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Conceptual Model for Automatic Early Warning Information System of Infectious Diseases Based on Internet Reporting Surveillance System[1]

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Objective To establish a conceptual model of automatic early warning of infectious diseases based on internet reporting surveillance system, with a view to realizing an automated warning system on a daily basis and timely identifying potential outbreaks of infectious diseases. **Methods** The statistic conceptual model was established using historic surveillance data with movable percentile method. **Results** Based on the infectious disease surveillance information platform, the conceptual model for early warning was established. The parameter, threshold, and revised sensitivity and specificity of early warning value were changed to realize dynamic alert of infectious diseases on a daily basis. **Conclusion** The instructive conceptual model of dynamic alert can be used as a validating tool in institutions of infectious disease surveillance in different districts.

Key words: Infectious disease; Automated warning; Information system

INTRODUCTION

Infectious diseases are the focus of disease control and prevention. Thirty-seven types of infectious diseases have been defined as notifiable in China. A real-time internet daily-case reporting system was established in 2004. In order to fully utilize surveillance data, to strengthen early detection, and to meet the needs of disease control and prevention in health institutions at different levels, it has become extremely urgent nowadays to study and develop an early warning platform of infectious diseases based on the established real-time internet reporting system.

The basic concepts of mobile percentiles method was used to establish a conceptual model of infectious diseases based on internet reporting system in order to realize dynamic alert with the unit of day [1,4] for control chart of dynamic alert that is widely used in foreign countries by taking the month/week as the unit. The method can also be used to reset the controlling parameters and correct the sensitivity and specificity of the alert threshold value in order to realize an early detection of outbreaks.

MATERIALS AND METHODS

Data Sources

The data were obtained from the internet reporting system of national notifiable infectious disease surveillance system. The information system was established based on the platform for national disease surveillance information system.

Research Methods

(1) For class A (Cholera, Plague) and B infectious diseases managed by class A (SARS, anthrax, poliomyelitis, and highly pathogenic avian influenza)[2], the alert value was given $n \geqslant 1$ cases, which would issue the alert information if $n \geqslant 1$ cases were reported.

(2) The basic principles[3-6] of mobile percentile method were used according to the former broken amount (to reduce the influence of outbreak to broken level of periodic history with the method of weighing as soon as possible) at the same historical periods (the last three or five years). The mobile periodic broken level was observed with the unit of day using the method of mobile account percentiles, and the

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percentiles at the same historical periods were calculated to confirm the alert threshold value and realize the dynamic automatic alert. The realization course of the automatic alert is shown in Fig. 1.

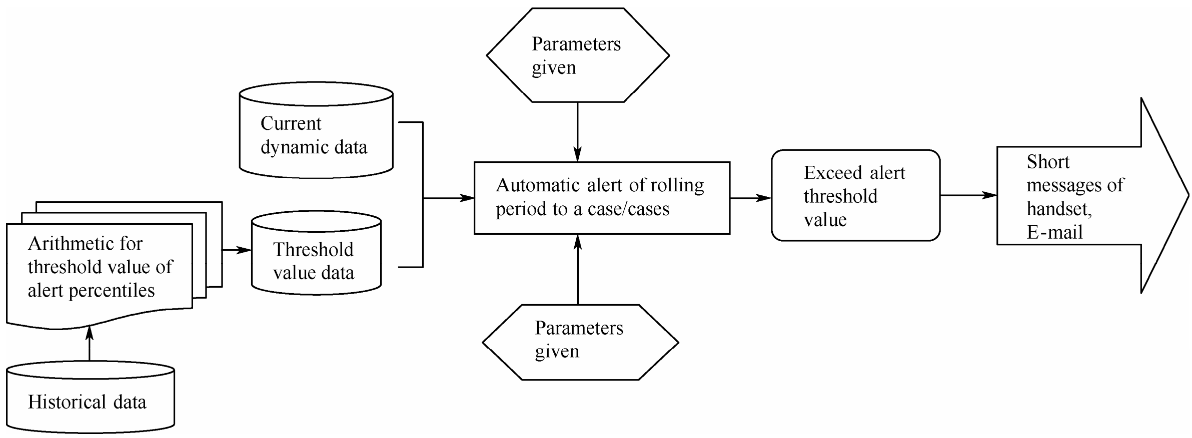

FIG. 1. Realization course for automatic alert of infectious disease outbreak.

RESULTS

Description of Dynamic Configuration Parameters

(1) Number of days for observed periods (W): it can be adjusted, and different infectious diseases should be given according to the length of its average delitescence.

(2) Comparative historical number of years (Y): the number of years that is backdated from the observed year was excluded, which was 3-5 years.

(3) Contemporaneous historical reciprocating periodicity (N): the scope for the number of days backdated from observed day was called a period. Contemporaneous historical reciprocating periodic multiple which was opposite by this period called reciprocating periodicity (N).

Dynamic Configuration of Alert Parameters

According to the characteristics of real-time dynamic case reporting of network reporting system, the dynamic alert of monitoring infectious disease was realized with the unit of days. Its configuration course is shown in Fig. 1. The general appraisal should meet its sensitivity and the differential through number of days for observed periods (W), comparative historical number of years (Y), contemporaneous historical reciprocating periodicity (N) and the alert threshold value (P) of percentiles.

Model of Statistical Method

(1) Periodic quantity (Wx): the summation of broken amounts (D) for n days within periods, namely $Wn = \sum_{i=1}^{n} Di$.

(2) Comparative historical number of weeks (Wn): the summation of opposite historical periods and reciprocating periodicity times the retrospective historical number of years (Y), namely $Wx = (2x\sum_{i=1}^{n} Wi + 1)xY$.

