded.

● Second, the results of the extrapolation prognosis depend on the length of temporal raw and are specified by the type of long standing development of the researched phenomenon.

● Third, the results of extrapolation prognosis have probable character and are limited by confidence intervals. The range of such limits, however, can be so broad that it makes the obtained results so "vague" that considerably limits possibility of their objective interpretation.

● Forth, extrapolation prognosis is realized by the "black box" principle, it is deprived of the possibility to analyse the caused factor and mechanism which form the temporal raw.

These limitations define our interest to more sophisticated and yet more objective factor method in the prognosis of the epidemic activity of tick-borne encephalitis, the area of which extends from Europe to Japan [2], [3].

The levels of connection turned out to be unstable according to what we have found out from our special preliminary research in study of connection stability between the long standing row of infection rate and some influential factors. Such unstable correlation between infection rate and influential factors strictly limits the possibilities of linear statistic models use. Thus, the prognosis goal setting was changed. The nature of which was to forecast indefinite index but infection rates which could be higher or equal to some extreme line given by an expert. Such goal setting is particularly important methodologically because the way of its realisation has a unique character and can be easily reproduced in other scientific spheres.

The factor prognosis research which we use has been divided into two stages. The first stage included the realisation of the epidemiological index and the questions concerning the potential prognosis results accuracy by the different statistic selection were also discussed. The aim of the second research stage was firsthand factor prognosis of critical infection rate of tick-bome encephalitis in a real time. Thus, while at the first stage of the investigation purely academic problems were solved and methodological approaches of putting it into practice were developed, the second stage can be of practical importance not only for tick-bome encephalitis but for wide range of other phenomena as well.

2. Main results of research

The experimental material for factor temporal prognosis presents statistic data on tick-bome infection dynamics during the last 30 years in a number of epidemic areas of Primorski Krai, previously determined by us [4].

On prognosis on the first investigational stage the use was made of influential factors that are long standing rows of average annual meaning of 8 meteorological factors of 3 meteorological stations, that characterise southern, middle and northern regions of Primorski Krai. The used meteorological factors include: average January temperature, absolute temperature minimum, average annual temperature, the length of non-frosty period, average May temperature, average snow blanket and snow-temperature coefficient.

On the second stage of temporal factor prognosis the materials on long standing dynamics of population Ixodes persulcatus - the main TE virus carrier were drawn in addition.

Methods of factor prognosis of critical levels of TE infection were based on the following algorithm worked out by us. Firstly, empirical information of TE and influential factors was introduced as the matrix of initial data in which rows indicate years and columns indicate index of infection and influential factors. Further, the years rows with critical level of infection and corresponding indexes of influential factors were emphasized. The emphasized years with critical levels of infection form intervals of particular influential factor meanings. However, these intervals may also include years in which the infection is lower than critical level that we emphasized earlier. Let's mark such years as "false critical". Having marked the amount of critical and "false critical" years as "x" and "y" accordingly. We have a ratio $p = x/(x + y)$ which can be interpreted as possibility to identify correctly the critical years on emphasized intervals of influential factors.

As a whole the developed method of factor temporal prognosis was based on the image recognition principle. But the quality prognosis, realized by original algorithm, was determined according to selection by number of non-critical years falsie taken for critical by the determined

final rule of recognition. And at the first stage of investigation the final rule of the year recognition as a critical was based on the condition of 100% this year being in the defined meaning intervals of influential factors of critical years.

However, at the second stage of investigation i.e. on prognosis of critical events in real time, it turned out that such condition is just of secondary meaning. This conclusion was made during numerous calculating experiments that we conducted.

As a result, new prognosis rule was established in which a number of identifying factors fluctuated between 50 and 75 percents of all the used ones. Critical infection rate was also chosen depending on statistic sample with the amount of critical years being more that one. It should be noted that during the repeated besting of prognosis rule, simplicity and speed of included calculations were of the primary importance.

On the whole, some most significant moments of conducted factor prognosis can be signed out. Thus, accuracy of factor prognosis totalled from 50 to 100 percents.

The maximum prognosis rate was provided southerner territories of investigated region, however, some other geographic regions characterized by close prognosis figures were mentioned.

The prognosis rate is considerably influenced by the amount and concrete set of affecting factors while the increase of used factors number does not always result in higher prognosis accuracy. This remarkable fact requires further thorough investigation and specification.

The received data concerning the connection between prognosis accuracy and used critical infection rate are also interesting. It was found out that in some cases this connection can be direct and indirect in the others. This quite substantial fact also requires serious analysis and consideration.

It was revealed that the usage of factual materials on long-term Ixodes perculcatus's population dynamics had not improved prognosis accuracy. It remained the same or even lowered. This tendency again proves our opinion about the insignificant influence of carriers population on human's suffering from tick-borne Encephalitis. If we compare the results of both the first and second stages of temporary factor prognosis, their considerable similarity can be marked.

3. Conclusion

On the whole, the developed method of critical infection rates temporary factor prognosis solves an extremely vital problem of non-linear .character, from the other side it has several important features.

• First, this method is quite easy for realization, but at the same time it is all-purpose; namely it is able to work with any information presented in the form of dynamic rows.

• Second, all the calculations performed with the aid of prepared program can easily be conducted manually.

• Third, the proposed method can be regarded as one of the highest level steps for real prognosis , based on dynamic cause-and-effect models.

• Forth, the method of critical disease rate analysis has good perspectives as it deals with a number of important problems. For example, how will the results of the prognosis change if the number and nature of the factors are altered? What is the effect of modifying the length of rows and critical disease ranges? How can the quality of the program of the prognosis be modified in case of correlating the disease and the influential factors with different logs? How is the influential factors hierarchy modified with regard to their prognosis importance in the course of temporal rows analysis? There also exits quite a number of vitally important problems. This work is the first and quite a modest attempt to solve some of these problems.

Thus, the developed temporal factor prognosis method being of both theoretical and practical interest, poses a number of important questions as well. Having solved the problems by means of wide-range testing of the proposed algorithm, it is possible to receive, for the future, a universal method of temporal factor prognosis.

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