Nurse Scheduling:

A Successful Multi-Site O.R. Implementation - Why?

by

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Abstract

As was pointed out at the ORSA-TIMS-AIIE Meeting in Atlantic City two years ago, the only multi-site successful implementation of an operations research study in health was the menu-planning and dietary inventory model developed by Joseph Balintfy et al. At that time, a second study was well underway to multi-site success. This latter study was the scheduling of nursing personnel. In the past year or so a Nurse Scheduling Package has been implemented at a dozen hospitals. This paper explores the reasons for the success of these multi-site implementations and suggests strategies for carrying other O.R. projects beyond their initial site.

"Nurse Scheduling: A Successful Multi-Site O.R. Implementation - Why?"

In the several decades which have seen a mushrooming growth of the methodology and applications of operations research, there have been many examples of successful individual as well as multi-site implementations of operations research models. Most of them have been in military and industrial settings. Unfortunately, there have been very few successful multi-site O.R. implementations in the area of health care delivery and management. Indeed, on November 9, 1972 at the Symposium "Health O.R.: A Critical Analysis" sponsored by ORSA Health Applications Section and the National Center for Health Services Research and Development, the two most widely quoted multi-site O.R. efforts were the diet and menu planning models and the scheduling of nurses in a hospital.

The purpose of this paper is to analyze why "nurse scheduling" has been one of these successful implementations, not only in a single hospital but in many hospitals in the United States and Canada. From this particular study of success, it will be shown that certain general conclusions can be drawn and these conclusions apply to many other studies, both industrial and governmental. In fact, many of the elements of success mentioned here have been mentioned by other operations researchers, including the very important application of menu planning and dietary control models by Professor Joseph Balintfy [1969, 1971, 1972, 1974].

Before proceeding to answer the question why these studies were successful and, in particular, why the nurse scheduling model implementation was successful, it is relevant to ask the question what is an O.R. implementation. This question is pertinent because there are many successful

applications on a multi-site basis of work often done by operations researchers and/or management scientists but which do not really qualify for the title "an O.R. implementation". Some of these other multi-site implementations are workload measurement and patient monitoring, patient billing systems, patient information retrieval system, systems analysis, and procedure manual documentation in hospitals. Why are most of these not O.R. studies? Following the approach elucidated by Professor Harvey Wagner in his Lanchester prize-winning book, Principles of Operations Research, there are several distinguishing characteristics of an operations research implementation:

1) There is a primary focus on decision making; that is, the principal results of the analysis must have direct and unambiguous implications for executive action.

2) The appraisal is made resting on economic effectiveness criteria; that is, a comparison of the various feasible actions must be based on measurable values that unequivocally reflect the future well-being of the organization. A recommended solution must have evaluated the trade-offs and have struck an optimum balance among the sometimes conflicting factors.

3) There is a reliance on a formal mathematical model.

4) There is a dependence on an electronic computer.

Now it is true that there are O.R. studies which have these characteristics in more or less varying detail. And perhaps there are even some studies which, in their successful implementation, may not have needed an electronic computer. However, for the most part, studies which have omitted any of the first three characteristics are usually in the domain of other

disciplines, such as industrial engineering, behavioral or organization theory, accounting, computer science, statistics, etc. This is not to say, of course, that O.R. practitioners restrict themselves to O.R. implementations. Indeed, many of them may at times not use mathematical models, not build decision making models, or not evaluate alternative systems and trade-offs in their analysis. But, for the purposes of this paper which concerns a successful implementation at many locations, the above criteria are met and, therefore, nurse scheduling is well-qualified to be called a successful multi-site O.R. implementation.

Section II. Elements of Success in Nurse Scheduling

In retrospectively reviewing the nurse scheduling implementation, it is apparent that there were many factors which contributed to the success of the implementation at many locations and, were these factors missing, it is unlikely that the project would have gone beyond the feasibility study stage. These factors are not necessarily listed in their order of importance, but rather in a manner which makes the presentation flow more logically.

1. Complexity and Universality: The nurse scheduling problem is a complex problem which exists in much the same form at many hospitals. There are two major aspects which make the problem difficult. The first aspect is the sheer size of the problem. That is, in determining the days on and off for a nurse, LPN, nurse's aid, medical technician, or ward clerk interacting with all other nursing personnel on a unit over a period of two to four to six or eight weeks results in the need to control many interacting variables. For example, if one has 15 nurses over a four week time frame,

there are 420 variables which must be specified in order to produce a schedule. Compounding this aspect is the fact that there are many constraints on the system and several objectives which must be met. Furthermore, in a large acute care hospital, there will be from 300 to 1,000 or more nursing personnel. Indeed, the problem takes on an immense size very rapidly. The second aspect which makes nurse scheduling a difficult problem is that the schedules produced must satisfy virtually all of the people over both the short and long run. This aspect is especially important in many large urban areas where there is a shortage of various classes of nursing personnel and/or where there are union constraints and regulations which must be met. Due to these many complexities, the task of scheduling nurses is usually very onerous and complicated to the individual or individuals charged with the job of producing schedules. Indeed, the schedules are required to meet the many constraints, preferences and desires of the individual nurses who must be scheduled and at the same time provide good workload allocations on a 24-hour 7-day week.

