The upper tolerance limits of nonepidemic daily morbidity for influenza and other acute respiratory diseases in the epidemic season*

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The start of an influenza epidemic may be detected by comparing actual daily morbidity from influenza and other acute respiratory infections with the upper tolerance limits of this morbidity for nonepidemic years. A method of constructing such tolerance limits for the autumn–winter season, when the probability of an influenza epidemic is greatest, is described. The results are illustrated by data relating to Moscow.

The main danger of influenza lies in its ability to cause epidemics or even pandemics. In a short period, a considerable proportion of the inhabitants of a town and even of a country may become infected. Influenza epidemics not only damage human health but cause great economic loss. It is therefore very important to undertake the necessary preventive measures in good time, and this can only be achieved by calculating the beginning of an influenza epidemic as exactly as possible. This can be done by comparing actual daily morbidity with the upper tolerance limit of morbidity for the corresponding period in nonepidemic years. Any excess over the upper tolerance limit may be considered to indicate the beginning of an epidemic.

Various methods have been proposed to achieve this aim. Savčenko & Popov (4) analysed the morbidity in the previous 10 weeks and used this to calculate the morbidity for the following week. Ivannikov & Marinčić (2, 3) found the tolerance limits of weekly morbidity for the whole year by using data from several previous nonepidemic years; mean values and standard deviations were calculated separately for each week. Serfling (5) designed a mathematical model to describe weekly mortality. He used a periodic function model and constructed a tolerance zone by means of the least-squares method.

In our study, the same idea of constructing a tolerance zone was used but some modifications were made: (a) morbidity but not mortality was considered; (b) the tolerance zone was designed only for those months in which epidemics were most likely to occur (November–February); and (c) daily instead of weekly data were studied in order to make the results more useful.

MATERIALS AND METHODS

The calculations were based on the daily morbidity from influenza and other acute respiratory diseases (there was no reliable means of differentiating between "influenza" and "other acute respiratory diseases") during the epidemic season (November–February) for 5 nonepidemic years (1960–1961, 1963–1964, 1965–1966, 1967–1968, 1970–1971) in Moscow. Thereafter, initial daily data for Moscow were recalculated as the rate per 10 000 inhabitants. It was also taken into account that the available reported data do not reflect actual morbidity but the number of persons taking medical advice; this number is always greater on working days (especially Mondays) than on nonworking days. Therefore, seven daily coefficients were computed and the reported data were divided into these coefficients. This phenomenon was recently noted by Barojan & Rvačev (1).

The data obtained in this way were used to construct the following regression:

\[ y = a + bx + cx^2, \quad x = 1, 2, \ldots, 120, \]  

where \( y \) is the recalculated daily morbidity and \( x \) is the number of the day of the week. The quadratic
coefficient $c$ was found to be significant but the linear one $b$ was not (see below). In contrast to that of Serfling (5), this function should not be periodic since the interval comprises only 4 months.

Further analysis revealed that morbidity from influenza and other acute respiratory infections has increased from about 30 cases per 10 000 inhabitants in the 1950s to about 40 per 10 000 in the 1970s. This has been due to improvement in the medical services in the USSR, which has had the effect of lowering real morbidity and at the same time reducing the lag between registered and true morbidity. A coefficient $(t)$ reflecting this trend was included in the calculations.

The relationship (1) estimates the mean level of morbidity typical for the potential epidemic period in a nonepidemic year. The upper tolerance limits estimating the morbidity level at the boundary with the epidemic values were calculated by the expression:

$$y_b = y + sU_{1-P/2},$$

(2)

where $s$ is the standard deviation and $U_{1-P/2}$ is the $P$ percentile of the normal distribution. This expression determines the morbidity level in excess of which, with probability $P$, an epidemic is indicated.

RESULTS AND DISCUSSION

The numerical values of the parameters obtained in the computations are as follows:

(a) The intra-weekly coefficients: Monday, 1.44; Tuesday, 1.38; Wednesday, 1.25; Thursday, 1.11; Friday, 0.79; Saturday, 0.74; Sunday, 0.30.

(b) The yearly trend coefficient: $t = 1.25$.

(c) The regression coefficients and their standard errors: $a = 10.16 \pm 0.38$; $b = (0.34 \pm 1.44) \times 10^{-2}$; $c = (0.37 \pm 0.12) \times 10^{-3}$.

(d) The standard deviation of the regression: $s = 3.03$.

Fig. 1 demonstrates the 99% upper tolerance limits of the nonepidemic daily morbidity from influenza and other acute respiratory infections in the autumn–winter season of 1975–1976 in Moscow (thick line) and the actual values of morbidity in the same period (thin line).
influenza and other acute respiratory infections in the autumn-winter season of 1975–1976 in Moscow (solid line) and the actual values of morbidity in the same period (dotted line). That year was an epidemic one and 18 January 1976, when the actual morbidity exceeded the corresponding upper tolerance limit, might be considered as the beginning of the epidemic. This method was used to form a similar graph for November–December 1976 and January–February 1977, and the beginning of an epidemic in Moscow was also indicated in good time.

The method described may be used in other towns where daily morbidity data are available. If such data are absent, weekly or 10-day data may be utilized (divided into the corresponding number of days) using, as the first approximation, the intra-weekly coefficients and the coefficient of the yearly trend computed for Moscow.

RÉSUMÉ

LES LIMITES SUPÉRIEURES DE TOLÉRANCE DÉRIVÉES DU Taux non épidémique de morbidité journalière due à la grippe et aux autres affections aiguës des voies respiratoires durant la saison habituelle d'épidémie

Le début d'une épidémie de grippe peut être déterminé en comparant la morbidité journalière réelle due à la grippe et à d'autres affections aiguës des voies respiratoires aux limites supérieures de tolérance s'établissant pour cette morbidité dans les années exemptes d'épidémie. Le présent article décrit une méthode permettant d'établir ces limites de tolérance pour la saison automn-hiver ou la probabilité d'une épidémie de grippe est la plus forte. Les résultats sont illustrés au moyen de données se rapportant à Moscou.

REFERENCES


