SIMULATION IN MENTAL HEALTH PLANNING

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Abstract

This paper describes two simulation models developed in the course of a research project undertaken for the North Carolina Department of Mental Health. The project performed a systems analysis of the alcoholism program currently being conducted by the Department in one of four regions in the state. One model is a micro simulation of individuals with problem drinking behavior and the resulting community actions in the handling of that behavior. This model is comprehensive in its detail; aspects of treatment, rehabilitation, program effectiveness, and cost are incorporated in order to provide extensive statistics used in the second model. The second model is a macro aggregative simulation which operates in a conversational mode and is used by management within the Department of Mental Health in their planning and budgeting process. The details of each model are discussed, results from the models are presented, and the initial reactions of the executives within the Department of Mental Health are summarized.

I. Introduction

The complex phenomena called alcoholism and the many public and private responses which these phenomena evoke constitute a significant problem both nationally and within the State of North Carolina. As a result the North Carolina Department of Mental Health undertook a project to develop a trial comprehensive program for one of the four mental health regions* within the State. This project combined the talents of four personnel types: (a) those currently involved in field operations of the alcoholism programs in the region, (b) a research staff from the Research Triangle Institute, the Departments of Sociology and Psychology of North Carolina State University and the North Carolina Department of Corrections, (c) executive decisionmakers responsible for alcoholism programming within the Department of Mental Health, and (d) advisors from the State Administration, State Legislature and responsible community leaders. The project objectives were:

a) To make explicit the necessary assumptions and to define the relevant terms required in describing the world of alcoholism.
b) To determine an operative model of alcoholism as experienced in the region.
c) To describe the current system and associated environment in which individuals with non-acceptable alcohol-drinking behavior are found.
d) To design a new system which more effectively and efficiently returns the individual to a social role acceptable to both the individual and the community.
e) To document and to implement this sytem design in the region.
f) To evaluate the new system's performance in order to determine those system components whose effectiveness or efficiency is less than expected.
g) To institute a vital program of system redesign that constantly adapts system performance to the dynamic environment and to increasing expectations of service.
h) Finally, to describe, evaluate, and recommend the appropriate efforts performed in this project for inclusion in other mental health planning activities.

The simulation models described in the following sections assist in designing a new system by providing a means of evaluating alternative program modifications. Results of the total research effort to realize all the above objectives have been reported elsewhere.[1]

II. Problem

A behavioral model of the system producing alcoholics was developed.[2] This model contains three basic phases: (a) the initial socially acceptable drinking behavior, (b) dependence drinking, and (c) public crises and labeling as an alcoholic. Individuals pass from the first phase to the second when alcohol is used to relieve stress. An individual enters the third phase when his drinking behavior is considered by someone (including himself) to be a problem and public action (a crisis and labeling) follows. The decision that the drinking behavior is a problem is related to informal rules of the person making the decision and to both formal laws and informal rules of the community. The following paragraphs outline a descriptive model of the private and public responses which an individual may experience as a result of a decision that he has a drinking behavior problem.

There are several assumptions made in this model. First, this is an overview of the various responses, a simplification, a supra-macro model in which individual experiences have been aggregated. The model assumes the existence of a typical heavy drinker and then indicates what he would encounter if this drinking resulted in his being committed to the corrections system, or if his drinking led his family to seek aid. In a sense every individual is atypical; the path of each individual varies.

A second assumption is that the response system begins with a detected drinking problem. Examples of system responses prior to problem recognition can be envisioned, e.g., aid to the family without knowing who has the problem.

A third assumption entails the crisis concept from the previous behavioral model. It is assumed that a crisis can either be physical, as the discovery of liver cirrhosis, or dysfunctional, as the inability to maintain acceptable social relations. It is assumed that a crisis is required prior to detection.

* The region that formed the basis for this study consisted of twenty counties in the south central section of North Carolina. The estimated population of the region is 1.5 million; Raleigh and Fayetteville are the major urban centers.

