OPERATIONS RESEARCH AND THE MENTAL HEALTH SERVICE SYSTEM

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ABSTRACT

On March 6 and 7, 1980, the Division of Biometry and Epidemiology, NIMH, in conjunction with the Health Applications Sections of the Operations Research Society of America, sponsored a meeting entitled, "Operations Research and the Mental Health Services System." The basic purpose of the meeting 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. The approach taken was a series of presentations of the major areas in mental health services research (MHSR), an assessment of the state of our knowledge related to operations research (OR) methodologies and their uses in health services research and an identification of promising areas in the future of OR contributions to MHSR. This paper is a summary of these findings.

KEYWORDS

Operations Research and the Mental Health Services System.

INTRODUCTION

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

- modeling need, demand and utilization in MHSR
- modeling and conducting program evaluation in MHSR
- modeling resource allocation in MHSR
- 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 are chosen for their significance in understanding the problems and systems aspects of MHSR and because OR has made some contributions to these and similar areas in the general health care system. Papers were presented in each area. Following 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.

General Conclussions

Operations Research, as a paradigm, has the potential for aiding decision makers in improving the planning, management and operation of the mental service system and of its interaction with other systems. Problems and issues are approached by first understanding the system being studied. This means defining the objectives/goals of concern, the flows of people, facilities, processes within and without 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 the ability to provide comprehensive data reduction on complex systems by capturing the system's logic. After the system has been modelled and the data gathered and synthesized, OR methodologies are then applied to provide decision support for system change and/or better system understanding. These methodologies have been used in many other sectors of the economy, including governmental, private industry, military and other public sector areas. OR's contribution to the resolution of issues in MHSR and these other sectors is through the improved efficiency and effectiveness of the delivery of mental health services and also in the use of quantitative models to describe and understand better the mental health system and its interactions with other systems.

However, because Operations Research is grounded in quantitative model building and systems analysis, it also has some limitations. We will briefly point out some of these limitations before going on to those research areas in which we believe Operations Research can make a substantive contribution. First, it may be possible to build quantitative models in some cases where the important descriptions of the systems involve subjective considerations which may not be 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 will work well only when the decision makers have identified both objectives and constraints. Simulation models must also have well identified transfer relationships, either in a probabilistic or deterministic sense. Third, data requirements of the models may be far greater than data availability. In this case, implementation would be precluded. However, indications for future data collection would be useful in this case. Finally, Operations Research models should be thought of as aids in the decision making process rather than the decision making process itself.

With these caveats in mind, it is still possible for the paradigm of Operations Research to be applied successfully to some of the 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. In order for OR to have its maximum impact on most of these complex problems, that from the very begining of work on a problem it is essential an operations researcher be an integral part of the team including 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 significant problems. For example, to quantify, in many cases seemingly non-quantifiable variables, the interaction of operations researchers with behavioral scientists, medical researchers and others, is needed. However, it cannot be over-emphasized that such interactions must occur at the inception of programs to be really useful at a later stage.

As a background to the meeting and as a description of the early work in OR/MHSR, the bibliography by Jack Scott has been a valuable aid. A similar activity should be undertaken describing the location and types of available MHSR data, both present and forthcoming. At present there are some survey reports and scattered knowledge about available data sources. For many models we would like to build,

the available data may not be adequate or perhaps in the wrong form and surrogates would have to be used. Furthermore all current data sets have their limitations at present in supporting large scale and sophisticated modeling efforts. But exploratory OR studies in many of the areas discussed later and some extensive studies on a national basis and in selected locales can be undertaken with existing data. Consequently, at an early date an inventory of existing data and their actual and potential use prepared by or with an operations researcher, would be very useful. It also may be useful to develop a portable data base from the NIMH research projects, as well as the research projects with MH data available from various other DHHS agencies. This data base could be made available at cost to all researchers interested in these OR/MHSR problems.

As a final comment, the meeting participants felt that for a research program in mental health services research to be effective through the NIMH's division of Biometry and Epidemiology, there should be an Operations Research person on the research grant study section. The study section needs such a member to aid in the evaluation of proposals with OR content.

Specific Research Issues for OR/MHSR

The 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 decision making, policy analysis, data availability and decision support systems. These activities are considered as traditional aspects of OR studies. Some less traditional and somewhat surprising activities suggested by OR attendees were assessment of patient needs and the development of the relative importance of program objectives. These latter activities could be undertaken jointly with research team members from other disciplines.

