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ABSTRACT

This report focuses on the use of linear programming models to address the issues of how vocational rehabilitation (VR) resources should be allocated in order to maximize program efficiency within given resource constraints. A general introduction to linear programming models is first presented that describes the major types of models available, their primary function, and how to evaluate them. The steps in the process of model building are then outlined. Following a general introduction to the vocational rehabilitation system, specific steps in the development of Rehabilitation Allocation Model (RAM-1), a prototypical linear programming model, are presented. Eight charts, including five flow charts, are provided. Appendix A lists five selected references on modeling and its application to human services. Appendix B contains a mathematical formulation of a linear programming model for multiperiod resource planning in a community support system. (YLB)

RESOURCE ALLOCATION MODELLING IN VOCATIONAL REHABILITATION: A PROTOTYPE DEVELOPED WITH THE MICHIGAN AND RHODE ISLAND VR AGENCIES

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ABSTRACT

RESOURCE ALLOCATION MODELLING IN VOCATIONAL REHABILITATION: A PROTOTYPE

Report by H. Stephen Leff, Ph.D., and Ralph R. Turner, Ph.D., Abt Associates, Inc., September 1982, 29 pp.

This report is the outgrowth of technical assistance in resource allocation modelling provided to vocational rehabilitation agencies in two states, Michigan and Rhode Island. Both agencies shared several needs, the most important of which was the exploration of techniques by which resources could be allocated based on the efficiency, or cost effectiveness, of services. The focus of the technical assistance, therefore, was on describing linear programming models and attempting to develop an illustrative linear programming model prototype for vocational rehabilitation.

The written report describes the uses of linear programming models, describes how to develop and evaluate a model, and presents a conceptual approach for a Rehabilitation Allocation Model (RAM) prototype. Unfortunately, the data necessary to operationalize such a model are not presently available from agency management information systems. The report concludes that such data may be developed in the future to help linear programming models realize their potential contribution to increasing the effectiveness of vocational rehabilitation resource allocation.

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I. INTRODUCTION

One might characterize the goal of vocational rehabilitation as an attempt to serve disabled people with equity, effectiveness, and efficiency. That is, vocational rehabilitation services ought to be distributed among clients of different types and in different locations in a manner that is "just" or "fair." As well, those services should produce appropriate change in clients and to do so while minimizing the agency resources consumption.

Mathematical models have been developed which can serve as tools to the vocational rehabilitation agency when administrative problems make solutions difficult to reach by intuition or reasoning alone. Four types of such models are: cross-sectional, time series, simulation, and linear programming models. Appropriate model application is dependent upon the goal area for which solutions are sought. Appendix A lists selected references on modelling and its application to human services.

Equity problems, generally involving status quo measurement and evaluation, have been the focus of cross-sectional modelling. One example of such modelling is provided by the Massachusetts Department of Mental Health (Cohen, Van Horne, & Leff, 1974), which developed a cross-sectional model to measure catchment area mental health need. The level of need was then contrasted with catchment area mental health resources. Both need and resources were expressed as proportions of state need and resources, and then used to compute equity ratios.

Effectiveness problems, on the other hand, have drawn the attention of modelers using both time series and simulation models. Such problems often involve answering questions such as, "Based on past performance, how many persons can we expect to rehabilitate next year?" or "What will happen to our rehabilitation rate if we change our client mix?" One example of simulation modelling for vocational rehabilitation is the model created for Michigan Rehabilitation Services by The Institute of Labor and Industrial Relations at the University of Michigan (Herstein, Schwartz, and Kett, 1981), which projects numbers of successful case closures as a function of case mix (severe and nonsevere client type).

Finally, efficiency problems are often solved using linear programming models, since these models compare alternatives with respect to some measure of effectiveness and in relation to resource constraints. Such models are particularly useful since the most effective solutions are often not feasible because of resource constraints. For example, an elaborate simulation project carried out in a midwestern state failed to be useful when the projected costs of the mental health strategy explored turned out to be far beyond what state government could afford. A linear programming model can be asked to explore only solutions feasible within a set of cost and other (e.g., space, personnel) constraints.

The current report focuses on the use of linear programming models to address the issues of how vocational rehabilitation resources should be allocated, in order to maximize program efficiency within given resource constraints. A general introduction to linear programming models is first presented, which describes the major types of models available, their primary functions, and how to evaluate them.

II. USES OF LINEAR PROGRAMMING MODELS

Much of this report focuses on the application of a linear programming approach to efficient resource allocation in vocational rehabilitation. However, the principles governing the utilization and evaluation of such models apply, to a large extent, to models in general.

Linear programming models are particularly useful when there are a number of tasks to be accomplished and not enough resources to carry out the work at some desired level. This situation requires some method of estimating the amount of resources to be allocated to each of the difference activities so as to optimize some criterion of system performance. The overall goal of such a method is to specify an objective, examine alternative ways of achieving the objective (i.e., decisions or factors that are within the control of agency managers) and select the optimal path of action, while at the same time recognizing the resource constraints and background factors (factors outside the agency managers' control) that exist. The solution of most such problems requires the use of a computer and an algorithm based on the simplex method for solving simultaneous equations.

However, the usefulness of linear programming models (and models in general) goes beyond their ability to find optimal solutions. Some other uses of such models are described below.

1. Program Monitoring. Once built, a model can be used to find out what particular variables determine system performance (e.g., number of job placements available). Moreover, the model can be used to specify how the system responds to changes in the values of these variables. These variables can then be monitored to check whether they are within acceptable limits given system goals. If they are not, system operations can be modified to bring the values into acceptable ranges; alternatively, system goals can be modified to reflect the fact that certain variable parameters are falling out of range.

2. Exploring Policy Options. Models can also be used to explore the consequences of specific policy options. Using model results, political

considerations, scientific theories or personal intuitions to suggest which variables to change, managers can employ models to perform simulated experiments that might be too expensive, time-consuming, or risky to actually perform. Models can be time-consuming to create. However, once a working model exists, it can be invaluable in allowing agencies to rapidly explore options they are considering. This is a particularly important benefit of models for agencies that must respond to repeated crises and have little time for experimentation or analysis.