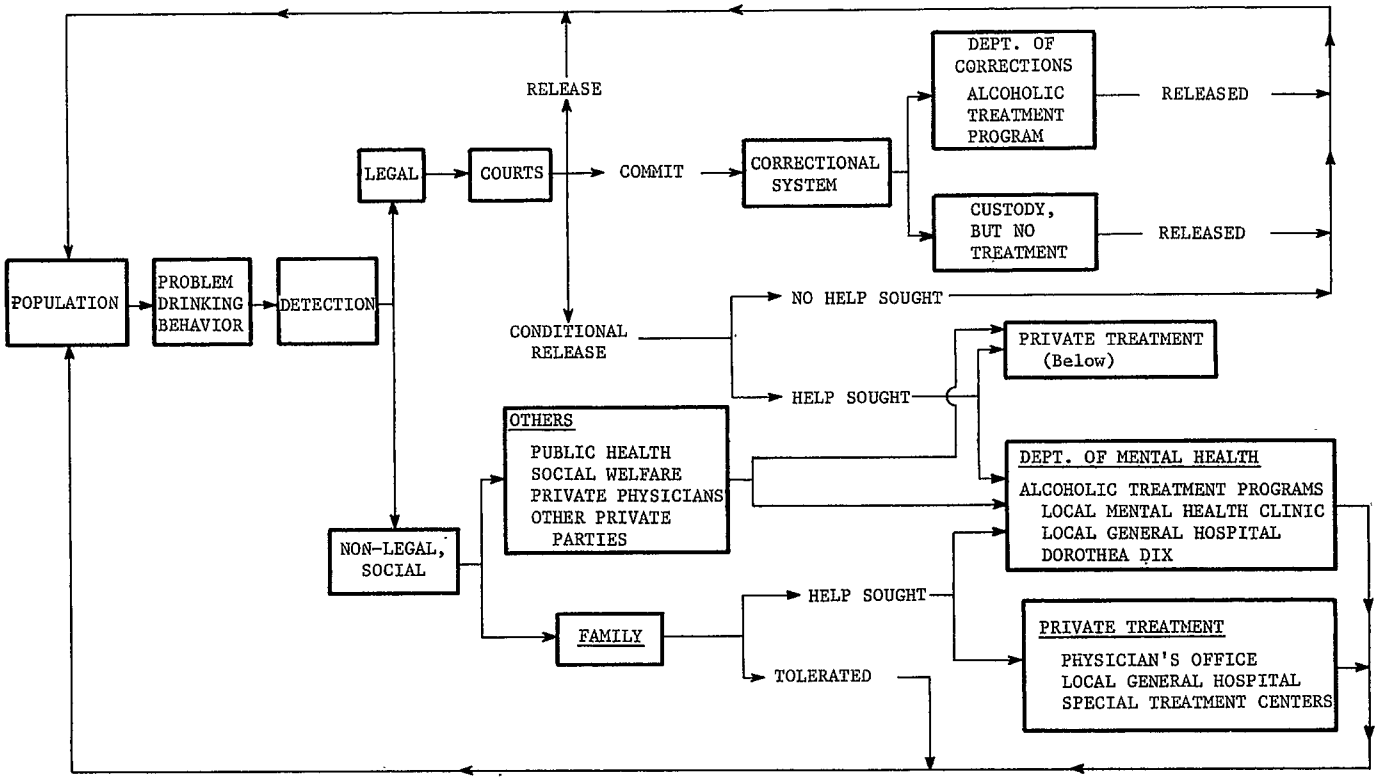

Fig. 1. The Public-Private System for Dealing with Problem Drinking Behavior.

Basically, the responses experienced by an individual who has a problem drinking behavior can be classified as public or private. A public response is one in which a recognized community institution is formally involved, e.g., an arrest by a policeman or initiation of a treatment program in a mental health clinic setting. Private responses are those experienced within families, at work, or in settings such as the church. The most formalized response is the public response entailed in detection and processing by legal agencies. All other responses both public and private are not so well structured or defined. As a result, these other nonlegal and social responses are far more difficult to simplify. A general outline of public-private responses is illustrated in Figure 1, "The Public-Private System for Dealing with Problem Drinking Behavior." This scheme shows in summary form the basic components of the system and indicates the potential circular flow that an individual can experience. The first three boxes (Population, Problem Drinking Behavior, Detection) represent Phases I and II of the behavioral model. Detection and the onset of Phase III can occur within a legal or a nonlegal social setting.

