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THE USE OF OPERATIONS RESEARCH IN HEALTH

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INTRODUCTION

OPERATIONAL RESEARCH (O.R.) techniques seem to have gained popularity in the field of health practice research for the past ten years and the health field has also begun its parallel development of O.R. and its application to complex problem of coordination and control. Health practice research has been defined by Grundy and Reinke (1973) as the formalized investigation of some aspects of the organisation and administration of health services in relation to objectives and socio-economic circumstances with the objective of achieving optimal use of a system for the delivery of health care services.

WHAT IS OPERATIONS RESEARCH?

To a lot of people, O.R. simply means "A scientific technique whose purpose is to improve efficiency that has been well-defined". Ackoff and Sasieni (1968) stressed that the definition of O.R. ought to cover the following essential characteristics:-

1. It is system-oriented. The essence of it lies in the systematic research for significant interaction in evaluating actions or policies of any part of the organisation.

2. It uses an interdisciplinary team to subject the team's work to critical review from the widest variety of these disciplines that are not represented on the team.

3. It applies scientific method to problems of control. In other words, the researcher constructs representations of the system and its operations (model) on which he conducts his research. Once the model has been constructed, it can then be used to find the optimal values of the controlled variables i.e. we can derive a solution to the problem from the model. A solution can be extracted from a model either by conducting experiment on it, i.e. by simulation or by mathematical analysis.

Therefore basically O.R. is a discipline that helps a decision-maker to decide which course of actions will yield the best measure of effectiveness. O.R. is not only concerned with how to make the best decisions but is also concerned with every facet of the decision-making process from actually defining the problem to determining what the best decision really is.

HEALTH PROBLEMS

Though there is no hard and fast rule in classifying problems in the realm of O.R., Ackoff and Rivett (1963) have suggested that many of the problems seem to fall in a classification similar to the eight areas listed below:-

1. Allocation	2. Waiting lines
3. Scheduling	4. Inventory
5. Competition	6. Replacement
7. Search	8. Sequencing.

As an illustration on the application to health practice research, two examples, one on linear programming, and another on transportation technique are given. The application mentioned merely helps to demonstrate where and how can some of the techniques be applied.

RESOURCE ALLOCATION AS AN EXAMPLE

This is part of resource allocation decision, dealing with the problem of determining the most efficient way to use resources to accomplish objectives. There are three elements which must be incorporated:-

(a) Specification of an objective function
(b) Alternative ways to accomplish the objective
(c) Constraints on the decision

When confronted with a problem of this type, the decision-maker must seek the optimal solution i.e. the solution which maximizes the result that can be produced with a given set of resources or minimizes the resources that must be used to produce a given result.

In fact, in the case of linear programming problems, the most difficult aspect of this technique is in the specification of the objective function which can be expressed in terms of a set of decision variables, and finally the constraints that limit the acceptable value of the decision variables.

Supposing a health planner wishes to determine the maximum number of health centres to be constructed during some period of time, given fixed health resources, and that there are four types of health centres:-

X_1 Main Health Centre (MHC)
X_2 Health Sub Centre (HSC)
X_3 Maternal and Child Health Centre (MCHC)
X_4 Midwife Clinic Cum Quarter (MCQ)

The decision-makers have to determine the optimal number of each type of centres to be built and Xs are the decision variables.

Therefore the objective function becomes

$$\text{Max. health centres} = X_1 + X_2 + X_3 + X_4$$

and it will determine the combination of the health centres.

Now also assume that the amount allocated to the different type of services for each type of health centres are as follows:-

Types of services offered

	Maternal and Child Care	*Clinical service*	*Health Education*	*School Health*
MHC	10,000	8,000	3,000	2,000
HSC	7,500	6,000	2,000	1,000
MCHC	15,000	7,000	2,000	2,000
MCQ	5,000	2,000	1,000	–

Finally, the capacity of the resources for the period of time under consideration can be estimated from past output levels.

Assume again that the following resources have been allocated to each type of service.