3. Compensating for Missing or Suspect Data. A common problem facing many vocational rehabilitation agencies is the lack of appropriate data for solving resource allocation problems. Models can be used to compensate for missing or suspect data by systematically applying different values for those variables and determining the sensitivity of the system to changes. Once this is done, multiple scenarios can be investigated to determine how an agency might be expected to perform if certain key values are too high or too low.

4. Examining Effects of Decisions Over Time. Many of the elements in vocational rehabilitation systems interact in loops and affect each other over time. The number of people who receive training will affect the number of people who need jobs. However, if counselors spend time trying to find people jobs rather than getting them into training, then the number of people needing jobs will also affect the number of persons trained. Such interactions result in non- or counter-intuitive system behavior over time. A particular problem that such behavior can cause is suboptimization. Suboptimization occurs when a particular decision appears attractive for a specific client group or time period, but turns out to be less than optimal in its consequences for the system as a whole or in the long run. Models provide technologies for tracing the effects of interacting decisions over time and, therefore, for discovering such non- or counter-intuitive system behavior.

5. Stimulating Theory Construction and Organizational Dialogue. Finally, the process of model building stimulates theory construction, facilitates the scrutiny of underlying assumptions and provides a check on reasoning. Since developing a model requires the specification of

exactly how a system under consideration works or is postulated to work, intuitions, theories and known facts must be drawn together into a set of explicit statements about relationships among operationally defined variables which are highly specific and logically consistent. This aids both theory construction and organizational planning. Just the act of bringing a group of agency managers together and discussing with them how they think their system works can be beneficial; managers become more aware of their own assumptions and those of their colleagues.

III. EVALUATING MODELS

Critical examination of linear programming models is, of course, necessary. Five central questions which can guide such evaluation are presented here.

1. Are the input data, the mathematical model, and the computing environment described in sufficient detail to evaluate the general quality of the development effort?

Data for models generally come from three sources: (a) management information systems, (b) evaluation research, and (c) expert judgment. Clearly we should expect the different types of data to vary in quality, with management information system data being the most accurate for modelling, and expert judgment data being the least accurate.

The mathematical model should be described in some detail. Although certain technical features of the model will be beyond the layman's understanding, a model's general workings should not be. The ability of a modeler to explain the model to the client may be an important clue as to how well the modeler has understood the agency's problem.

The computer programs that a model uses may be especially prepared for the model or come from an established modelling package. Generally it is better to use such packages when possible since they are more likely to be error-free.

2. Have the input data been explored for anomalous cases and coding and keypunch errors?

3. What simplifying assumptions have been made in the model?

Any model will simplify reality. If important aspects of management's reality have been omitted from a model, then its usefulness to managers will be seriously diminished. "The policy maker has the responsibility to make sure that the modeler has built in the features that may affect the decision. The modeler does not always know what is on the decision maker's agenda." (Hoaglin, et al., 1982, p. 209).

4. Have the model's output data been analyzed in detail? Are the data reported in a manner that facilitates analysis?

Anomalies in a model's output data provide important clues as to how good the model is. However, to find anomalies, model results have to be analyzed in great detail. It is easy to overlook the odd finding in the great outpouring of data that most models provide. Model results must be thoughtfully presented in a manner that facilitates data inspection, analysis and interpretation.

5. Are the results consistent with other knowledge? Are they reasonable?

We should expect most model results to be reasonable and consistent with what is already known. However, an important feature of models is their ability to find fresh insights counter to the prevailing wisdom. Nevertheless, "Any unreasonable result should be challenged to learn whether it represents an error or what aspects of the model or input data may be responsible for it." (Hoaglin, et al., 1982, p. 210).

Whenever possible, a model should be evaluated according to the validity of its projections. One effective test can be made by applying the model to a situation that has already occurred. The model is manipulated to make the same decisions made in the real situation, and the results are compared. A second method is to follow a model's suggestions in a current situation and then to compare its projections with what really happens. This type of test is particularly difficult to bias. If no real situation is available for testing, a third method for evaluating a model involves comparing its results to those of other models with an analysis of the different predictions.

IV. THE PROCESS OF MODEL BUILDING

The essence of modelling lies in its approach to problem-solving -- in the way it looks at a total system, abstracts the essentials, and tests out the advantages of alternative ways of manipulating those essentials. The approach involves five sequential steps. (Halpert, Horvath & Young).

1. Defining the problem. This step involves building a conceptual framework for the program being modeled, which includes an identification of the objectives of the organization, an enumeration of the types of clients to be served, a survey of the alternative courses of action to be considered, and specification of any and all constraints to be considered. While seemingly obvious, it is often enlightening to hear the variety of objectives produced by different "actors" in the agency.

2. Constructing the model. Once the problem has been defined, the next step is to convert the objectives into quantifiable variables and establish functional or mathematical relationships among them.

3. Collecting data for the model. As has been noted, data for the model may be produced from a management information system, from evaluation research, from expert judgment, or it may be from any combination of these sources.

4. Deriving a solution or solutions from the model. Generally, models are used to provide multiple solutions reflecting different assumptions or different data. Sometimes the output is directed at finding an optimum path of action. However, as has been noted, a model may also be run to discover a new relationship or insight. When models yield neither immediately applicable new solutions nor new insights, they at least confirm the wisdom of a course of action or insight already favored.

5. Testing the model. Methods for evaluating models were discussed in Section III, above.

6. Implementing the solution. Implementing solutions may be different since organizations are often resistant to change and motivated by other

than the rational criteria on which a model may be based. Care and diplomacy need to be used when using modelled solutions to administrative and political problems. Nevertheless, by carefully considering the manner in which model results are fed back to an organization, they can often be used to support policies that are prescribed by a model.

7. <u>Observing the effects of the model-based changes on system performance</u>. The purpose of this step is to validate the model and determine whether the solutions from the model give a correct representation of the system, or whether further modifications to the model (or the data that drive it) are necessary. Basically this task entails comparing observed system performance with model results and tracking model deviations back to either flaws in the model or its data.