Modeling Need, Demand, and Utilization in MHSR

The definitions of need, demand and utilization used here are: "utilization" is the provision of a service to a client; "demand" is the expressed desire of a client for services; and "need" is the presence in an individual of a pathological condition amenable to treatment. This last item is a definition of a medical need; there is also the case with all three definitions, where the individual perceives a condition which may not be pathologically present. This latter also has implications for resource consumption and allocation. The major question of interest in this area is what models can accurately describe and relate need, demand and utilization of mental health services? The first subject, need, is most often considered as an epidemiologic problem, and the latter two, demand and utilization, as health services research. However, they are obviously related. Consequently any mental health system changes which affect demand and/or utilization may induce major shifts in unmet needs to a demand for services. OR, 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.

It is important to note that 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 must not only be appropriate for the decisions of interest later but must be clearly specified with regard to the definitions used and the interrelationships discovered. Fortunately NIMH has recently completed a significant study of the definitions of mental disorders which is available in DSM III. In addition, data from epidemiological studies on incidence and prevalence of many MH diseases have been completed or are underway. These studies illuminates the medical need for MHS. There are

still major questions relating the demand and utilization of MHS to need. As in all health care, utilization depends not only on incidence, but also on constraints such 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). In collecting data on demand and utilization, we usually deal with existing programs and institutions. Consequently, the data is confounded by such factors as censored samples, very long periods to achieve steady state conditions (after 3-10 years in certain chronic care settings) and the difficulty of separating the underlying stochastic mental health processes from transient effects of policy changes in the system. Some of the modeling techniques and systems analysis methods or OR may prove useful in understanding these relationships.

The participants at the meeting discussed these and other aspects of needs, demand and utilization. Following are some of the major research topics which were suggested:

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 data.

Some OR methodologies which could be considered are: analysis of variance and regression, cluster analysis, marketing assessment, econometric models, time series models, markov or deterministic flow models, subjective probability models built on delphi or nominal group process techniques and multi-attribute utility models.

2. Based on MH definitions of specific diseases and epidemiologic studies of incidence and prevalence, assess the level and variability of demand (perhaps its probability distribution) at various entry points in the system by intensity and case mix in order to determine bottle-necks 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 distribution relationships. Monte Carlo simulation would be of great use.

3. Assess the utilization of chronic care MH facilities. OR models are required, which 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 which measure the interacting components of need, demand and utilization. Many of the above-mentioned methodologies are applicable as well as cost-benefit and cost-effectiveness methods.

5. Build a long term data collection system for decision support requirements. In addition to some previous methodologies, management information systems, decision support systems and man/computer interface knowledge is required.

6. For utilization, build resource consumption models based on case mix and severity measures...these resources consumed are the different manpower, facilities, technologies, and supplies used to diagnose and treat the disease. OR methodologies involve patient flow models, resource consumption grouping models and simulation.

In each topic OR researchers should work with MH researchers, epidemiologists, and behavioral scientists to help form the appropriate definitions of medical need, demand, and utilization appropriate for later models of resource allocation and large scale MH system interactions. The required data for these descriptive and/or decision models may very well require different definitions for different purposes. For

example, "need" may at times include physician defined medical need and at other times patient defined perceived need (possibly not medical) because each has different utilization relationships.

Modeling and Conducting Program Evaluation in MHSR

As noted in the section on need, demand and utilization, there are complex relationships which are still not well understood among these variables as well as the relationships among diagnosis, treatment and outcome. How then should we go about the assessment and understanding of the effectiveness of mental health services? In addition how do we evaluate the relationship between treatment and outcome? The mental health literature contains examples of attempts at conceptual models of program evaluation. However, most of the approaches and designs in studies of program evaluation have been experimental or quasi-experimental designs on defined client populations. Classical experimental design (such as the analysis of covariance with randomized treatment) has been useful in many non-human 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. However, in mental health programs evaluation (MHPE) the dynamics most often provide critical insight into the value of programs. Furthermore, the controlled clinical trial implied by the classical design is difficult to justify if one treatment is presumed to be superior given the current atmosphere of reluctance to deny potentially helpful treatment to individuals. One way around this latter criticism is to use quasi-experimental designs, but the statistical validity of conclusions may suffer from lack of randomization. Furthermore, this approach does not capture the dynamics of the treatment-outcome process. (However, there are situations where the experimental or quasi-experimental design models are appropriate and effective.)

The use of models which 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 since the flow of patients through various states must be accurately measured. The participants at the meeting discussed these and other aspects of MHPE and the following research topics were suggested:

1. Clearly define the objectives of any program which is to be evaluated. The OR researcher, in conjunction with the MH researchers, behavioral scientists, administrators, governmental executives and legislators must know clearly what is to be achieved with whom or the program will be difficult or impossible to evaluate. This should be done at the start of the program. OR methodologies of use would be delphi, nominal group technique, priority weighting, conjoint analysis and other multi-dimensional scaling techniques.