The nonlegal and social responses cover a wide range of situations exhibiting large degrees of variation. Usually the first social unit realizing a problem with the drinking individual is the family. In this setting the problem drinking behavior may be tolerated for some time before any treatment program is sought. If the family tolerates the behavior and if the drinking individual is not detected by the legal authorities, the total family condition may deteriorate to the point that other public agencies become aware of the condition. In these cases the drinking individual or his family may be seeking assistance in handling either the primary drinking problem or some secondary problem.

Treatment is sought for the individual once his behavior is publicly detected or when the behavior is no longer tolerated within his immediate social setting. Two types of treatment (excluding that within the criminal justice system) are available: public treatment--performed under the auspices of the Department of Mental Health, and private treatment--performed by private physicians or special facilities for that purpose. The treatment programs are varied but basically involve detoxification (if necessary) and rehabilitation. The purpose of rehabilitation is to return the individual to a useful social role; it may include private and group therapy for the individual, private and group therapy for his family, vocational training, etc.

In certain advanced states of physical disability, the treatment program must be conducted within a hospital setting. This may occur within the local community hospital, or if the case is severe, then treatment may be sought within a state supported inpatient alcoholic treatment program.

The formalized public response embodied in the legal process is initiated by police intervention and may continue to include incarceration. It should be noted that many variations can be found within the confines of the legal/judicial set of responses. In certain instances, the police may return the individual to his home, or they may keep him overnight to be released the next morning. Drinking may result not only in public drunkenness, but also in other criminal activity such as stealing or forgery. If the individual is apprehended on the latter charges, it is very likely that he will not undergo an alcoholic treatment program while incarcerated; it is also unlikely that he would be identified as an alcoholic upon release (making potential follow-up treatment by local agencies unlikely).

The system for handling alcoholic behavior involves several public agencies, including Mental Health, Public Health, Correction, Social Services, and Motor Vehicles. Estimates of the number of individuals that pass through each segment of this system were made. In addition, the cost associated with handling these cases was estimated. A summary of these estimates is presented in Table 1, "Annual Alcoholic Caseload and Costs for the Major Agencies." The indications of numbers of individuals varies from agency to agency; in mental health and corrections, the number is the actual caseload of patients undergoing some formal alcoholic treatment and/or rehabilitation program. Caseloads for public health and welfare are estimates of the number of alcohol-related cases out of the total caseload seen by public health nurses and social workers. These public health/social services estimates are considered conservative (low) by many field people, but because of the ill-defined nature of this estimate, such a conservative approach is warranted. Caseloads for the Motor Vehicle Department are arrests for alcohol-related charges. Cost figures for handling these caseloads are imputed from current department budgets.

Table 1

ANNUAL ALCOHOLIC CASELOAD AND ESTIMATED COSTS FOR THE MAJOR AGENCIES IN THE REGION

Agency	Caseload	Costs
Mental Health	2,368	$ 660,000
Corrections	1,358	$1,876,000
Public Health and Social Services	1,760	$ 486,000
Motor Vehicles	10,947	$ 394,000
Total		$3,389,000

Major efforts currently performed by the Mental Health Department Alcoholism Programs are in this third or problem drinker handling phase. Department managers needed a tool by which modifications to these programs could be evaluated. Two simulation models of the handling system were developed to provide this capability. A conversational summary model was developed to provide managers with a rapid assessment of alcoholism program modifications. The conversational input designated the appropriate data set for areas within the region and provided the selected program options. The output is presented in the form of a clinic report listing costs and performance measures up to five years in the future. This model is designated the executive's model. The second model, designated the experimenter's model, is comprehensive in detail and is used to provide a versatile laboratory for system manipulation. A full range of alternative paths for handling individual drinking behavior is included. Most statistics on internal system performances are available, e.g., queue lengths, average time in queue, paths followed, etc. Statistics derived from the experimenter's model are used in the executive's model. The following two sections describe the models.

III. The Executive's Model

A. General

The executive's model simulates the aggregative operations of the major components within the problem drinking handling system. In addition, the local mental health alcoholism operations are simulated at a micro level, i.e., the simulation is conducted on an individual basis. The model is resident in a time-sharing computer (Call-a-Computer GE 265), is written in a modified FORTRAN, requires 53,200 characters of disk storage and requires approximately one minute of CPU time to simulate one year of local operations. Conversational inputs provide a means of user interaction to determine the impact of various program alterations both in terms of cost and performance. A general representation of the simulation is presented in Figure 2, "The General Sequence of Events in the Executive's Model."

