A BEFORE AND AFTER TRIAL OF THE EFFECTIVENESS OF NETWORK ANALYSIS IN HEALTH OPERATIONS MANAGEMENT

Lt Col R BHALWAR^{*}, Lt Col M SRIVASTAVA⁺,
Lt Col SS VERMA[#], MRS M VAZE^{**},
BRIG VW TILAK⁺⁺, VSM

(Department of Preventive and Social Medicine, Armed Forces Medical College, Pune and Station Health Organization, Kirkee)

ABSTRACT

An intervention trial using "before-and-after" approach was undertaken to address the question whether network analysis as a health managerial tool of control can favourably affect the delays that occur in planning and executing the antimalaria operations of a Station Health Organization in a large military station. Exposure variable of interest was intervention with a network diagram, by which the potential causes of delay along the various activities were assessed and remedial measures were introduced during the second year. Sample size was calculated using conventional alpha and beta error levels. The study indicated that there was a definite beneficial outcome in that the operations could be started as well as completed in time during the intervention year. There was reduction in time requirement in 5 out of the 9 activities, the exact 'p' value being 0.08, by both parametric and non-parametric tests. The use of network analysis in health care management has been recommended.

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KEY WORDS : Health services research; Health care; Health plan implementation; Malaria; Network analysis; Operations research.

Introduction

In recent years, a considerable amount of stress has been laid on the importance of adopting a scientific approach in the field of health care delivery using modern management techniques [1,2]. These methods are likely to substantially enhance the operational efficiency of health services by achieving the optimum output [1].

The Armed Forces have developed specialized epidemiological and health care units called the Station Health Organisations (SHO) which are vested with the overall responsibility of providing comprehensive health care to troops and families in their area of jurisdiction. Thus they provide an ideal setting for the application of modern management techniques. One of the top priority tasks of the SHOs is to ensure meticulous antimalaria measures through continuing antilarval measures, residual imagocidal spraying during transmission

season, epidemiological surveillance and so on. Most of the vector control measures are in fact the responsibility of the individual service units with the SHOs providing technical advice, supervision and assessing the outputs in terms of fixed parameters of surveillance like vectorial studies and disease incidence. The diversity of responsibilities as regards malaria control coupled with the lack of resources and possibly a general lack of appreciation of the importance on part of consumer units often leads to a situation in which the antiadult residual insecticidal spray (an important facet of antimalaria measures) is often found lacking in terms of adequacy, timeliness, or quality.

It was against the above backdrop that the present study was undertaken to assess whether network analysis can be used to identify and evaluate the following aspects of antiadult residual insecticide operations in a large station :-

^{*}Reader, ^{**}Lecturer in Biostatistics, ⁺⁺Consultant and Head, Dept of Preventive and Social Medicine, ⁺Associate Prof, Dept of Hospital Administration, AFMC, Pune - 40; [#]Commanding Officer, Station Health Organization, Kirkee.

- (i) Actions in which delay can occur.
- (ii) The putative causes of such delays and the possible remedial measures.
- (iii) Evaluation of whether removal of the causes of delay as identified on network analysis can improve the timeliness of operations during the next year.

Material and Methods

The study was carried out at a large SHO which provides health cover to a sizable number of service units spread over an area of 375 square kilometres.

Prior to starting the study a detailed epidemiological assessment using entomological, spatial, and disease-incidence parameters was undertaken. The input variables which were identified to be of relevance for operational planning and control of antimalaria operations were the availability of spraying pumps in adequate numbers and serviceable state, adequate number of persons well-trained in spraying operations, and adequate stocks of anti-adult residual insecticides and larvicides in all the units under health cover.

On the basis of the above mentioned three input variables a list of activities and events in respect of each of them as worked out. Estimates of time required for each activity was worked out on the basis of previous 3 years data available with the SHO and taking the mean of 'best' and 'worst' estimates.

The first phase which extended from October 1989 to September 1990 was taken as the 'control' period during which the delays occurring at each activity were analyzed and remedial measures were worked out. The second phase (October 1990 to September 1991) served as the actual 'trial' period for the network. During this period, the time taken for each activity as tentatively allotted after taking into consideration the reduction in delay which was visualized due to enforcement of the remedial measures. The network diagram was then drawn in a backward fashion [3,4].

The target date for starting the first round of antiadult residual spray was 15th March and the target date for completion was 15th September. For these target dates the tentative dates of initiation and completion of planning phase were

worked out as 1st October and 15th March respectively. During the first year of the study, the planning phase was started on 1st October and a network diagram was completed as each activity was completed, plotting the time taken for each activity.

The exposure variable of interest was the actual intervention with the remedial measures for reducing delay, which was thus treated as a dichotomous variable. The outcome variable of interest was actual time taken for the entire network scheduling which was thus recorded on a continuous scale. The research outcome of interest was whether there is a significant reduction in average time taken to complete the operations after intervention with the remedial measures, as assessed from the network.

