The Hospital with More Beds Has a Higher Probability of Experiencing an Outbreak of the Hospital Infection

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SUMMARY: The dependence of the incidence of the hospital infection on the number of the beds was studied by using SIR model with the computer simulation. We obtained the result that the hospital with more beds has a higher probability of experiencing an outbreak. The integration of smaller hospitals into a larger hospital was once considered economically advantageous and such a policy has been implemented in Japan since the early 1980s. This analysis, however, warns against the policy.

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The number of the beds in a hospital could be very important for the management of the hospital. The medical equipment for the diagnosis such as radiography and CT scan, and those for the treatments could not be supported from the income of the hospital if the hospital size is small. On the contrary, the hospital with a lot of beds gets the benefit from using such equipment usually. The cost of the central management office will also be lower in the larger hospital than the smaller one.

The incidence rate of the nosocomial infection, however, is higher in the hospital with higher number of beds. What is more, nosocomial infection is sometimes fatal. About 15% of the hospital deaths could be related to pneumonia caused by nosocomial infections (1) which prolong patients' hospital stays and increase medical expenditure directly or indirectly. According to a study conducted in the United States, nosocomial infection accounted for 15% of all hospital charges (1). Thinking from the view point of the hospital infection, the hospital with the smaller number of the bed has an advantage over the larger one. So, the larger number of the bed has a disadvantage in the cost against the hospital infection, which leads to speculate there will be the most suitable number of the bed totally.

Our model (2) is based on the following assumptions: (i) all the beds (b) are occupied, and there is no new admission nor discharge during the study. The number of MRSA carriers at time 0 is m0. (ii) Infection by MRSA is a random process. The number of individuals infected by MRSA emitted by a carrier follows the Poisson distribution with average hit λ (constant). From time t to t+1, there will be M(b,t) such events, where M(b,t) is the number of MRSA carriers at time t. (iii) The number of MRSA carriers at time t+1 is expressed by the formula M(b, t+1) = (1-k)M(b,t) + R(b,t), where R(b,t) is the increase of MRSA infected individuals during time t to time t+1 and k is the MRSA cure rate during the same period. The simulation program was written in C Language on a Sun Ultra Enterprise 450 with SunOS 5.6 (Sun Micro Systems, Palo Alto, Calif., USA).

Figure 1A shows 50 simulations for a hospital with 100 beds and 10 MRSA carriers at time 0 (b = 100, m0 = 10). Here, λ (average hit) in the Poisson distribution was 1.05, and k was 0.95. MRSA outbreak occurred in 4 out of 50 trials. Figure 1B shows simulations for hospitals with 100, 250, 500, and 1,000 beds with the same λ and k values and with the same number of MRSA carriers (m0 = 10) at the start.



Fig. 1. Simulation of MRSA epidemic.

Here, the probability of nosocomial infection outbreak (outbreak is defined by MRSA infection in 40% or more of the patients) is plotted against the number of the beds. The probability of the outbreak increases with the number of the beds. Therefore, even if two hospitals different in size take the same hospital infection control measures, i.e., k and λ values being the same, the hospital with more beds has a higher probability of experiencing an outbreak. The integration of smaller hospitals into a larger hospital was once considered economically advantageous, and such a policy has been implemented in Japan since the early 1980s. This analysis, however, warns against such a policy.

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