B. Options in the Conversation Input

The user-machine conversation begins with a computer query as to which area is to be simulated (the mental health region is partitioned into eight local autonomous areas). This causes selection of an appropriate data set for the simulation. Then the user is asked to specify which options are to be included in the simulation. These options include:

1) Addition or deletion of local staff personnel.
2) Provision of a "half-way house" capability for those individuals needing structured living arrangements.
3) Increase or decrease in the estimated population by a given percent.
4) Use of a regional alcoholic rehabilitation center by a certain percent of those patients that normally would go the regional mental hospital.
5) Rerouting of certain types of alcoholics from the corrections system into the mental health system.

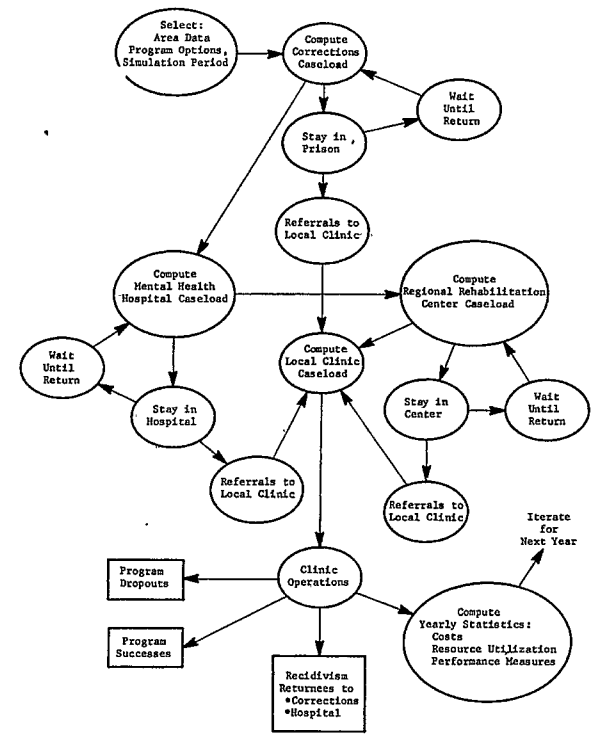

Fig. 2. The General Sequence of Events in the Executive's Model.

6) Budgeting a given amount of money for early detection programs.

The user then indicates the length of the simulation period; the maximum period allowed is six years.

C. Model Processes

The simulation process begins by computing the caseloads for both the corrections system and the mental health hospital. These computations, based on regression equations derived from region data, are summarized in Table 2. The computed caseload figures are incremented by returnees to those institutions from the local clinic operations. The regional hospital caseload is decremented by the number of detoxification cases performed within the local clinic.

A ratio of mental hospital caseload to local clinic caseload is derived from program data. The local clinic caseload is then computed from this ratio and the mental hospital caseload. A record is generated for each individual represented by this caseload, and stored in this record are values for the month of initial visit, diagnosed severity of drinking problem (a three level classification based on program data), point of initial contact with the system and an effectiveness measure for the rehabilitation program computed during clinic operations simulation. This record is then placed in a queue to await processing through simulated local clinic operations.

Monthly clinic operations are simulated by removing each record from the queue whose date of initial visit is not greater than the current month. Both the type and amount of resources used by this individual are computed and these values accumulated. The probability of using any resource and the average amount used are stated in the data set for the local clinic. An effectiveness index is computed for each simulated individual based upon clinic services used and is added to a weighted value of the previous month's index. Based upon the individual's time in the system and his effectiveness index, his record may be removed because (a) he is cured (long time, high effectiveness), (b) he is a dropout (low effectiveness), or (c) he exper-

Table 2

CASELOAD EQUATIONS USED IN THE EXECUTIVE'S MODEL

Monthly Corrections Caseload

$$CL = C_1 \{.015\ P(i,1) + .002\ P(i,2) + 14\}\ S(j) + C_c(m)$$

C_1 - Proportionality constant

$P(i,1)$ - Number of farmers in the area for year i

$P(i,2)$ - Number of males in the area for year i

$S(j)$ - Corrections seasonal adjustment factor for month j, $1 \leq j \leq 12$

$C_c(m)$ - Returnees from local clinic operations and from previous incarcerations for month m of the simulation

