

EXECUTIVE SUMMARY
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I. INTRODUCTION

On March 6 and 7, 1980, the Division of Biometry and Epidemiology, National Institute of Mental Health, in conjunction with the Health Applications Section of the Operations Research Society of America, sponsored a meeting on "Operations Research and the Mental Health Service System." The basic purpose was to bring together a group of leaders in mental health services research and health operations research to develop a coherent and rational set of research priorities in the interface of these areas. Participants made presentations on the major areas in mental health services research (MHSR), assessed the state of our knowledge related to operations research (OR) methodologies and their uses in health services research, and identified promising areas in the future of OR contributions to MHSR.

Although there are many promising areas for OR in MHSR, the meeting focused on four major areas:

1. Modeling of need, demand, and utilization in MHSR;
2. Modeling and conducting program evaluation in MHSR;
3. Modeling resource allocation in MHSR; and
4. Modeling large-scale system interactions of the mental health sector with other major societal sectors, such as the general health care system, the criminal justice system, and the financing system for health.

These areas were chosen because they are significant in understanding the problems and systems aspects of MHSR, and also because OR has made some contributions to this area and similar areas in the general health care system. Papers were presented in each area. After presentation of the paper, two or three discussants addressed issues in the paper, raised new issues, and helped clarify the role of OR in MHSR in regard to these issues.

II. GENERAL CONCLUSIONS

Operations research as a paradigm has the potential for aiding decision-makers in improving the planning, management, and operation of the mental health service system and its interaction with other systems. Problems and issues are approached by understanding the system being studied, that is, defining the objectives or goals of concern, the flows of people, the facilities and processes within and outside the system, the inputs to and outputs from the system, and the data needed to develop OR models of the system. A powerful advantage of OR analysis and OR models in MHSR is their ability to provide comprehensive data reduction on complex systems by capturing the

system's logic. After the data are gathered and synthesized and the model of the system developed, OR methodologies are used to aid in decisionmaking processes and in better understanding the dynamics and operation of the system.

These methodologies have been used in many other sectors of the economy, including private industry, military, and government and other public sectors. OR's contribution to the resolution of problems in MHSR is twofold: improved efficiency and effectiveness of the delivery of mental health services, and improved understanding of the mental health system through quantitative modeling of this system and its interactions with other systems.

Because operations research is grounded in quantitative model building and systems analysis, it has limitations. We will briefly point out some limitations before going on to those research areas in which we believe operations research can make a substantive contribution.

First, it may not be possible to build quantitative models in some cases where the important descriptors of the systems involve subjective considerations that are not quantifiable.

Second, the assumptions necessary for the available models may be unrealistic, and it may be extremely difficult to build realistic models for certain problems. For example, optimization models work well only when the decision-makers have identified objectives as well as constraints. Simulation models must also have well-identified transfer relationships in either a probabilistic or a deterministic sense.

Third, data requirements of the models may be far greater than data availability. In this case, implementation of the model would be precluded although indications of need for future data collection would be useful.

Finally, operations research models should be thought of as aids in the decisionmaking process rather than as the decisionmaking process itself.

With these caveats in mind, it is still possible for the paradigm of operations research to be applied successfully to some important problem areas in mental health services research. However, an important point must be made here. Most mental health problem areas are complex and require knowledge from many disciplines for their solution. For OR to have its maximum impact on most of these complex problems, it is essential that, from the very beginning of work on a problem, an operations researcher be an integral part of a team that includes medical sociologists, mental health professionals and administrators, behavioral scientists, economists, computer scientists, epidemiologists, statisticians, and others, as appropriate. No one person can amass sufficient knowledge to handle these problems alone. For example, to quantify what in many cases seem nonquantifiable variables, the interaction of operations researchers with behavioral scientists, medical researchers, and others is needed. However, such interaction must occur at the inception of programs to be useful at a later stage.