2. Study the cause-effect relationships between diagnosis-treatment-outcome. OR should work with MH researchers in the development of severity indices and multi-dimensional measures of outcome by different treatment modalities and treatment locales. This work is essentially defining the flow of patients through the stochastic process and all the possible states at each stage (begining, intermediate and final). The OR methodologies which could be used are markov and semi-markov chains/processes. Subjective probability estimating techniques could be extremely useful here.

3. Develop data systems. The data collection and management must efficiently be structured for regular periodic recording and (usually) computerization. If possible, patient tracking/linkage across the general health and other social system

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

5. Develop stable baseline transition matrices which 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 for the evaluation of a program. If a new program for the same disease, severity, and similar 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 available, as yet, for these stable baseline transition matrices. At present it may be feasible for a few mental disorders, e.g. schizophrenia. OR methodologies of interest involve the use of observation and statistical analysis via "intensive" or "extensive" design. Basic statistical research is also needed in the area of covariate adjustment in stochastic processes.

6. Investigate how 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 which visits certain states 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 prior to 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/flow or process models for use in program evaluations. What are the objectives, decisions, information needs and constraints which make one model more appropriate than another. This research involves an evaluation of the program evaluation methodologies in various MHSR contexts themselves.

Modeling Resource Allocation in MHSR

Modeling resource allocation decisions in MHS requires as inputs: the results from needs, demands and utilization area and the inputs and state-variable outputs of the program and evaluation area. However, much of the data collection, patient flow, and outcome measure research efforts suggested in the previous sections must be developed with an appreciation of how this information will be used in resource allocation-decisions. Too often the work done and data obtained in one research area is not useful in another, but with some prior thought could easily have been. It is in the resource allocation area that the interaction of other research and

data sources become most apparent.

The major question in this section is the determination of the resource mix (facilities, programs and manpower) which will deliver the most effective array of mental health services to a community, to a state, and to the nation. Although some of the constraints and objectives are easily modelled, many behavioral/social/political constraints and objectives require a great deal of work. 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, but perhaps more importantly at the regional, state and national levels. Much of the funding of MHS and new programs comes from these latter levels and relate to 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, of quality and of availability of mental health care.

However, what has been missing to date from the use of OR in MHSR is a clear understanding of which decisions are important at each level, who the decision makers are, what are the criteria and objectives controlling their decisions and what types of models best support these decision making processes. To aid decision making effectively in many decision arenas, 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 topics and methodologies for resource allocation broached 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 which types of decisions allocate the greatest proportion of funds and which have the greatest potential for health impact. It is this systems analysis work which will lead to the development of objective functions, constraints and transfer functions needed later. In this area a considerable amount of data already exists, particularly at the federal level. However, a coordination and understanding of the relevant material is needed.

2. At the federal level, build models to aid in decisions concerning the allocation of funds to direct and indirect care (services, treatments, facilities, programs) and to research and demonstration. Appropriate OR methodologies would be mathematical programming, simulation, scheduling and hybrid models.

3. At the federal level, model the manpower needs by specialties with regard to the allocation of training and education funds and also for services for the disadvantaged. This involves also the determination of the appropriate mix of manpower categories for the needs, demands, programs and institutions developed in the preceding areas. OR methodologies of use are forecasting (time series, regression, subjective estimating), mathematical programming and markov decision models.

4. Model the optimal mix of federal, state and regional resources between prevention and treatment sectors of MHS based on objectives, constraints and transformations found in topic 1 above. Here again, mathematical programming simulation, input-output and econometric models would be useful.

5. Conduct more basic OR research in large-scale multi-objective 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 HSA plans in the country. (This effort also fits into topic 1 above.)

7. At the state level, model the optimal resource needs and allocations among inpatient long term and acute psychiatric care, CMHCs, nursing homes and other institutional and non-institutional settings. This modeling should consider the optimal mix of the federal, state, regional and local funding of this care. OR methodologies are mathematical programming, simulation, and markov decision processes.

8. Paralleling the modeling in (7) above, build state, regional and local manpower and facilities planning and allocation models. The same OR methodologies might by used as well as forecasting models.

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

10. Build interactive support models for operating on-going 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 prior to model construction. Many of the previously mentioned methodologies could be used as well as decision analysis, subjective probability analysis and other behavioral techniques mentioned in prior areas. Some of these types of interactive support models are currently being used in general acute health care institutions.

Modeling Large-Scale Systems Interactions

A major task facing many MH planners is how to conceptualize, organize and operate a mental health care system which can cost-effectively provide the full range of services required by the nation. To accomplish these comprehensive goals, it is imperative that the MH planning efforts emphasize the importance of increasing interactions and inter-dependence among governmental 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 inter-dependence of the mental health services system and other social service systems, e.g., criminal justice, general health care, alcohol and drug abuse, and the educational system? It has been clearly demonstrated that the individuals with mental disorders are often not seen in the specialty mental health sector over long periods of time; instead they tend to use the general health care system and other social systems often. 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 with mental disorders. These large scale system interactions are extremely important to characterize because of trends in health care services in the United States. In particular, it is important to model large-scale system interactions in addressing such issues as national health insurance and increasing privatization of the mental health service system.