V. A REHABILITATION ALLOCATION MODEL PROTOTYPE: VERSION 1 (RAM-1)

In this section of the report, a prototypical linear programming model for vocational rehabilitation is presented. Following a general introduction to the vocational rehabilitation system, specific steps involving the RAM-1 construction are presented.

THE VOCATIONAL REHABILITATION SYSTEM

Chart 1 shows a schematic summary of client flow through the vocational rehabilitation system, prepared by the Vocational Rehabilitation Division of the Rhode Island Department of Social and Rehabilitation Services.

Not shown in this chart is the fact that vocational rehabilitation agencies serve clients falling into different disability groups. Persons with different disabilities move through the same statuses, although service packages and costs, as well as rates of movement, differ dramatically between some disability types.

SPECIFIC STEPS IN THE DEVELOPMENT OF RAM-1

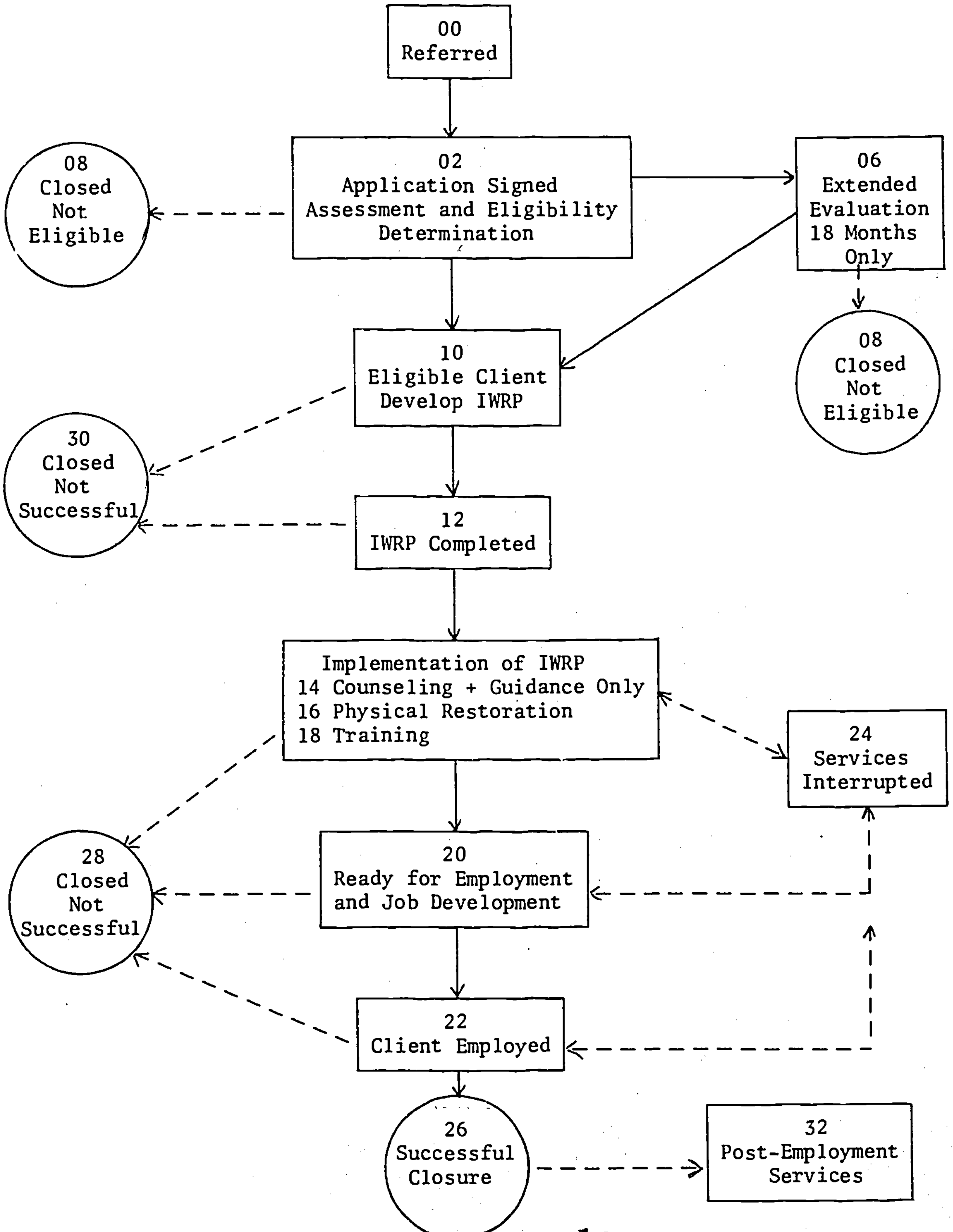
Step one in building RAM-1 is the development of a conceptual framework for describing how a vocational rehabilitation system works and the decisions open to the managers of the system. This framework must consist of a Client Status Progression, a Client Service Pathway, a set of Service Package Options, a set of the possible movements clients can make from one status to another after receiving services, definitions of system goals or objectives, the set of system constraints, a planning horizon or time frame, and the time periods into which this planning horizon will be divided.

Step two is the translation of the conceptual framework into mathematical equations and a computer program.

Step three is the collection of three types of data: 1) service package option costs, 2) transitional probabilities, or movement rates per time period for movements between client statuses as a function of receiving particular

Chart 1

Status Flow in the Vocational Rehabilitation Process



service package options, and 3) values for constraints, e.g., budgets and numbers of jobs available per time period.

The remaining steps are described in Section IV above, and relate more to the running and validation of the model than to its development. We turn now to the RAM-1 conceptual framework.

Client Status Progression

Chart 2 shows the Client Status Progression which was developed for RAM-1 and the code conventions associated with each client status. This progression is intended to apply to any disability category. However, one question remaining to be answered is whether the model would be run for each disability group separately or for all disability groups together. The latter alternative would pit one disability group against another and possibly violate the goal of equity, since the model would probably prefer to serve less severely disabled persons unless outcomes for the various disability groups were weighted differentially. The number of disability groups precludes a model in which all groups are distinguished; the number of statuses (number of disability groups x 5) would be unmanageable. However, disability groups might be collapsed into superordinate groups, such as severely and nonseverely disabled, as long as groups that were collapsed were similar in the service packages they required. An alternative to this approach would be to run the model for each disability group separately. This would involve the risk of suboptimization. However, this risk could be evaluated by comparing the results of model runs using both approaches.