As a background to the meeting and as a description of the early work in OR/MHSR, the annotated bibliography compiled by Jack E. Scott (Volume II) has been a valuable aid. A similar activity should be undertaken describing the location and types of available MHSR data. At present, there are some survey reports and scattered information about available data sources. For many models we would like to build, the available data may not be adequate or perhaps may be in the wrong form, and surrogates would have to be used. Furthermore, all current data sets would have limitations in supporting large-scale and sophisticated modeling efforts. Nevertheless, exploratory OR studies in many of the areas discussed later in this volume, and some extensive studies on a national basis and in selected locales, can be undertaken with existing data. Consequently, an inventory of existing data and their actual and potential use should be prepared soon by or with an operations researcher. It also may be useful to develop a portable data base from both the NIMH research projects and the research projects using mental health data made available by various agencies of the Department of Health and Human Services. This data base could be made available at cost to all researchers interested in OR/MHSR problems.

According to meeting participants, if a research program in mental health services research is to be effective through NIMH's Division of Biometry and Epidemiology, there should be an operations researcher on the research grant study section. The study section needs such a member to help evaluate proposals with OR content.

III. SPECIFIC RESEARCH ISSUES FOR OR/MHSR

Meeting participants discussed many research issues lying at the interface of operations research and mental health services research. These issues involved using OR approaches for system understanding, system description, model building and decisionmaking, policy analysis, and decision support systems activities considered traditional aspects of OR studies. Some less traditional and somewhat surprising activities suggested were assessment of patient needs and the relative importance of program objectives. These latter activities could be undertaken jointly with research team members from other disciplines.

A. Modeling Need, Demand, and Utilization in MHSR

Any examination of the mental health service system begins with an analysis of the concepts of need, demand, and utilization. In the present context, utilization refers to the provision of service to a client. Demand represents the expressed desire of a client for services. Need refers to the presence in an individual of a pathological condition amenable to treatment. The latter concept of need is most often considered an epidemiologic concept, while demand for and utilization of services are considered to fall within the province of health services research. The major question is, What models can accurately describe and relate need, demand, and utilization of mental health services? It is important to note the interrelatedness of these three concepts, because

changes in the mental health service system that affect demand and utilization may induce major shifts in needs for services. The major challenge for OR is identification and development of models that can accurately describe and interrelate need and demand for and utilization of mental health services. Operations research, in conjunction with other disciplines, can make significant contributions in assessment of methodologies and in the characterization of the relationships between need, demand, and utilization.

The results derived in this area will provide basic data and modeling inputs for the work on program evaluation, resource allocation, and large-scale systems interactions. Consequently, the data and models not only must be appropriate for the decisions of interest later but also must be clearly specified with regard to the definitions used and the interrelationships discovered. Fortunately, NIMH has recently completed a study of the definitions of mental disorders, and it is available in the Diagnostic and Statistical Manual of Mental Disorders (Third Edition, 1980).

In addition, epidemiological studies on incidence and prevalence of many mental health diseases have been completed or are under way. These studies describe the medical need for mental health services. There are still major questions relating the demand and utilization of mental health services to need. As in all health care, utilization depends not only on incidence but also on such constraints as reimbursement mechanisms, accessibility, quality of care, and an often ill-defined relationship between treatment and outcomes (i.e., cause-and-effect relationships in the treatment setting). When collecting data on demand and utilization, we usually deal with existing programs and institutions. Consequently, the data are confounded by such factors as censored samples, very long periods to achieve steady-state conditions (after 3 to 10 years in certain chronic care settings), and the difficulty of separating the underlying stochastic mental health process from the transient effects of policy changes in the system. Some of the modeling techniques and systems analysis methods of OR may prove useful in understanding these relationships.

Participants at the meeting discussed these and other aspects of need, demand, and utilization. Some of the major research projects suggested by participants for applying operations research follow.

1. Build general OR models of demand and utilization involving such factors as reimbursement regulations, accessibility, available manpower, facilities and programs, general health treatment centers, and demographic trends.

The following OR methodologies could be considered: analysis of variance and regression, cluster analysis, marketing assessment, econometric models, time series models, Markov or deterministic flow models, subjective probability models built in delphi or nominal group-process techniques, and multiattribute utility models.

2. Use mental health definitions of specific diseases and epidemiologic studies of incidence and prevalence to assess the level and variability of demand (perhaps its probability distribution across the population and across

time) at various entry points in the system. In this way, researchers can determine bottlenecks for potential new programs or policies. OR methodologies of interest are parametric network flow models, which would relate medical need to demand and to utilization, and statistical and probabilistic models of causal and/or distributional relationships. Monte Carlo simulation would be of great use.