2. General Quantifiability: The nurse scheduling problem is quantifiable in a general way, yet is easily particularized for each hospital. It is possible to build a mathematical model which is flexible and comprehensive, and which meets nurse preferences, objectives and constraints for virtually any general acute care hospital. Yet, by changing parameters of the model, it can be easily particularized to the specialized constraints, preferences and objectives for any given site. For example, each individual's preferences for working parallel with others, working part-time, rotation restrictions, fixed patterns, weekends off, stretches, split days off, etc. can be

included in the mathematical model. Furthermore, many hospital preferences and restrictions, such as one or two week pay periods, maximum and minimum working stretches, number of weekends off over certain time periods, schedule horizon, the beginning day and length of pay periods, general rotation policies and use of part-time and/or float personnel, can also be accommodated within the model. The objective of the model is to trade off these preferences and desires against the fact that there must be enough nurses on duty in the appropriate nursing classes to meet the demand for their services on each shift of each day of each week, and yet satisfy the constraints of the system. This objective and the constraints have been quantified and parameterized. (For the details of the mathematical model, see Miller, Pierskalla and Rath [1974].) The parameters are then adapted to meet the needs of each implementation site.

3. Optimality: In the nurse scheduling problem, more than just a "feasible solution" is needed. Indeed, feasible solutions are not too difficult to find when a particular nursing unit is overstaffed but become considerably more difficult to find for those units which are understaffed (the use of cyclical schedules has had some vogue and, for overstaffed units, is reasonably easy to implement). However, most feasible solutions do a very poor job of satisfying nurse preferences, yet at the same time meeting the demands on each nursing unit. This fact is especially true when the unit is below or at its required staffing levels. For this reason, the best possible, i.e., optimal (or near optimal), solution is required. The nurse scheduling model provides a solution which is consistently far better than past practice, is near-optimal and often optimal.

4. Sponsorship: In order to solve the general nurse scheduling problem, it was necessary to have a sponsor who would fund the research and the developmental effort. In this case of nurse scheduling, the sponsor was the MEDICUS Corporation. However, as in the case of menu planning and dietary control, the sponsor could just as well have been a hospital or governmental agency or agencies.

5. Teamwork: A competent, multi-disciplinary, well-organized team of people is needed to do the R & D model effort. Actually, it is conceptually possible for an individual with many talents in operations research, computer science, statistics, and information systems, as well as data processing and report generation, to have done the work, although the time frame would have been considerably extended, and such an individual would, indeed, be hard to find. Furthermore, the team must interact with many different users of the schedules in order to understand the full behavioral and organizational implications of the implementation. Without these aspects designed into the system, it would be impossible to implement at any particular site, let alone many different locations.

6. Successful Pilot Study: Prior to multi-location implementation, it is necessary to develop a successful pilot study and implementation. Here it is necessary to establish standards for the maintenance of a quality data base, a training program for well-trained people to operate the system, and sufficient feedback loops and interactions between the users and the system designers to guarantee successful parametric adjustments of the system to meet the needs of the hospital. (For the details of the implementation aspects at a particular location, the reader is referred to the paper by Miller, Pierce and Pierskalla [1975].)

7. Followthrough: For successful multi-site implementations, it is necessary to have a skilled organization to carry through these implementations and guarantee their continuing success. In nurse scheduling, this organization again was the MEDICUS Corporation. MEDICUS provided a well-trained staff who understood the nurse scheduling system and its implementation aspects and who were capable of teaching hospital personnel how to maintain a quality data base and operate the system. This staff was knowledgeable in such areas as sales, marketing, and cost benefit analysis, and they were adept at convincing hospital administrators at other locations that the nurse scheduling system could indeed solve the problems involved in nurse scheduling.

Section III. Generalizations and Conclusions

When one ponders upon each of the above areas, it is apparent that many of the areas must be present in order to have even a single site O.R. implementation. Perhaps the key multi-site aspects of the problem are that it is a very difficult problem but it exists in much the same form at many locations and, because of this latter aspect, it can be quantified in a general way which is flexible and comprehensive. For example, it is not necessary to resort to a simulation to solve the problem for a particular hospital, since a general model may be built to do the job. The other perhaps major aspect of the multi-site success was that there was a skilled organization of people of many talents who were willing to carry through the necessary sales, marketing, and cost benefit analysis, as well as the computer science, information systems training, organizational and behavioral analysis, statistics, and indeed operations research aspects of

the problem from one location to another. In the area of nurse scheduling, as well as that of dietary control and menu planning, it is not true that if you build a better mousetrap, the world will beat a path to your door. You must convince that world that you indeed have a better mousetrap which will solve its mouse problem.

For the successful multi-site implementation of other general O.R. models, there may be additional factors not mentioned above which contribute to their success. However, it is doubtful whether many or any of the seven key factors above are missing. Indeed, they are usually found in significant degrees. Therefore, in recommendation to people interested in expanding the scope of O.R. implementations to many locations (such as those people in government agencies responsible for handling R & D concerning health care problems), it is recommended that a competent team of researchers be formed. The team members must have abilities not only in operations research, data processing, statistics, behavioral and organizational science and other disciplines, but also abilities and interests in selling, marketing, data gathering, and day-to-day training and implementation. In this way, implementation of the O.R. model at many sites has a reasonable chance for success.

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