In discussing the Client Status Progression, it is important to highlight a simplification made in the model's development. It is assumed that clients move from one status to another as a function of the status they are in immediately prior to receiving service and as a function of the service package option they receive. The model does not consider the client's past history. (In technical terms, such models are referred to as first order Markov chain models.)

One way such a model can be made to take a client's history into account would be to further divide the statuses shown into those for new clients and those for clients returning to the system. This would be important if new clients and returning clients had drastically different outcomes.

Chart 2

RAM-1 Client Status Progression

CLIENT STATUS	DEFINITION/CODE CONVENTION
(0) GEN. POP. IN NEED OF SERV.	+ PERSONS NOT REACHED INCIDENCE + 08 + 28 + 30
(1) APPLICANT STATUS: READY FOR SCREEN/ EVAL.	02 + 06
(2) ACCEPTED ELIG: READY FOR IWRP/PLAN IMPLEM.	10 + 12 + 16 + 18 (CLIENTS WHO ENTER 10 OR 12 CANNOT LEAVE STATUS UNTIL AFTER THEY ENTER 14, 16 OR 18. CLIENTS ENTERING MORE THAN ONE CATEGORY COUNTED ONLY ONCE.)
(3) SERVICE COMPLETED: READY FOR JOB PLACEMENT	20
(4) JOB PLACEMENT COMPLETED: WORKING	26
(5) WORKING: NEED FOR POST EMPLOY. SERVICES	32

However, it is important to be conservative in creating client categories. One can quickly wind up with an unmanageable number of client categories, even given the capacity of modern computers. For example, given three disability groupings and five statuses, dividing clients into new clients and repeaters would result in a system of 30 client statuses. In our experience, models with over a dozen categories become very difficult to implement.

Service Pathway and Service Package Options

Chart 3 shows the RAM-1 Service Pathway and the client statuses associated with each service package in the pathway. No service pac e is shown for client status (4) "Working," since a working client is not assumed to be in need of service unless he or she moves to status 32.

Chart 3 also shows that each service package is conceptualized as having two options: a more extensive services option and a less extensive one. Table 1 describes how these options might differ for the various service packages. Discussions with vocational rehabilitation personnel suggest that it is reasonable to assume such differences in service packages. Each option would have to be defined and priced for each disability type or grouping.

System Goals/Objectives and Constraints

Given this system's framework, system goals or objectives and system constraints can be defined in a variety of ways which permit an assessment of differential resource allocation solutions. For example, goals and objectives might include the following:

a. maximize number of 26s;
b. maximize number of 26s and minimize number of 08s, 28s, 24s, and 30s; and
c. maximize client earnings in dollars.

Constraints, on the other hand, might involve:

a. agency budget in dollars,

Chart 3

RAM-1 Service Pathway

MODEL STATUS	CODE CONVENTION	RECEIVES	SERVICE PACKAGE
(0)	INCIDENCE OR 08 OR 24 OR 28 OR 30	→	(0) OUTREACH: (A) More Extensive; (B) Less Extensive
(1)	02 OR 06	→	(I) SCREEN & EVALUATE: (A) More Extensive; (B) Less Extensive
(2)	10 OR 12 OR 14 OR 16 OR 18	→	(II) IWRP & PLAN IMP: (A) More Extensive; (B) Less Extensive
(3)	20	→	(III) JOB PLACEMENT: (A) More Extensive; (B) Less Extensive
(5)	32	→	(V) POST EMPLOY. SERVS.: (A) More Extensive; (B) Less Extensive

[1] Model Status (4): "working" omitted since no service is associated with this status.

Table 1

RAM Service Package Options

SERVICE PACKAGE	(A) MORE EXTENSIVE	(B) LESS EXTENSIVE
(0) OUTREACH	ACTIVE RECRUITMENT ACTIVITIES	NO RECRUITMENT
(I) SCREEN/ EVALUATE	OUTSIDE CONSULTANTS	NO OUTSIDE CONSULTANTS
(II) IWRP & PLAN IMPLEMENTATION		
Personal Needs	Full	No or Partial
Intercurrent Illness	Yes	No
Training	College Books & Supplies	Trade School No Books and Supplies
Attendant Care	Full	Cost Shared
Home Modification	Full	No or Cost Shared
Maintenance	Full	No or Cost Shared
Transportation	Full (Purchase)	No or Partial (Lease)
Equipment	Full	Partial or Cost Shared
Counseling & Guidance	Intensive	Minimal
(III) JOB PLACEMENT	JOB COUNSELING & DEVELOPMENT	INFORMATION & REFERRAL ONLY
(IV) PAST EMPLOYMENT	SEE (II)	SEE (II)

1. Each Service Package Option needs to be defined and priced for each type of disability, or disability grouping. Disability groupings are only possible if service needs and choices are similar.

b. counselor time, and
c. availability of jobs.

Planning Horizon and Time Period

Given that most state and federal planning is on an annual basis, that many client programs take several years to complete and that models become less accurate the further into the future they are asked to project, a three-year planning horizon was adopted for RAM-1.

The model's time period is the smallest unit of time recognized by the model. All client movements and resource expenditures take place on a per time period basis. The RAM-1 time period selected was one month. Few client movements can take place in less than a month and months can be easily aggregated into years for relating them to budget periods.

Movements Between Client Statuses

Charts 4-8 show current conceptions of which movements between client statuses are possible. Table 2 summarizes these movements in a transition probability matrix. There is uncertainty about several movements which needs to be clarified for final specification of the model. It should be noted that movement rates specific to the receipt of each service package option must be estimated. An important part of what the model considers is the differential effectiveness of the various service package options.