3. Assess the utilization of chronic care mental health facilities. OR models are needed to handle superimposed transient and long-term patients and the effects of changing policies, such as deinstitutionalization. Some methodologies of interest are Markov models and simulation.

4. Assess the use, validity, and cost of hybrid models that measure the interacting components of need, demand, and utilization. Many of the above-mentioned methodologies, as well as cost-benefit and cost-effectiveness methods, are applicable.

5. Build a long-term data collection system to meet needs for decision support. There are needs for management information systems, decision support systems, and knowledge of the man-computer interface, in addition to some previous methodologies.

6. Build resource consumption models based on case mix and severity measures for utilization research. Resources consumed are the manpower, facilities, technologies, and supplies used to diagnose and treat the disease. OR methodologies involve patient-flow models, resource consumption grouping models, and simulation.

OR researchers should work with mental health researchers, epidemiologists, and behavioral scientists to form the definitions of medical need, demand, and utilization appropriate for later models of resource allocation and large-scale mental health system interactions. The required data for these descriptive and decision models may require different definitions for different purposes. For example, "need" may at times include physician-defined medical need and at other times patient-defined need (possibly not medical), because each has different utilization relationships.

B. Modeling and Conducting Program Evaluation in MHSR

As noted in the preceding section, there are complex relationships among need, demand, and utilization, as well as among diagnosis, treatment, and outcome, that are not understood well. How then should we go about assessing and understanding the effectiveness of mental health services? How do we evaluate the relationship between treatment and outcome?

The mental health literature contains examples of attempts at conceptual models of program evaluation. Most of the approaches and designs in studies of program evaluation, however, have used experimental or quasi-experimental models of defined client populations. Classical experimental design (such as

the analysis of covariance with randomized treatment) has been useful in many studies in agriculture, health, and industry. But even in these settings it is essentially a two-fixed-point observational approach (pre- and post-treatment) and does not capture the intermediate dynamics of change.

In many cases, these dynamics are not important. In mental health program evaluation, however, the dynamics most often provide critical insight into the value of programs. Furthermore, given the current reluctance to deny potentially helpful treatment to individuals, the controlled clinical trial implied by the classical design is difficult to justify if one treatment is presumed to be superior. One way around this difficulty is to use quasi-experimental designs, but the statistical validity of conclusions may suffer from lack of randomization. Neither does this approach capture the dynamics of the treatment-outcome process. (Situations exist, however, where the experimental or quasi-experimental design models are appropriate and effective.)

Models that capture the dynamics of the stochastically changing treatment-outcome process are coming into greater use. These models measure the (usually probabilistic) flows of patients. Markov, semi-Markov, and simulation models are the most commonly applied. The data requirements may be great because the movement of patients between states must be accurately measured. The participants at the meeting discussed these and other aspects of mental health program evaluation. The following research goals were suggested:

1. Define clearly the objectives of any program to be evaluated. The OR researcher, in conjunction with mental health researchers, behavioral scientists, administrators, government executives, and legislators, must know clearly what is to be achieved with whom; otherwise, the program will be difficult or impossible to evaluate. This should be done at the start of the program. Useful OR methodologies are delphi, nominal group technique, priority weighting, conjoint analysis, and other multidimensional scaling techniques.

2. Study the cause-effect relationships between diagnosis, treatment, and outcome. OR should work with mental health researchers in the development of severity indices and multidimensional measures of outcome by different treatment modalities and locales. Essentially, this work is defining the flow of patients through a stochastic process and all the possible states at each stage (beginning, intermediate, and final). The OR methodologies that could be used are Markov and semi-Markov chains or processes. Subjective probability estimating techniques could be extremely useful here.

3. Develop data systems, including data collection and management information systems structured efficiently for regular periodic recording and, usually, computerization. If possible, patient tracking or linkage across the general health system and other social systems should be entered into the data base. OR methodologies to be used are decision support systems, including management information, validation, and computer file structuring systems.