However, the data needs for large-scale systems interactions models, although perhaps not extensive, may be difficult to obtain because of the complexity of movement of patients through the various systems. These 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 macro level flows, then better planning and treatment of MH disorders may be possible. There are also important dynamic trands (and possible cycles) which affect the delivery of mental health care. Many of these trends are characterized in Table 1.

TABLE 1

IMPORTANT TRENDS FOR U.S. HEALTH CARE SERVICES

I. Structural Delivery System Changes

1. Long-term to short-term
2. Inpatient to community based
3. Increase in general long-term beds
4. Increase in third party coverage

II. Demographic Shifts

1. Increase in per cent aged
2. Increase in high-risk adolescents

III. Social Problem Shifts

1. Increase in crime rate
2. Increase in alcohol-drug use rate
3. Increase in divorce rate and family fragmentation

IV. Attitude Shifts in General Population

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

V. Cost-Containment Priority in Public Policy

1. Increase in emphasis on cost, access, and quality
2. High estimates of economic burden of mental illness

These trends have stong effects on the specialty mental health sector (state and county MH hospitals, private MH hospitals, hospitals with psychiatric visits, CMHCs, private practice psychiatrists and psychologists, and other MH treatment centers and providers), the general hospital, nursing home and primary care sectors, other human services and social sectors and the criminal justice, education and welfare sectors. All of these impacts affect the budgetary and resource allocation policy and decision process. As a consequence, research is needed to understand these large-scale systems interactions so better policies and decisions can be taken.

Before describing the specific research areas, it should be mentioned that smaller, more likely successful research projects would perhaps have a higher short run payoff, both in ability to understand and affect decisions in the mental health system. Large-scale mental health system or interaction models with other systems would be very 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. Some similar large scale systems are available in the department of energy, the military and in private industry. These have taken many man years to develop at the expense of millions of dollars. For this reason, a first good approach would be to build a conceptual framework and conceptual modeling effort for such large scale systems in order to understand the data needs, data flows, transformations, objectives and constraints of the systems as well as the dynamic trend factors affecting each element of the total system, but not build the actual large-scale models themselves until later. Instead, start building and implementing submodules of specific aspects of the mental health ser-

vices 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 topics:

1. At the national and state levels, design large-scale systems flow models of the MH interface among the MH sector and the other sectors mentioned above. The decisions would be the policies affecting and affected by the trends in Table I and the flow of MH 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, hybrids of these, forecasting, subjective estimation, markov decision flow models and econometric input-output models.

2. Use models of the large-scale system designed in (1) above to build subsystem modules which could interact with or provide input to the macro model. Some of the subsystem modules could come from the models suggested in the previous three sections (NDU, PE, and RA) and others could come from models built in other sectors such as alcohol and drug abuse, criminal justice, welfare, education (such as schools for mental retardation), etc.

3. Paralleling the data analysis and evaluation effort in MH mentioned earlier, provide this effort for data collection in the interface areas among the various systems. Again this work should involve an operations researcher to bring the broad systems analysis perspective for future modeling efforts. OR methodologies of interest here are systems analysis, decision support systems and statistical techniques.

4. Build inter-sector transfer models of the MH sector with one other sector. These models would also be modules for the large-scale system interaction designed in (1) above. Special emphasis should be placed on a model relating the MH sector to the general health sector. This model is needed because there are many important interactions involving treatment, facilities, personnel, financing and other primary and secondary illnesses. The same OR methodologies would also be appropriate as in (1) above.

5. Conduct research on the implementation and use of large-scale interactions models for planning, policy and decision making. In this effort evaluate the models' validity, efficacy, sensitivity and ability to address political and behavioral aspects. This work on model validation for decision making is similar to the program evaluation work of the second section and some of the same methodologies apply. (As a side note, much work is ongoing on this topic for the large-scale energy planning models of DOE.)

6. Investigate the dynamics of primary and secondary effects of the trends in Table I on the MH sector. Methodologies of interest are analysis of variance, regression, feedback flow models and subjective decision analysis techniques.

In conclusion, the mental health services research area is rich in interesting and important topics for research and implementation amenable to the application of OR approaches and methodologies. This meeting has provided a list of topics in four promising areas and by their very selection has prioritized them as important in the interface of these two disciplines. It is hoped that the Division of Biometry and Epidemiology, NIMH, will find these results useful in the allocation of some of their funds to support research and implementation on these significant topics.

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