Monthly Mental Health Hospital Caseload

$$ML = M_1 \{.026\ P(i,3) + 17\}\ M(j) + C_m(m)$$

M_1 - Proportionality constant

$P(i,3)$ - Number of professional and technical employees in the area for year i

$M(j)$ - Mental Health Hospital seasonal adjustment factor for month j

$C_m(m)$ - Monthly correction for month m; incremented by returnees from the local clinic or previous hospital stays and decremented by detoxification programs at local level

Monthly New Clinic Patients (Not Referrals From Corrections or Hospital)

$$LCL = ML \cdot R \cdot SG \cdot EF \cdot G(i)$$

ML - Monthly mental health caseload

R - Ratio of local clinic spontaneous patients to mental health hospital caseload for the area

SG - Increasing staff effectiveness, an increasing function of time of the form $\{S - e^{-t/2.4}\}$ where S is the new staff level and t is the time since the new staff member was added

EF - Early detection program effect, an increasing function of early detection budget of the form $\{2 - e^{-EB/4}\}$ where EB is the early detection budget in thousands of dollars

G(i) - The planned expansion of local clinic operations for year i

iences recidivism. In the latter case, transition probabilities from the clinic to other components of the total system are used to determine the simulated individual's next appearance.

Based upon accumulated statistics, the basic operational costs for the local clinic, the hospital, and the corrections system are computed.

D. Model Outputs

A report is generated for each simulated year that summarizes costs, caseload characteristics, and resource utilization. In addition, two measures of program effectiveness are included: (a) the number of cases of recidivism and (b) the number of days that individuals are out of the community either committed to the regional mental hospital or incarcerated in the corrections system.

A typical set of curves based on results from two model runs are presented in Figures 3 through 5. In these figures, one curve represents the estimation of conditions under the program currently implemented. The second curve indicates the effect of (a) additional staff, (b) incorporation of a half-way house, (c) referral of first offenders from corrections to the local clinic, and (d) emphasis on early detection. These results are based on data for a four-county area in the region.

IV. The Experimenter's Model

A. General

The experimenter's model also simulates the problem drinker handling system but does so in a detailed comprehensive manner. The basic elements simulated in this model are indicated in Figure 6, "Major Elements of the Experimenter's Model." The actual steps simulated in one of these elements are shown in Figure 7, "Events in the Legal Activity Element," which affords some indication of the level of detail reproduced.

The computer program for this model uses a special simulation package (GPQS) which is a pre-processor for FORTRAN,[3] requires 175,000 bytes of core storage in an IBM 360/75 and requires one minute on the 75 to simulate a sample drinker population of 2,000 for one year.

B. Model Processes

The problem drinker handling system is conceived to be a multi-queue system. Individual drinkers are processed through multi- and single-server activities until the behavior reaches a state that is tolerated. The five basic activities (see Figure 6) are:

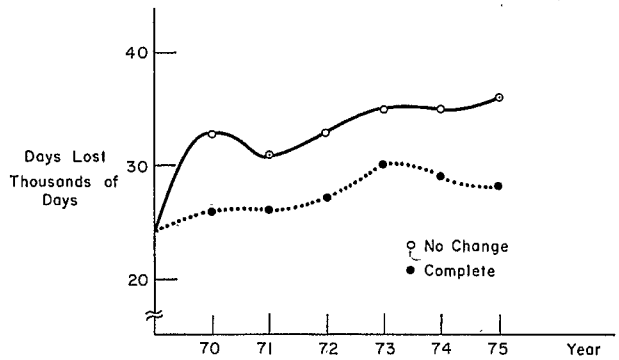

Fig. 3. Days Lost Under Two Programs.

Days Lost - days in which individuals are out of the community either in prison or the mental health hospital.

1. Legal. Those processes and resources that are used in legal detection, trial and retention.

2. Detoxification. Those processes and resources that are used in immediate medical detoxification.

3. Individual. Those processes and resources that are used in providing therapy to the individual drinker. Included here are psychiatric, counselative, supportive, and vocational rehabilitation services.

4. Family. Those activities in which the drinker's family are provided with counseling in the nature of the problem.

5. Community. Those activities to provide structured living arrangements in the community (e.g., a half-way house).

The mean rate of problem drinker generation is supplied as input data. Generated according to a Poisson distribution, each drinker is first assigned a label denoting severity of the drinking problem and secondly a detection source. The detection source indicates who initially "routes" the drinker into the handling system. The detection source is a function of the severity and certain social-demographic characteristics (for example, low income males are more apt to be tolerated by the family, not seek aid, develop extensive drinking problems, and finally be detected by legal authorities).