4. Define the linking of a sufficiently broad battery of program performance and patient functioning measures for a thorough program evaluation. It

is necessary for the OR researcher to be a member of a multidisciplinary team for the construction of scales. OR methodologies listed in items (1) and (2) are applicable here for the mental health aspects and cost aspects using accounting and financial management measures and techniques.

5. Develop stable baseline transition matrices that represent the epidemiology and natural history, in a medical sense, of mental disorders against which to measure change. This work closely relates to item (2). If we can develop such matrices, there is less need for the clinical trials approach to program evaluation. If a new program for a given disease, severity, or other factors has a different set of transition probabilities, inferences about the program may be drawn. It should be noted that for many mental disorders there may not be adequate data for estimation of stable baseline transition matrices; however, it may be feasible for a few mental disorders, e.g., schizophrenia. OR methodologies of interest involve the use of observation and statistical analyses by means of "intensive" or "extensive" design. Basic statistical research is also needed in the area of covariate adjustment in stochastic processes.

6. Investigate ways to handle the missing data problem from partial or incomplete patient-flow observations. A similar problem exists with aggregate data analysis when all that is known is the proportion of a cohort visiting in a certain state at a given time. OR methodologies of interest draw from statistical inferences and from sensitivity analysis.

7. Conduct parametric analysis on the transition matrices and other coefficients in the models. Useful OR tools are simulation, topics from mathematics such as analysis and topology, and statistical analysis of the variation in estimated parameters. Subjective estimates and expert opinion may prove useful here also.

8. Investigate macro approaches to overall system or program evaluations before making decisions to implement, terminate, or replicate programs. A very useful OR methodology for this purpose is decision analysis with objective or subjective bayesian estimates of the probabilities involved. This approach could be combined with a deterministic flow model in the decision process.

9. Investigate the cost-effectiveness and applicability of experimental, quasi-experimental, stochastic process, and decision analysis or process models for use in program evaluations. What are the objectives, decisions, information needs, and constraints that make one model more appropriate than another? This research involves an evaluation of the program evaluation methodologies in various MHSR contexts themselves.

C. Modeling Resource Allocation in MHSR

Modeling resource allocation decisions in MHSR require as inputs the results from need, demand, and utilization research, and both inputs and state-variable output of the program evaluation. Much of the data collection,

patient-flow, and outcome-measure research efforts suggested in the previous section must be developed with an appreciation of how this information will be used in resource allocation decisions. Too often, the work done and the data obtained in one research area are not useful in another, but could have been if they had been given prior thought. The interaction of other research and data sources becomes most apparent in the resource allocation area.

The major question addressed in this section is the determination of the resource mix (facilities, programs, and manpower) that will deliver the most effective array of mental health services to a community, State, and Nation. Although some of the constraints on and objectives of mental health services are easily modeled, many behavioral, social, and political constraints and objectives require a great deal of basic research. Because of multiple objectives and "binding" versus "fuzzy" constraints, the modeling of resource allocation (although in many cases straightforward) presents some interesting and difficult research issues. Short-term operational and long-term planning models useful in mental health services must be defined and assessed. These models are needed at the institutional level and, perhaps more importantly, at the regional, State, and national levels. Much of the funding of mental health services and new programs comes from the State and Federal level and is influenced by overall planning and allocation of funds. Thus, models are needed to provide these allocations in the most cost-effective manner with appropriate consideration of access to and quality of availability of mental health care.

What has been missing to date is a clear understanding of which decisions are important at each level, who the decisionmakers are, what are the criteria and objectives controlling their decisions, and what types of models best support these decisionmaking processes. To aid decisionmaking, we must develop easy-to-use interactive computer programs that automatically access appropriate current data bases, produce useful management information, flag potential problem areas, and make recommendations for resource allocations. Some of the research goals and methodologies for resource allocation suggested at the meeting follow:

1. Describe the existing system by looking at the flow of resources (facilities, programs, manpower, dollars) in mental health care at the local, regional, State, and national levels. Also, determine the types of decisions that allocate the greatest proportion of funds and have the greatest potential for health impact. This systems analysis work will lead to the development of objective functions, constraints, and transfer functions needed later. A considerable amount of data already exists, particularly at the Federal level, although the relevant material must be coordinated and understood.