Sample size was calculated using the conventional levels of two-tailed alpha error of 0.05 and beta error of 0.20, and with the power of the study to detect a difference as 80 per cent. The same worked out to 256 days in both the groups, i.e., before the intervention (the first year) and after the intervention (the second year). It was decided to actually use a much larger sample size to improve the precision of estimate and hence the entire 2 year period, i.e., one year of 'control' period observation and one year of 'intervention' period observation was studied. The method of total consecutive sampling was thus used for making the observations. Confounding was controlled by holding constant all the other factors, excepting for the intervention of network analysis, during the control and intervention years.

Results

Network analysis during the control phase (first year) - The network diagram is presented in the Figure. It was observed that during the control year, the spraying operations could actually start on 15th April 90 as against the target of 15th March 90. The completion of spraying operations was also delayed by 45 days and could be completed on 30th October 90 as against the target of 15th September 90.

It was observed from the network diagram of the control year that the potential delay was likely to have occurred during 5 different activities (activity codes A, D, B, F and I). The details of these

Fig. 1 : Network diagram of planning and execution of antimalaria activities.

TABLE I

Possible cause of delay and remedial measure assessed from the network analysis of control period

Main head	Activity code	Details of activity	Possible cause of delay	Remedial actions proposed
Spraying equipment	(A)	Asking units about details of spraying equipment	Postal delay; procedural delays within units	Personal checking of equipment by SHOs instead of asking for reports
Spraying equipment	(D)	Administrative actions to make up deficiencies	Lack of priority by units formation Headquarters and dependent depots	Personal discussions of SHO with concerned officers of units, formation headquarters and dependent depots
Trained personnel	(B)	Checking availability of trained personnel with units for carrying out spraying	Lack of appreciation among units regarding importance of proper spraying by trained persons	Personal discussions of SHO with Unit Commanders, and allotting vacancies to units for training by SHO on a presumptive basis
Hygiene chemicals	(F)	Awaiting availability of hygiene chemicals from dependent supply unit	Low priority by supply unit to procurement of insecticides	Constant liaison by SHO with concerned officers of supply unit and formation headquarters
Conduct of antiadult residual insecticidal spray	(I)	Undertaking of spraying by trained persons of the units	Rounds were slow in progress due to a number of trained persons within units becoming unavailable due to leave, transfers etc.	Training an additional 50% reserve over and above the usual requirement

activities along with the possible causes of delay were analyzed and the remedial measures were worked out. The details are presented in Table 1.

Network analysis during the intervention phase (second year) - The remedial measures as worked out above were applied during the second year. Care was taken not to change any other factor in the SHO or units, except for the above mentioned intervention, which could potentially confound the exposure-outcome relationship. The network diagram during the second year is presented in the Figure. It was observed that during this year the spraying operations could be started and completed on the target dates of 15th March 91 and 15th September 91 respectively. The gain in time was maximum in respect of training of personnel (60 days) followed by procurement of hygiene chemicals (30 days), procurement of spraying equipment (20 days), actual conduct of spraying operations (15 days), and assessment of availability of spraying equipment (10 days).

Statistical analysis of the parameters of effectiveness - The overall 'time achieved' due to the intervention was 135 days which came forth from 9 different activities. The mean gain was 15 days $\pm$ 20. The median gain was 20 days with a range of 0 days to 90 days. Since the data points for the 9 different activities in the two years under comparison were correlated a paired sample 't' test was done which indicated an exact p value of 0.08 (90% confidence intervals (CI) of difference between means = 2.59 to 27.40; 95% CI = -0.38 to 30.38). Keeping in view the fact that the data tended to have a 'non-normal' distribution, non-parametric test was also applied which indicated an exact p value of 0.08. The results are summarized in Table 2.

Discussion

From the above findings it is observed that network analysis as a managerial method of controlling the health operations favourably improves the time-related efficiency. The probability of such observations having occurred due to random (sampling) variations was less than 8 per cent. Interest-

TABLE 2

Comparison between the time taken during control and intervention years for the various activities

Xdi (Mean difference)	Sdi (SD of mean difference)	(n)	Median	Range
-15	20	9	-20	0-90

(Minus sign indicates a reduction in time taken during intervention period).

Paired 't' test : $t = 2.25$, $df = 8$, $p = 0.08$

(95% CI = -0.38 to 30.38; 90% CI = 2.59 to 27.41)

Wilcoxon signed rank test : $T = 1.89$, $p = 0.08$

ingly, the network had two critical paths (events 1-2-5-7 and 1-4-6-7) both spanning over 165 days in the trial year. The slack time available for events 1, 3, and 7 was 45 days.

Extensive search on Medline as well as library search did not reveal studies undertaken in similar health settings using this strategy. It is, therefore, perceived that use of network analysis as a tool for managerial control may be considered at pertinent areas by various health care units. In addition it is also suggested that additional replicate studies be conducted, to make a comparative assessment of this technique in the management of key result areas of large health care and epidemiological establishments, both in the Armed forces as well as in other health care delivery organizations. Such comparative studies are likely to render valuable guidelines for execution of both short-term and long-term health programmes, avoiding delays and unnecessary expenditure on account of delayed preventive, promotive and curative care.

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