DEVELOPING AN OPERATIONAL DECISION RULE FOR IDENTIFYING THE FATAL CASE DOCUMENTS AT RISK OF BEING RETURNED THROUGH MATHEMATICAL MODELLING

Lt Col UB MISRA^{*}, Col SKP MATWANKAR⁺,
Lt Col R BHALWAR[#]

ABSTRACT

Incomplete or inaccurately filled fatal case documents are often returned to the hospital by higher headquarters, causing delay in the completion of procedural formalities. A mathematical model was developed to identify those fatal case documents which are at an increased risk of being returned so that the corrective action may be taken a priori. The data was subjected to a multiple logistic regression analysis. Diagnostic test characteristics were worked out and a Receiver Operating Curve analysis was done to find out optimum operating points on the slope, and the following mathematical rule was developed :

$7.06 = 1$ (if age > 50 years) - 4.5 (if age ≤ 12 years) + 9.88 (if serving person) + 2.75 (if ex-serviceman) + 4.5 (if dependent son or daughter) + 6.38 (if time lag > 10 days).

This rule carries a sensitivity of 53 per cent and specificity of 75 per cent.

MJAFI 1998; 54: 47-48

KEYWORDS : Mathematical model; Medical documents; Operations research

Introduction

A mathematical model is a simplified representation of a system, processes or relationship [1]. It can be utilised to predict the best of several alternatives in a decision making process. These models have been used in health sector for handling variety of problems.

In Armed Forces hospitals the fatal case documents are forwarded to higher headquarters for perusal after the same have been completed in the hospital. Many a times it happens that the documents are returned from the higher headquarters due to some observations. In view of the above, it was proposed to create a mathematical model to predict which documents had a high probability of being returned due to observations so that preventive measures could be taken before dispatching the documents from the hospital.

Material and Methods

The predictor variables for developing mathematical models were, age, status of the deceased (whether serving, ex-servicemen or dependents with details) and time lag between death and dispatch of documents from statistics section of the hospital.

The mathematical model was developed using statistical procedures which have already been validated in a large scale study in Armed Forces [2]. The outcome variable was kept on a binary

dichotomous variable (documents returned/not returned), and the data was entered into a multiple logistic regression analysis [3]. The beta coefficient and constant values were used to calculate predicted probabilities based on the model and Hosmer-Lemeshow test was used to test the goodness of fit of the model. Diagnostic test characteristics were worked out between actual outcomes and those predicted by the model and a Receiver Operating Characteristics (ROC) curve analysis was undertaken to find out the optimum point at which the best trade off between true and false positives was obtained. The predictor variables included were :

Age 1 (paediatric age category, scored "1" if the deceased was ≤ 12 years otherwise zero),

Age 2 (older age category, scored "1" if age was 50 years or more),

Rel 1 (scored "1" if the deceased was a serving person),

Rel 2 (scored "1" if deceased was an ex-servicemen),

Rel 3 (scored "1" if the deceased was the son or daughter of a serving person or ex-servicemen)

Time lag (scored "1" if the time gap between date of death and dispatch of documents to Senior Adviser Pathology was more than 10 days).

The data, having been categorised and numerically coded, was analysed by multiple logistic regression analysis, with the dichotomous outcome and a total of 6 predictors as mentioned above. The results of coefficients, their standard errors, and odds ratio were calculated. The values of beta coefficient and constant were fed back into the model to calculate the individual predicted probabilities of return. The data was then grouped into class intervals

^{*}Post Graduate Trainee, ⁺Prof and Head, Dept of Hospital Administration, [#]Reader and Epidemiologist, Dept of Social and Preventive Medicine, Armed Forces Medical College, Pune 411040.

based on the predicated probabilities using class interval of 0.05. The actual outcome (document returned/not returned) was then tabulated against these class intervals of predicted probabilities. With the help of this data, the diagnostic test characteristics, viz., sensitivity, specificity and false positive proportions (i.e., "1-specificity") were worked out at various levels of probability cut-off points. The data was used to develop the ROC curve. The area of utility under the curve was found to be fairly large. It was also noticed that the "optimum operating point (OOP)" on the slope corresponded to sensitivity level of 0.53 and (1-specificity) level of 0.25. This, in turn, corresponded to a probability cut-off point of 0.2. Thus, at the probability cut off point of 0.2 and above, the best trade - off between sensitivity (true positives) and false positives was apparent.