2. Build models to aid in decisions at the Federal level concerning the allocation of funds to direct and indirect care (services, treatments, facilities, programs) and research and demonstration. Appropriate OR methodologies are mathematical programming, simulation, scheduling, and hybrid models.

3. Model the manpower needs by specialties with regard to the allocation of funds at the Federal level for training and education and services for the

disadvantaged. This also involves determining the appropriate mix of manpower categories for the needs, demands, programs, and institutions developed in the preceding areas. Useful OR methodologies are forecasting (time series, regression, subjective estimation), mathematical programming, and Markov decision models.

4. Model the optimal mix of Federal, State, and regional resources between prevention and treatment sectors of mental health services based on objectives, constraints, and transformations discussed in item (1). Here again, mathematical programming, simulation, input-output, and econometric models would be useful.

5. Conduct more basic OR research in large-scale multiobjective programming with application to MHSR. Basic methodologies needed here are mathematics, statistics, computer science, and the theoretical background areas of OR.

6. Collect and evaluate the resource allocations and consumption regarding the hundreds of Health Systems Agencies plans in the country. (This effort also fits into item 1 above.)

7. Model the optimal resource needs and allocations at the State level among inpatient long-term and acute psychiatric care, community mental health centers, nursing homes, and other institutional and noninstitutional settings. This modeling should consider the optimal mix of Federal, State, regional, and local funding of this care. OR methodologies are mathematical programming, simulation, and Markov decision processes.

8. Build planning and allocation models for State, regional, and local manpower and facilities. The models should parallel those discussed in item (7) and could use the same OR methodologies as well as forecasting models.

9. Construct on a more micro and detailed level, local and regional planning models of items (7) and (8), using similar methodologies.

10. Build interactive support models for operating ongoing programs or institutional systems. These models would do patient and personnel scheduling and allocation, facility location and sizing, inventory management, diagnostic decision aiding, and treatment protocol management. Case studies might be useful here before construction of a model. Many of the previously mentioned methodologies, as well as decision analysis, subjective probability analysis, and other behavioral techniques, could be useful. Some of these types of interactive support models are currently being used in general acute health care institutions.

D. Modeling Large-Scale Systems Interactions

A major task facing many mental health planners is how to conceptualize, organize, and operate a mental health care system that can provide cost-effectively the full range of services required by the Nation. To accomplish

this comprehensive goal, it is imperative that the mental health planning efforts emphasize the importance of increasing interaction and interdependence among government agencies, other service delivery organizations, and the people needing, providing, and financing the care.

The major question in this section is, What is the nature of the interdependence of the mental health service system and other social service systems (e.g., criminal justice, general health care, alcohol and drug abuse, and education)? It has been clearly demonstrated that some individuals with mental disorders are often not seen over long periods of time in the specialty mental health sector, because they tend to use the general health care system and other social systems. Indeed, there is evidence that persons with mental disorders who also use the general health care sector utilize it twice as intensively as patients not diagnosed as having mental disorders. Characterization of these interactions between large-scale systems is extremely important in view of certain current trends in health care services in the United States. In addressing such issues as national health insurance and the increasing size of the privately funded mental health service system, it is particularly important to model large-scale systems interactions.

Data needed for modeling large-scale systems interactions may be difficult to obtain, however, because of the complex way patients move through the various systems. Movements, treatments and outcomes, and the budgetary facilities and provider personnel define the transformations and interactions among the systems. If it is possible to define these macrolevel flows, better planning and treatment of mental disorders may be possible. Important dynamic trends (and, possibly, cycles) of health care services also affect the delivery of mental health care. Many of these trends are characterized in table 1.

These trends have strong effects on the specialty mental health sector--state and county mental hospitals, private mental hospitals, hospitals with psychiatric units, community mental health centers, private practice psychiatrists and psychologists, and other mental health treatment centers and providers. They also affect the general hospital, nursing home, and primary care sectors; other human services and social sectors; and the criminal justice, education, and welfare sectors. As a result, of course, the budgetary and resource allocation policy and decision processes are affected.