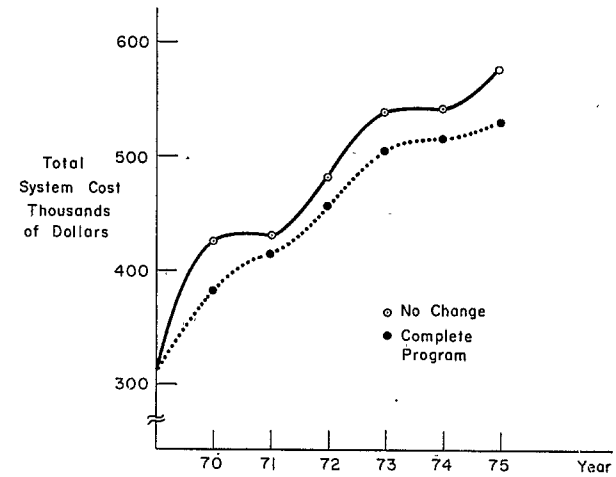

Fig. 4. Total System Cost for Two Programs.

Total System Cost - the sum of local clinic, mental health hospital and corrections costs.

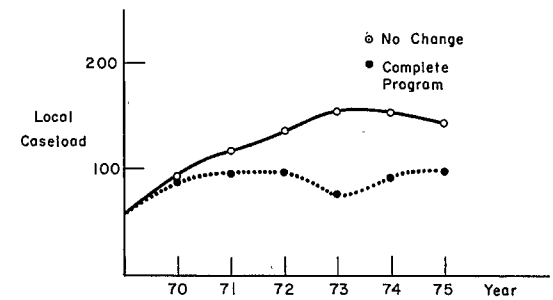

Fig. 5. Local Caseload Under Two Programs.

Local Caseload - each patient entering the clinic for a treatment/rehabilitation series.