Results

Development of mathematical rule :

Using the equation for the various coefficients derived from multiple logistic regression log Odds of "D" = $a + b_1 x_1 + \dots + b_n x_n$

Since, Odds = Probability/(1-Probability)

Therefore, log (probability/1-probability) = $a + b_1 x_1 + \dots + b_n x_n$

Since the optimum operating point corresponded with the probability cut off value of 0.2, substituting the value, we get :

$\log (0.2/1-0.2) = a + b_1 x_1 + \dots + b_n x_n$ but, $\log (0.2/1-0.2) = \log (0.25) = (-) 1.39$

Substituting the value of constant (a) and coefficient (b1, b2 -----b6) we get :

$-1.39 = -2.52 + (-0.718 \times \text{Age } 1) + (0.16 \times \text{Age } 2) + (1.58 \times \text{Rel } 1) + (-44 \times \text{Rel } 2) + (0.72 \times \text{Rel } 3) + (1.02 \times \text{Time lag})$

Dividing both sides of the equation by 0.16 (to convert the smallest coefficient value of 0.16 to unity), we obtained the following :

$-8.69 = -15.75 + (-4.5 \text{ if age } \leq 12 \text{ years}) + (1 \text{ if age } > 50) + (9.88 \text{ if serving soldier}) + (-2.75 \text{ if ex-serviceman}) + (4.5 \text{ if dependent son or daughter}) + (6.38 \text{ if time lag } > 10 \text{ days})$, carrying -15.75 to the left side we obtained the final mathematical rule as follows :

$7.06 = 1(\text{if age } > 50 \text{ years}) - 4.5 (\text{if age } \leq 12 \text{ years}) + 9.88 (\text{if serving person}) - 2.75 (\text{if ex-serviceman}) + 4.5 (\text{if dependent son or daughter}) + 6.38 (\text{if time lag } > 10 \text{ days})$

Discussion

This rule may be stated in very simple terms as

follows:

If the age of the deceased was > 50 years, give 1 otherwise give zero (i.e., do nothing).

If the age was 12 years or less subtract 4.5 otherwise nothing.

If the deceased was a serving person, add 9.88, otherwise nothing.

If the deceased was ex-serviceman, subtract 2.75, otherwise nothing.

If deceased was dependent son or daughter, add 4.5 otherwise nothing.

If the time-lag between the date of death and date of dispatch of the documents to Senior Adviser (pathology) is more than 10 days, add 6.38, otherwise nothing.

Add up all the scores as above.

If the total score is 7.06 or less, the document has little likelihood of being returned. However, if the total score exceeds 7.06, then the probability of this document being returned due to some or the other reasons is high. This rule carries a sensitivity of 53 per cent and specificity of 75 per cent. This mathematical model can be of utility in assisting the hospital administrator in improving his decision making process. It has the advantage of being extremely simple in its application to the extent that even a junior clerk can apply it, to forecast whether a given fatal case document is likely to be returned or not.

REFERENCES

1. Weihrich H, Koontz H. Management of global perspective. 10th ed. Singapore: McGraw-Hill, Inc., 1993; 643.
2. Bhalwar R, et al. Clinico - epidemiological algorithm for predicting systemic arterial hypertension at high altitude through mathematical modelling. Medical Journal Armed Forces India, 1994; 50: 175-80.
3. Nauhria RN, Prakash R. Management of systems. 1st ed., New Delhi: Wheeler Publishing, New Delhi 1995; 188.