DATA SOURCES

Recent inquiries indicate that data for the full-scale version of RAM-1 are not readily available from agency management information systems. It is certainly possible that the data could be developed from evaluation research data alone or in combination with management information system data. However, an extended literature search and review would be necessary to make that determination. Data based on expert judgment could also be used alone or in combination with data from other sources. However, the validity of such data would have to be carefully considered.

Chart 4

RAM-1 Flow Chart

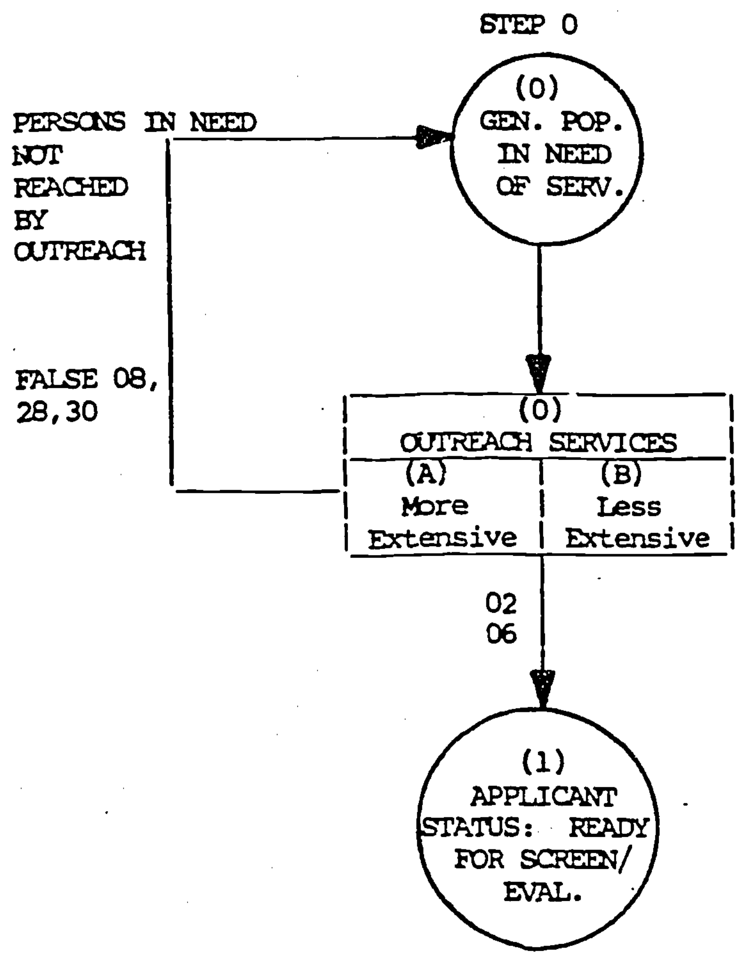


Chart 5

RAM-1 Flow Chart

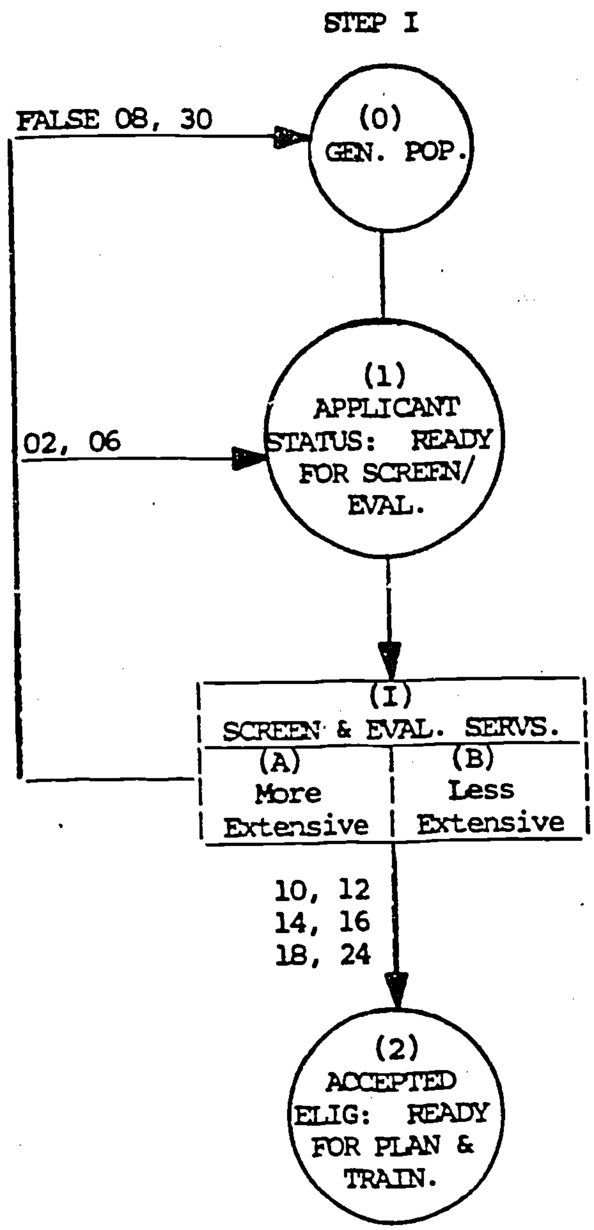


Chart 6

RAM-1 Flow Chart

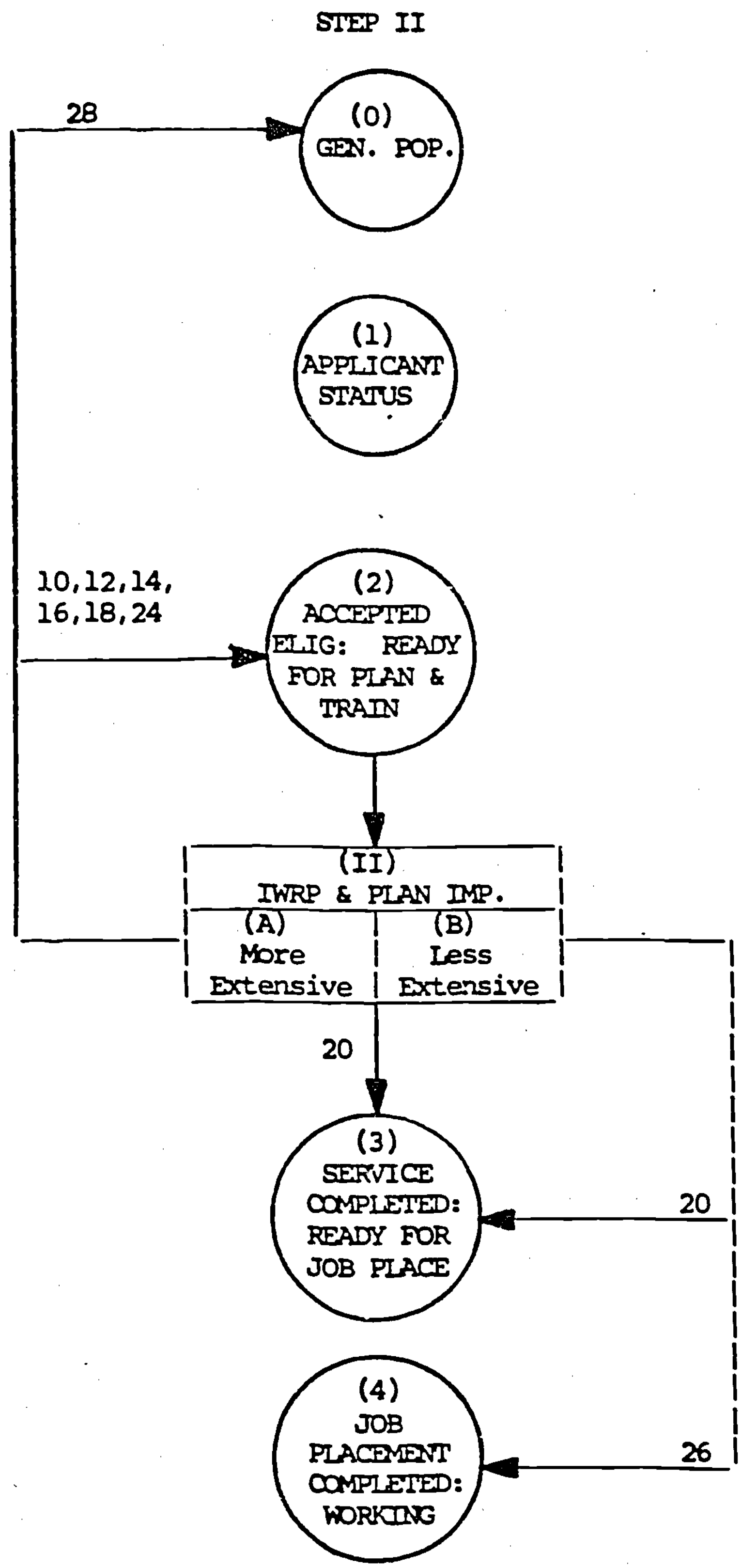


Chart 7

RAM-1 Flow Chart