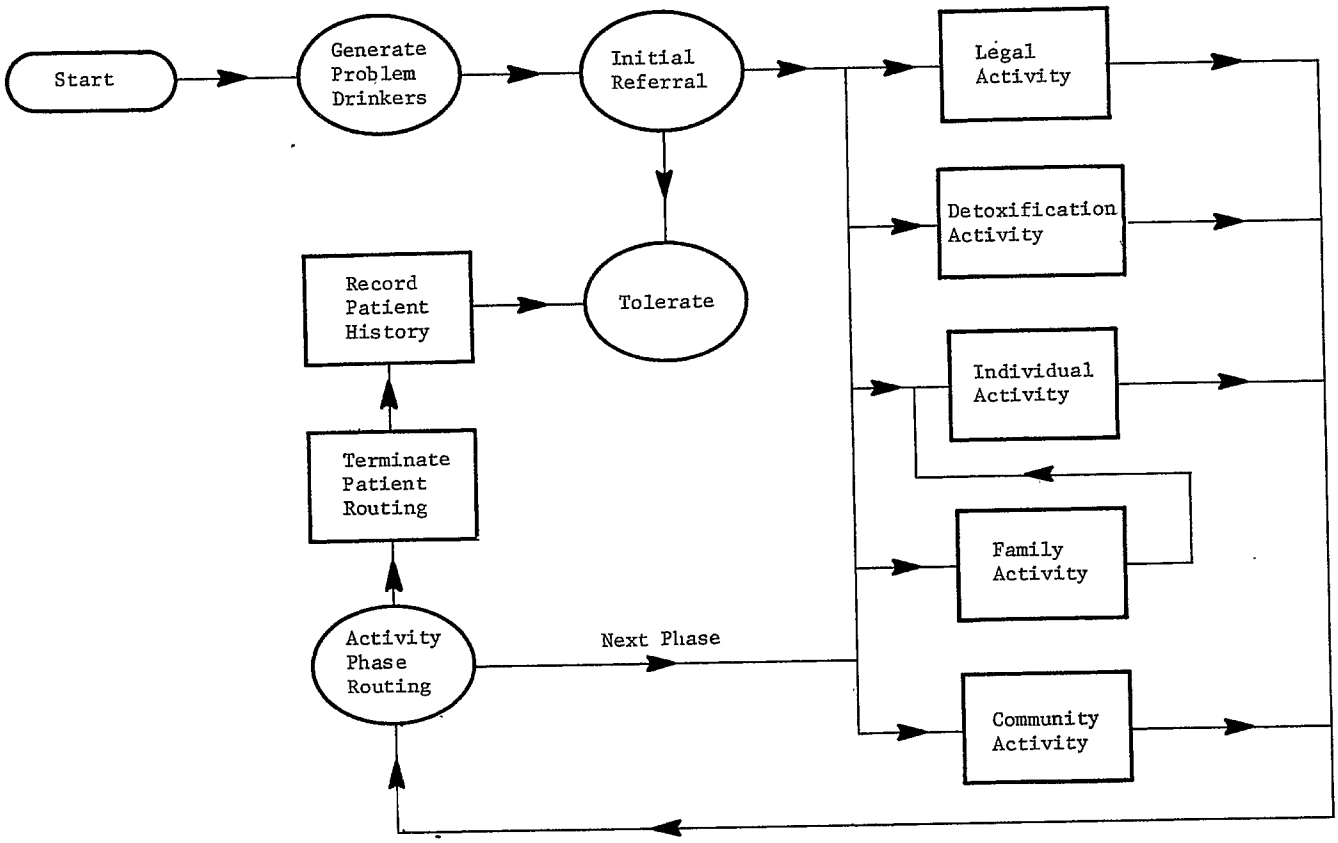

Fig. 6. Major Elements of the Experimenter's Model.

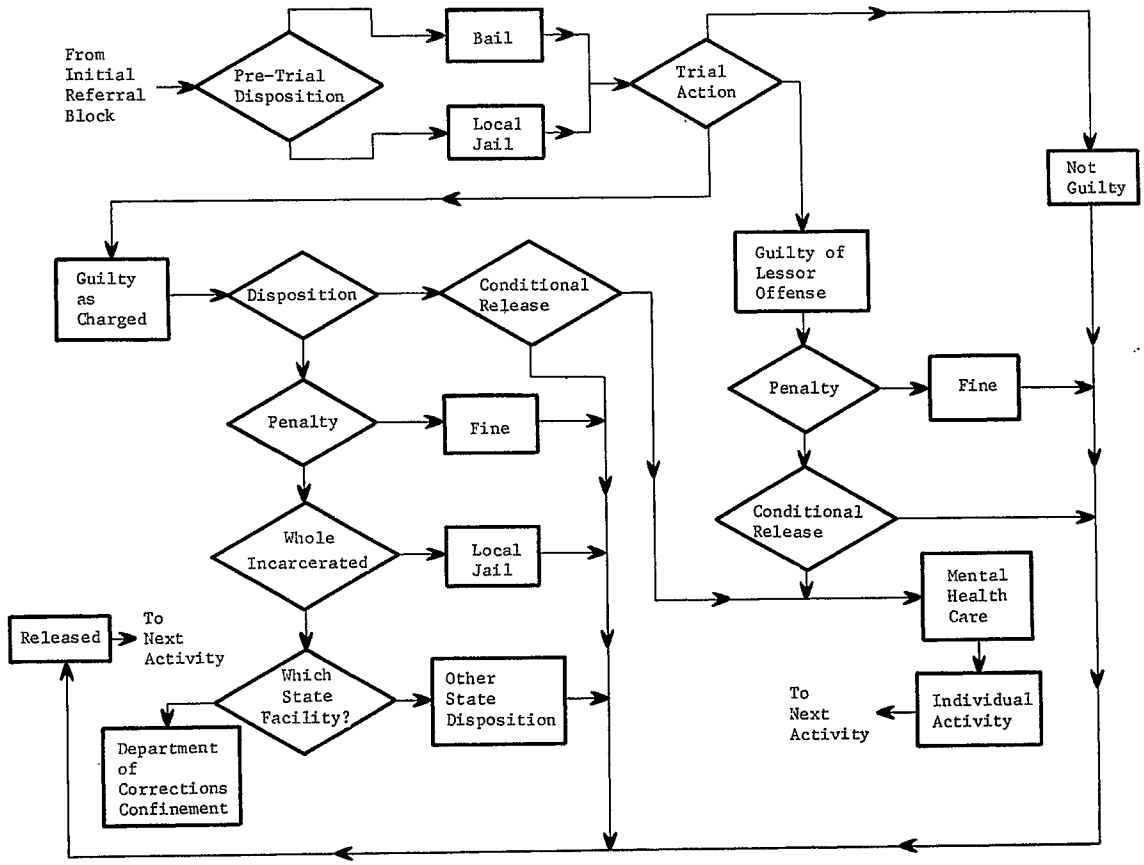

Fig. 7. Events in the Legal Activity Element.