(3) Account for comparative historical percentiles: the percentiles were obtained by calculating the periodicity and periodicity of reciprocating period with consecutive number while the retrospective historical years were opposite to the period, total Wx periodicities.

(4) The percentiles Xp were directly calculated with original surveillance data to find out the location of relevant percentiles between the minimum (the first value in the ordered series) and maximum value (the *n* value in the ordered series). The locus of p part accounted for the spacing (*n*-1) between the first numeral and the n numeral at the left, and the 1-p part at the right. Therefore, if the d was defined as the locus of the percentiles Xp, the formula is as follows[3]:

$$\left\{\begin{array}{l} d=1+(n-1)p \\ Xp=X([d])+(X([d+1])-X([d]))(d-[d]) \end{array}\right\}$$

Where [d] is the integeral part of d and X([d]), and X([d+1]) indicates the observed values when the loci are [d] and [d+1] respectively.

Examples of Model Application

Daily broken amount on an infectious disease reporting is shown in Table 1. If the percentile for the alert threshold value of infectious disease outbreaks was P_{90}, the currently observed time was 11 days, the time of dynamic retrospective observed period (W) was 4 days, retrospective historical number of years

(Y) was 5 years, and contemporaneous historical reciprocating periodicity (N) was 1 period. The dynamic alert of the infectious diseases was determined according to the said principles.

TABLE 1

Daily Reporting Number of an Infectious Disease

Date	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
2000 Year	10	12	2	5	8	6	1	2	6	5	8	4	2	1	23
2001 Year	12	2	5	8	6	1	2	6	5	8	4	2	1	4	2
2002 Year	8	4	2	1	23	10	12	2	5	8	6	1	2	6	5
2003 Year	2	1	23	10	12	2	5	8	6	1	2	1	2	6	5
2004 Year	10	12	2	5	8	6	1	10	12	2	5	8	6	1	4
2005 Year	4	2	1	12	10	5	2	10	8	12	22				

Note. *Unit=one day.

By substituting the above parameters into the formulation $Wn=\sum_{i=1}^{n} Di$, and then the current periods (W) were 52 cases. By substituting them into the formulation $Wx=(2x\sum_{i=1}^{n} Wi+1)xY$, and then the result of comparative historical number of weeks could be obtained (Table 2).

TABLE 2

Observed Periods of Infectious Disease

Date	4th -7th Day	8th -11th Day	12th -15th Day
2000 Year	20	21	30
2001 Year	17	23	9
2002 Year	46	21	14
2003 Year	29	17	14
2004 Year	20	29	19
2005 Year		52	

By substituting the historical periods in Table 2 into the formulation $\left\{\begin{array}{l} d=1+(n-1)p \\ Xp=X([d])+(X([d+1])-X([d]))(d-[d]) \end{array}\right\}$, the current periods (47 cases) in the results were more than the threshold value of P_{90} (47 cases), and then the alert message was issued (Table 3).

TABLE 3

Dynamic Percentiles of Infectious Disease

Percentiles Px	Locus of Percentile Xp d	Integer Part of D [d]	Percentiles Xp
50	8.0	8	29
60	9.4	9	30
65	10.1	10	31
70	10.8	10	32
75	11.5	11	34
80	12.2	12	37
90	13.6	13	47
95	14.3	14	49

The number of days was kept for retrospective observed period (W), and a day was taken as the unit to calculate the dynamic observed periodicity (Wx) and alert threshold value (P) of relevant dynamic periodicity, which could realize the dynamic automatic alert to infectious disease breaking (Fig. 2).

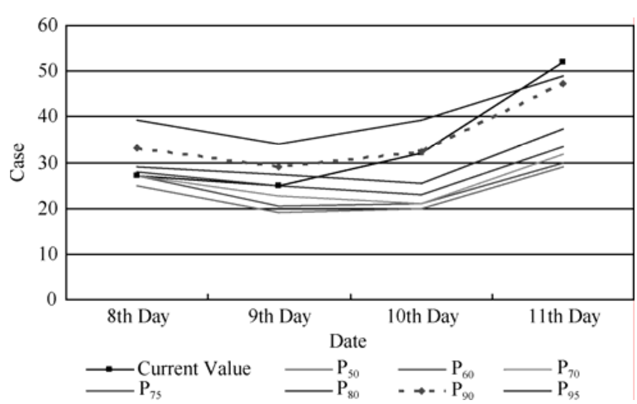

FIG. 2. Control chart of dynamic percentiles of infectious diseases.

DISCUSSION

An outbreak of infectious diseases can be early identified and the development and change of paroxysmal public health events can be traced by establishing a surveillance alert information system for analyzing the reporting information. The automatic alert for the outbreak of infectious diseases provides evidence based information for decision-making departments to take early interventions, thus minimizing potential hazards caused by them. It is important to duly adjust operating rules of the system, combine dynamic GIS in collecting alert case reports, find early outbreak of exceptional infectious diseases, and take appropriate interventions with the unit of days by taking the county (region) as the unit to duly increase and modifying computation rules and configuration alert parameters.

Various cognizant and unknown infectious diseases can be prevented and monitored by establishing an early automatic alert surveillance system for infectious disease outbreak based on the system for national network reporting of epidemics. Timely and effective responses to paroxysmal public health events are not only important for human health, but also indispensable of social economic development and social stability. To prevent paroxysmal public health events, such services as information consultation and health education should be provided for the society and the public by using information source and bringing the value of public health information source into play through the alert analysis of surveillance[7]. The paper describes the conceptual model of the alert information system and the method of verification based on the infectious disease surveillance network reporting system. However, due to insufficient data of historical cases, only a conceptual model can be provided, which needs to be further verified in actual surveillance practice.

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