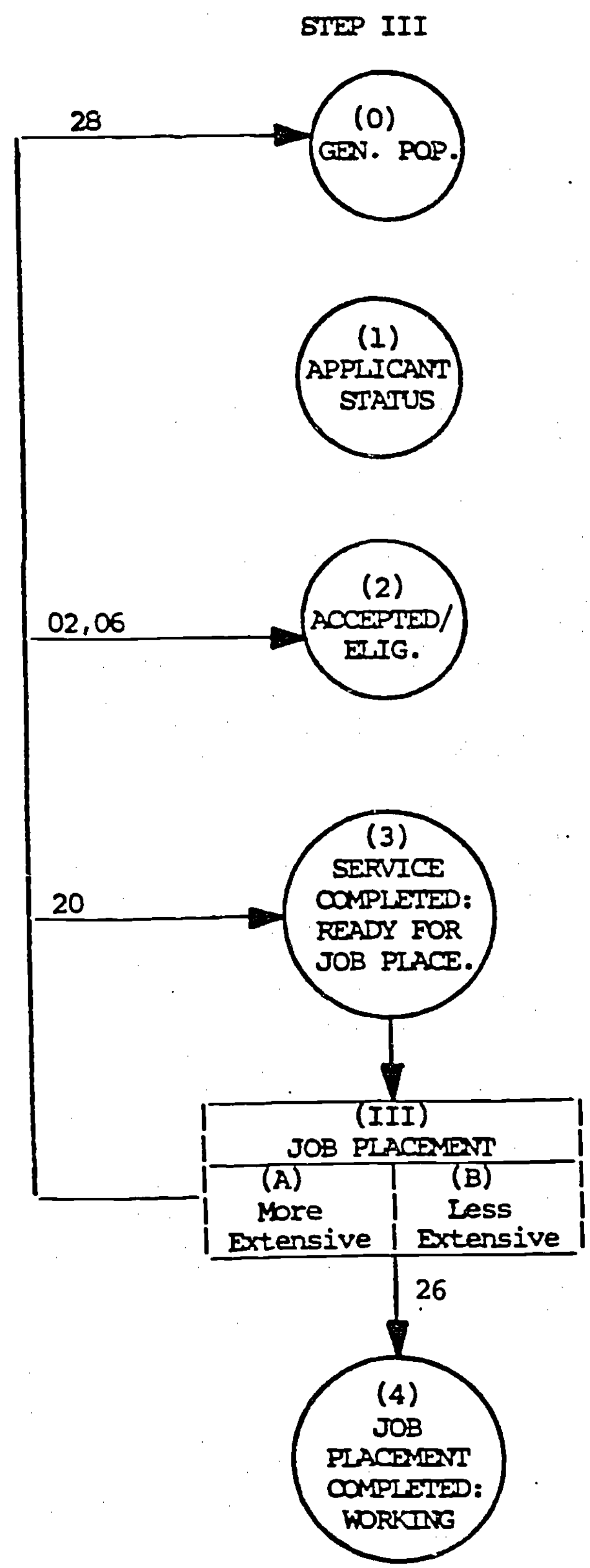


Chart 8

RAM-1 Flow Chart

STEP IV

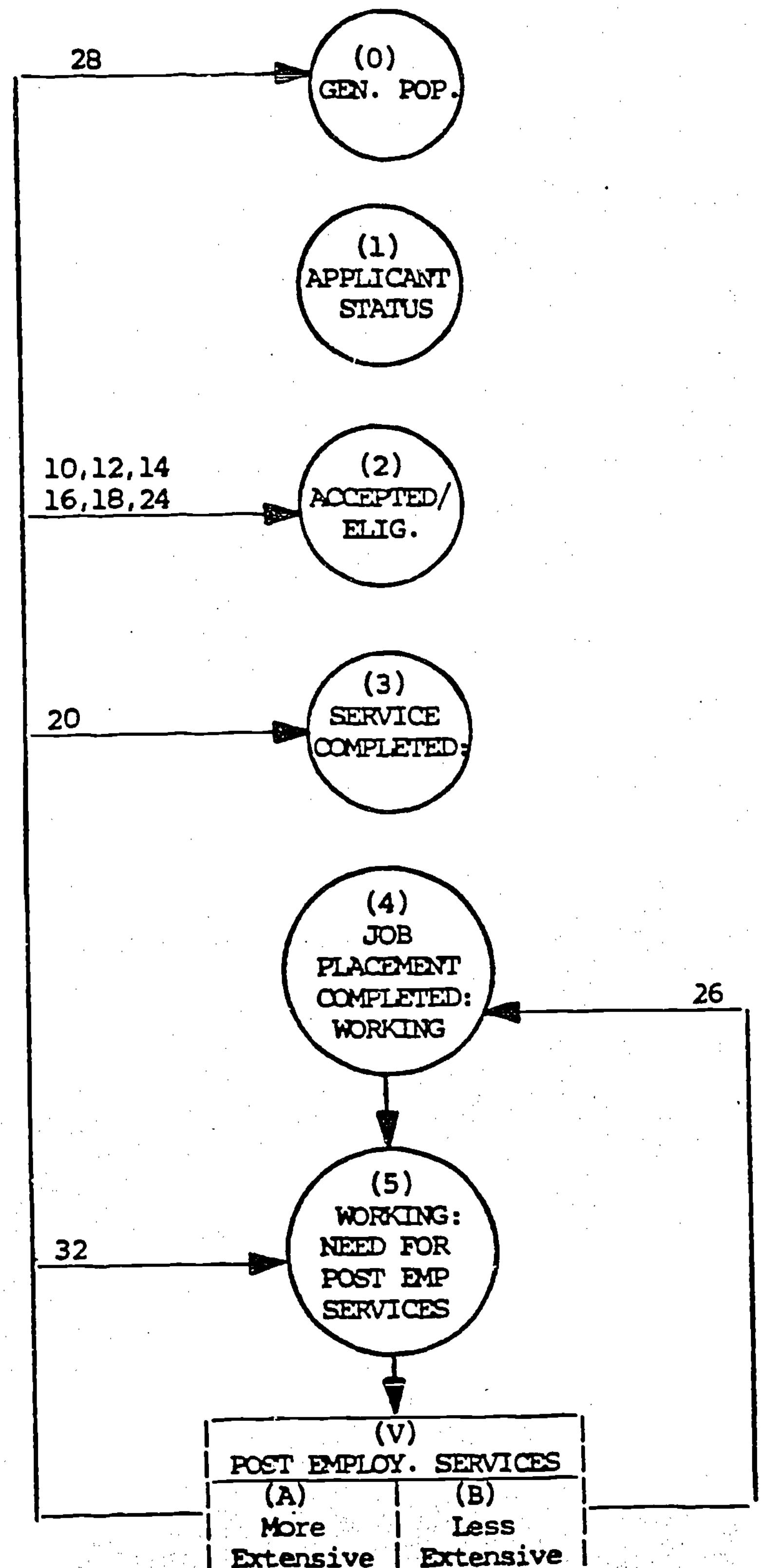


Table 2

RAM-1 Transitional Probability Matrix

(for movement from one client status to another)

From: \ To:	STATUS 0	1	2	3	4	5
STATUS 0	_____	_____	/////	/////	/////	/////
1	_____	_____	_____	/////	/////	/////
2	_____	/////	_____	_____	_____	/////
3	_____	//////	?	_____	_____	/////
4	_____	/////	?	?	_____	_____
5	_____	/////	?	?	_____	_____

Key:

_____: probability of movement between two statuses

/////: no movement possible between these two statuses

? : unclear whether movement is possible between these two statuses

It is possible to approximate the data needed for a minimal version of RAM-1 from data provided by the federal R-300 data set. Presented in Chart 9, this minimal RAM-1 is designed to suggest how a vocational rehabilitation resource allocation model would work. It is not intended to be useful for actual resource allocation planning or decision-making. One way to confirm the suitability of the R-300 data base for providing the necessary data for the minimal RAM-1 would be to attempt to extract the data from the R-300 data base. The data requirements for the minimal RAM-1 are shown in Table 3.

MATHEMATICAL FORMULATION AND COMPUTER PROGRAM

Appendix B contains a mathematical formulation of the RAM-1. This formulation has been translated into computer programs using a programming package, Subroutines for Experimental Optimization (SEXOP) mantained on a PRIME 400 minicomputer. Modelling packages of this type are often available in university-based business and engineering schools.