To improve policies and decisions, research is needed to understand these large-scale systems interactions. Smaller research projects would perhaps have a higher short-run payoff in ability both to understand and to affect decisions in the mental health system. Large-scale mental health system models or models of interaction with other systems would be costly to develop. Although these latter models are essential for total system understanding (and have been suggested by others over the past decade), they involve a large commitment of funds and a highly skilled team of people who can work together on large projects.

Similar large-scale systems are available in the U.S. Department of Energy, the military, and private industry. These have been developed at the

Table 1. Important recent trends for U.S. health care services

STRUCTURAL DELIVERY SYSTEM CHANGES

Long-term to short-term
Inpatient to community-based
Increase in general hospital beds
Increase in third-party coverage

DEMOGRAPHIC SHIFTS

Increase in percent and number of aged
Increase in high-risk adolescents

SOCIAL PROBLEM SHIFTS

Increase in crime rate
Increase in alcohol and drug use rate
Increase in divorce rate and family fragmentation

ATTITUDE SHIFTS IN GENERAL POPULATION

Increase in acceptance of mental illness
Increase in interest in informal self-help systems

COST-CONTAINMENT PRIORITY IN PUBLIC POLICY

Increase in emphasis on cost, access, and quality
Increase in high estimates of economic burden of mental illness

expense of many man-years and millions of dollars. For this reason, a good approach would be to build a conceptual framework and conceptual modeling effort for such large-scale systems to understand the data needs, data flows, transformations, objectives, and constraints of the systems as well as the dynamic factors affecting each element of the total system. This first stage would not include building the actual large-scale models themselves. Instead, it would start by building and implementing submodules of specific aspects of the mental health service system itself. Although large-scale system models are needed, the current data base and levels of funding may not be appropriate.

The meeting participants formulated the following research goals:

1. Design large-scale systems flow models of the mental health interface among the mental health sector and other sectors at the national and State level. The decisions would be the policies affecting and affected by the trends in table 1 and the flow of mental health patients into and out of the various sectors. It is necessary to define the transformations and

constraints, including budgetary and reimbursement, and to evaluate different optimal decisions and their consumption of resources for various objectives. OR methodologies of interest are mathematical programming, simulation, systems analysis, forecasting, subjective estimation, Markov decision flow models, and econometric input-output models.

2. Use models of the large-scale system designed in item (1) to build subsystem modules that could interact with or provide input to the macro model. Some of the subsystem modules could come from the models suggested in the preceding sections, and others could come from models built in other sectors, including alcohol and drug abuse, criminal justice, welfare, and education (e.g., schools for the mentally retarded).

3. Provide analysis and evaluation for data collected in the areas of retardation among the various systems. Again, this work should involve an operations researcher to provide the broad systems analysis perspective for future modeling efforts. Pertinent OR methodologies here are systems analysis, decision support systems, and statistical techniques.

4. Build models representing flows or transfers between the mental health sector and one other sector. These models would also be modules for the large-scale system interaction studies mentioned in item (1). Special emphasis should be placed on a model relating the mental health sector to the general health sector. This model is needed because there are many important interactions involving treatment, facilities, personnel, and financing. The OR methodologies in item (1) would also be appropriate here.

5. Conduct research on the implementation and use of large-scale interactions models for planning, policy, and decisionmaking. Evaluate the models' validity, efficacy, and sensitivity to address political and behavioral issues. This work on model validation for decisionmaking is similar to the program evaluation work to be described in the next section, and some of the same methodologies apply. (The DOE is doing much work in this area in regard to large-scale energy planning models.)

6. Investigate the dynamics of primary and secondary effects of the trends in table 1 on the mental health sector. Appropriate methodologies are analysis of variance, regression, feedback flow models, and subjective decision analysis techniques.

IV. CONCLUSION

The mental health services research area is rich in interesting, important topics for research and implementation that lend themselves to the application of operations research approaches and methodologies. This meeting produced a list of research projects in four promising areas important in the interface between operations research and mental health services research. It is hoped that not only researchers in OR and MHSR, but researchers and administrators in the Federal Government--especially the Alcohol, Drug Abuse, and Mental Health Administration and NIMH--and State governments and agencies as well will find

these results useful in allocating some of their efforts to support research and implementation on these topics.