Maternal and child care	$C_1 = 200{,}000$
Clinical service	$C_2 = 150{,}000$
Health education	$C_3 = 50{,}000$
School health	$C_4 = 30{,}000$

With all the information available, the problem can then be expressed as follows:-

$$\text{Max. health centres } Z = X_1 + X_2 + X_3 + X_4 \qquad (1)$$

Subject to

$$10{,}000X_1 + 7{,}500X_2 + 15{,}000X_3 + 5{,}000X_4 \leq 200{,}000 \qquad (2)$$

$$8{,}000X_1 + 6{,}000X_2 + 7{,}000X_3 + 2{,}000X_4 \leq 150{,}000 \qquad (3)$$

$$3{,}000X_1 + 2{,}000X_2 + 2{,}000X_3 + 1{,}000X_4 \leq 50{,}000 \qquad (4)$$

$$2{,}000X_1 + 1{,}000X_2 + 2{,}000X_3 \leq 30{,}000 \qquad (5)$$

$$\text{where } X_1, X_2, X_3 \text{ and } X_4 \geq 0 \qquad (6)$$

Equation 1 is the objective function. Equation 2 to 5 are constraints which state the total quantity of each service consumed by different type of establishment cannot exceed the capacity of the corresponding resources. Equation 6 represents non-negativity constraints. Since it is not my intention to illustrate the computational part of the problem, interested readers can refer to any elementary text of O.R. for reference. The solution to this problem would indicate the combination of health centres that would be built in order to maximize the total number of health centres.

Of course this example has oversimplify the realistic situations where in fact much more factors and constraints would have to be considered. This particular technique of linear programming is applied to situation where, because of limited capacity of facilities, limitations of finance, manpower and other kinds of restrictions, it is necessary to calculate what mixture of activities or allocation of resources would best meet a defined objective. Wolfe (1965b) has applied linear programming to the assignment of nursing personnel to the activities that must be performed on a nursing unit. The problem is to determine the assignment pattern that minimizes personnel cost subject to a number of constraints reflecting the value of assigning different categories of personnel to different tasks and the requirement that every task be performed. Holland (1970) has worked on developing methods to evaluate the locations of hospital in rural areas.

AN ASSIGNMENT PROBLEM AS AN EXAMPLE

Another example is on the referral relationship between the scattered health centres and hospitals. Assuming that there are six centres where patients can be referred to three hospitals, with clinical referral loads and hospital capacities for acceptance of referred as shown in Table I. Certain referral patterns are likely to be more costly than others due to factors of transportation and inconvenience. Assuming that the cost differentials can be quantified and are constant, we can then use transportation technique to solve the problem.

The optimal assignment is shown by this technique as displayed in Table II. The actual mechanics of this technique are discussed elsewhere. The important element is that it provides an economical basis for allocation of resources in the fact of limiting constraints.

Table I

Data for assessing clinic-hospital relationship

	Health Centres						
Hospital	a	b	c	d	e	f	Hospital Capacity
	"unit cost for health centres to hospital"						
A	1	8	1	4	15	8	60
B	4	9	2	5	2	5	100
C	5	12	10	13	4	4	70
Referrals	20	30	60	50	40	30	230

CONCLUSION

The O.R. approach is not an easy road to problem solving because health systems, particularly, present difficulties not found in industrial situations where O.R. has been applied. Difficulties include, the number of decision-makers, social and psychological features have a considerable bearing on the effective operation of the system, objectives are frequently ill-defined and often the subject of controversy or conflict. All these factors cause health care systems to settle into a state of relative stabily from which it may be difficult to shift them. Secondly, in health systems, we are dealing with open systems which means that the individual components i.e. staff and patients are frequently changing thereby altering the system characteristics. Such complex considerations usually cannot be fully reflected in a model. Hence it would be necessary to give careful and explicit consideration to the manner in which models are to be used.

Table II

Optimal solution for referral

	Health Centres						
Hospital	a	b	c	d	e	f	Hospital Capacity
A	20	–	40	–	–	–	60
B	–	–	20	40	40	–	100
C	–	30	–	10	–	30	70
Referrals	20	30	60	50	40	30	230

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