Chart 9

Minimal RAM-1 Flow Chart

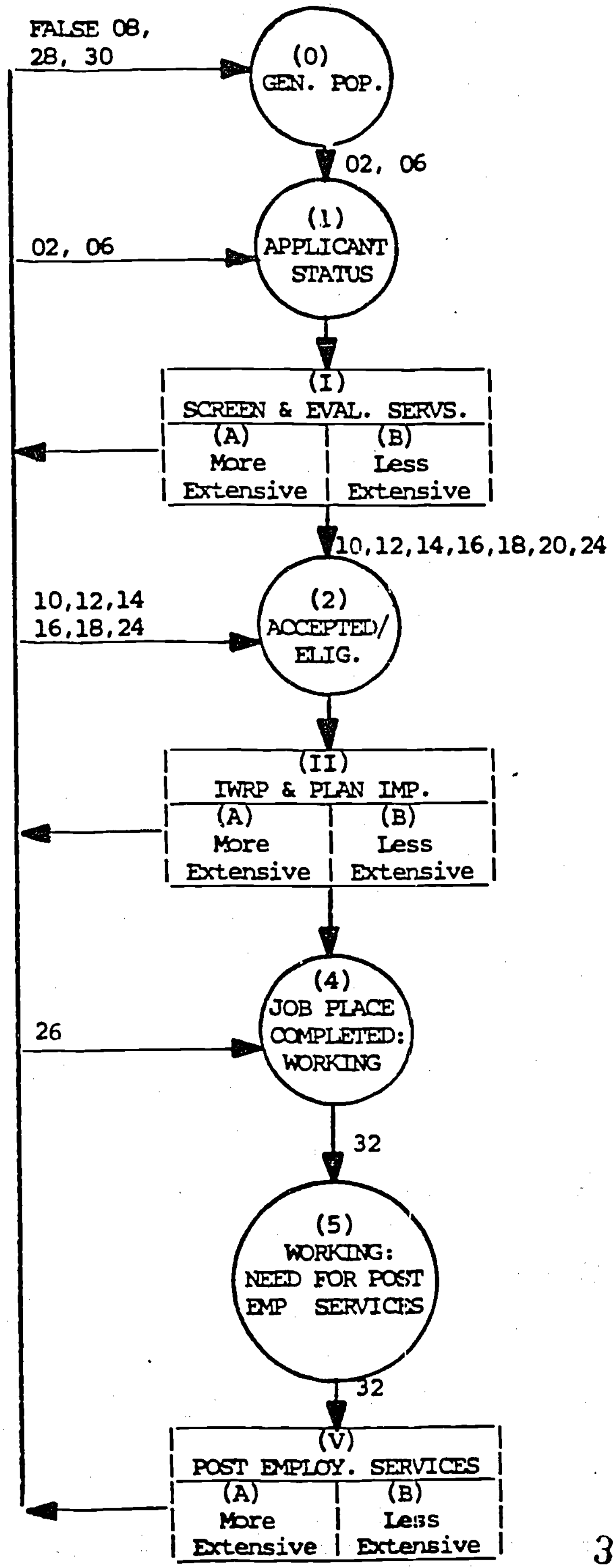


Table 3

Data Requirements for Minimal RAM-1

1) Transitional Probabilities (Monthly)
(for movement from one client status to another)

From: \ To:	STATUS 0	1	2	4	5
STATUS 0	_____	_____	/////	/////	/////
1	_____	_____	_____	/////	/////
2	_____	/////	_____	_____	/////
4	_____	/////	?	_____	_____
5	_____	/////	?	_____	_____

2) Monthly Service Package Option Costs For:

	A	B
I	_____	_____
II	_____	_____
III	_____	_____

Key:

_____: probability of movement between two statuses

/////: no movement possible between these two statuses

? : unclear whether movement is possible between these two statuses

VI. FUTURE DIRECTIONS

The experience of the consultant in providing this technical assistance strongly suggests that resource allocation modelling has a significant contribution to make to planning in vocational rehabilitation agencies. No major obstacles to developing a conceptual framework for such modelling or to translating this framework into mathematical equations and computer programs were encountered. The most significant difficulty to be overcome is the availability of data. However, such data might be developed from management information and evaluation research sources. If these sources prove inadequate, special studies could be conducted. If this option is not feasible, expert judgment could be used to estimate model parameters.

University-based business and engineering schools with active operations research departments may offer additional resources for pursing this work further. The potential contribution of operations research techniques to the vocational rehabilitation, as well as other human services fields, has not yet been realized. Nevertheless, as the need for services grows and resources shrink, the potential contribution of these methods will increase.

APPENDIX A

APPENDIX A

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APPENDIX B

APPENDIX B

FORMULATION OF RESOURCE PLANNING MODEL

We have formulated a linear programming model for multiperiod resource planning in a community support system. This formulation is detailed below.

INDICES

$i, j,$ ∿ client type

k ∿ client service package

t ∿ time period

VARIABLES

x_{ikt} ∿ number of type i clients placed in service package k at time t

y_{it} ∿ total number of type i clients at time t

PARAMETERS

R_{kt} ∿ number of openings in service package k during time t

C_{ikt} ∿ per client cost of caring for type i clients in service package k over time period t

I_{jt} ∿ net input at time t of type j clients

F_{ij} ∿ probability of functional shift from i to j during any time period, conditioned on being in care package k during the time period

CONSTRAINTS

$\sum_k X_{ikt} = Y_{it}$ $\forall$ i, t : the sum of clients in service packages must total clients in system

$\sum_i X_{ikt} \leq R_{kt}$ $\forall$ k, t : clients in system cannot exceed space available in service package k in time period t

CONSTRAINTS (continued)

$I_{jt} + \sum_k \sum_i P_{ij}^{k} X_{ik,\,t-1} = Y_{jt}$ j, t : the total number of clients of type J in time period t equals the number of new clients, plus old clients as predicted by the probability transition matrix

$X_{ikt} \geq 0;\ Y_{it} \geq 0$ $\forall$ i, k, t: nonnegativity of decision variables

COST FUNCTION

$\sum_i \sum_k C_{ikt} \; X_{ikt}$: program cost in time period T

NOTES ON MODEL

(i) Model breaks planning horizon into equal-sized periods. Model assumes that client type movement is represented as a discrete time Markov chain, where transition rates depend on type of client and the service package.

(ii) The variables X_{ikt}, Y_{it} correspond to the expected number of clients in a particular category at time period t.

(iii) System cost is assumed to be linear in the number of clients.

(iv) Resource limitations are assumed to be represented in terms of number of clients.

(v) This version of the model assumes that the resources are fixed. An alternative would be to permit the model to expand the resources at some cost.

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