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Application of EWMA and CUSUM models to School Absenteeism Surveillance for Detecting Infectious Disease Outbreaks in Rural China

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Objective

To explore the optimal model and its related parameters via EWMA and CUSUM (C1, C2, C3) models in school absenteeism surveillance for early detection of infectious disease outbreaks in rural China.

Introduction

Absenteeism has great advantages in promoting the early detection of epidemics (1). School absenteeism surveillance could timely detect the aggregations of absentees in time and space, so as to provide effective early warning and prevention and control of infectious diseases outbreaks in schools. Since April 1, 2012, an integrated syndromic surveillance system (ISSC) has been implemented in rural Hubei Province, China. With school absence data, finding the optimal model and related appropriate parameters for early warning of epidemics is necessary and practical.

Methods

Data for this study was obtained from the web-based data of ISSC in one primary school in Shayang County of Hubei Province, China from April 1, 2012 to January 31, 2013. Exponentially Weighted Moving Average (EWMA) and Cumulative Sums (CUSUM, C1, C2, C3) models were applied on data of absentees due to illness retrospectively to detect suspected outbreaks. Youden's index was calculated to optimize parameters before an optimal model was finally chosen.

Results

The warning signal frequencies under EWMA and CUSUM models with different parameters were shown in Table 1 and Table 2. The efficacy of different models with optimal parameters: the Youden's index of EWMA (λ=0.25, c=2.0) was 0.82, of C1 (k=0.5, c=2.0) was 0.95, of C2 (k=0.5, c=3.0) was 0.98, of C3 (k=0.5, c=5.0) was 0.97, which suggested that C2 (k=0.5, c=3.0) had the highest efficacy (Table 3).

Conclusions

EWMA and CUSUM models are commonly applied to syndromic surveillance system with short-term history baseline data for early warning, with higher sensitivity to tiny changes than the general control chart method. Balancing sensitivity and specificity of the models, C2 (k=0.5, c=3.0) was chosen as the optimal model. EWMA and CUSUM models were used to detect suspected outbreaks retrospectively with the the accumulation of data fluctuation in the past, so they could not detect sudden fluctuations in the process well. In the future, we still need to further explore more robust and effective early warning model for school absenteeism surveillance.

Table 1. Warning signal frequency under EWMA model with different parameters

λ	Threshold parameter (c)					
	0.5	1.0	1.5	2.0	2.5	3.0
0.05	50	37	28	22	19	16
0.10	40	27	20	13	8	8
0.15	43	25	17	9	7	5
0.20	40	27	17	13	6	4
0.25	43	31	21	12	6	4
0.30	46	38	25	17	4	7

Table 3. The Youden's index of different models with the optimal parameters

Model	Parameters	Sensitivity(%)	Specificity(%)	Youden's Index
EWMA	λ=0.25, c=2.0	83.33	98.95	0.82
CUSUM				
C1	k=0.5, c=2.0	100.00	94.74	0.95
C2	k=0.5, c=3.0	100.00	97.89	0.98
C3	k=0.5, c=5.0	100.00	96.84	0.97

Table 2. Warning signal frequency under CUSUM model with different parameters

κ	Threshold parameter (c)						
	2.0	2.5	3.0	3.5	4.0	4.5	5.0
C1							
0.5	12	8	6	3	2	2	2
1.0	8	6	3	2	2	2	2
1.5	6	3	2	2	2	2	2
C2							
0.5	20	17	10	7	6	5	5
1.0	17	10	7	6	5	5	4
1.5	10	7	6	5	5	4	4
C3							
0.5	46	43	36	31	26	22	19
1.0	38	32	24	22	18	17	14
1.5	29	22	19	16	14	12	12

Keywords

School absenteeism; Surveillance; EWMA; CUSUM

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