Given the source of detection and behavior characteristics, the routing through the system is determined by probabilities assigned to the various branching points. For example a patient that has been drinking for 20-30 years with prior rehabilitation center treatment is likely to use the regional detoxification facility frequently. The low social class chronic alcoholic who uses the legal system or who is continuously in the legal system, will continue to use this means of being detected and processed through this element of the response system. These transition probabilities from activity in one period to the same or another activity in the next period are used in the activity phase routing element to control the processing experienced by the individual drinker.

The processing within each activity phase is similar, although each activity has its characteristic times and costs. Processing involves determining the length of time spent in the activity (in days) and the contact time between the drinker and system personnel. The utilization of activity resources are computed and accumulated. This utilization or cost is based upon given treatment or work units where the unit is defined in the input data. For example, in detoxification involving inpatient hospital medical care, a unit of resource utilization will involve personnel and facilities required for a patient day. Activity within a block is generally performed in terms of a multi-serving type process, although some activities are simulated as single servers.

An individual continues moving through the activity maze until he reaches an absorbing state--one of the alternatives contained in the routing transition probability matrix.

C. Model Outputs

Extensive output reports are generated to record simulated operations. These include:

1) Routing Activity Summary - summary of all block activities in terms of patients processed.
2) Cycle Travel Time - travel times through the various activities on an individual and a system basis.
3) Cycle Costs - resource costs both in terms of individual and system contributions.
4) Cycle Effectiveness Units - the effectiveness of system personnel contact with patients summarized by drinker type and by activity phase.
5) Phase Activity - time and resource utilization summarized by activity phase.
6) Patient Description - problem drinker characteristics of the simulated individuals including type, prognosis, sex, age, and last activity phase encountered.

Interpretation of these output reports is time consuming, and most investigations require several runs with varying input data. The summarization of the output from this model and its inclusion in the interactive executive's model are considered mandatory for use in management decisionmaking.

V. Model Validity

Data used in these models are derived from the local clinic operations, from State statistics, and from national sources. The goodness of the data covered the full range from highly reliable to marginally acceptable. Since the local operations began recently (a maximum of two years data), there are minimal data for model development and less for validation. Model results for both general operations and internal details appear reasonable, and they do replicate the data used in their development.

These models are used in predicting future program costs and performance. Basic to these predictions are estimates of future populations in the region. The population projection technique used for these predictions has been checked against the 1970 census and found to be acceptable.

Finally, these models are incorporated in the larger adaptive system for alcoholism program evaluation and planning within the Department of Mental Health. Part of this system is a feedback information activity that will provide a basis for judging the accuracy of model predictions, for determining the necessity of re-estimating model parameters and, if needed, for providing the data for the re-estimation. These intended efforts should insure a high degree of long-term model validity.

VI. Model Acceptance

Only the executive's model has been introduced to department management. This was accomplished by, first, a half-day seminar that ended with each area manager simulating his activities for some future period. Initial reactions and criticisms were noted and modifications made where possible. The model was then used by each area in detailed planning sessions to prepare plans and budgets for the next five years. Acceptance of the model has proceeded from the initial novelty stage to a beginning realization of its potential as a planning tool.

VII. Conclusion

The usefulness of simulation as a planning tool has been demonstrated elsewhere.[4] In this study, two simulation models were incorporated in a system analysis/synthesis to provide Mental Health Department managers with a tool for planning-budgeting operations. The use of a conversational summary model for interaction with management promotes a maximum use of the results produced by the analysis imbedded in the comprehensive model. Such a two-model approach overcomes certain difficulties arising in understanding large modeling efforts since the manager-user, with a minimum interaction timewise, acquires an internalized acceptance of the results--these results are both given in familiar budget and performance terms and are immediately responsive to the user's manipulation of decision variables.

Acknowledgments

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