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A Group Decision Support Framework for Consensus Ranking of Technical Manager Candidates

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In many developed countries, today's socioeconomic environment has expanded the role of the technical manager. Organizations capable of recruiting technical managers with adequate management education and interpersonal skills, in addition to technical expertise, are more likely to be successful in managing their limited resources. A technical manager's success is also dependent on the manager's acceptance by his/her subordinates, peers, and superiors, and the decision to hire a technical manager should be made with their participation. Many of these individuals have little background or experience in hiring, and they need appropriate decision support. This paper presents a framework to help a group of decision makers define and articulate a hierarchy of hiring criteria and subcriteria and rate each of the candidates on that hierarchy. To improve consistency among group members, the proposed group decision support system (GDSS) combines the Analytic Hierarchy Process (AHP) with the Delphi principles of anonymous feedback and iteration. Given the decision makers' desire for a consensus choice, the framework deviates from the normal practice of AHP, and uses the Maximize Agreement Heuristic (MAH) to arrive at the final ranking of the candidates. An application to the ranking of nurse manager candidates at a hospital in the United States is presented.

Key words—group decision support system, human resource selection, multicriteria decision making, Analytic Hierarchy Process, Maximize Agreement Heuristic, Delphi

1. INTRODUCTION

IN MOST LARGE ORGANIZATIONS in both developed and developing economies, there exist some organizational units that are highly specialized and technical. For example, at NASA's space shuttle processing facility, one organizational unit focuses on the electrical engineering systems, another on the mechanical engineering systems, and yet another on the communications systems. Highly specialized academic departments at most research universities represent another example. Intensive care, pediatrics, and coronary care are some of the technically specialized units in a hospital. The managers of such technically specialized units are often hired entirely on the basis of their technical expertise even though, almost a century ago, Frederick Taylor [49] argued that a manager's job was fundamentally different and that promoting the best worker in a unit to the manager's job was not a good idea.

In recent years, an increasing number of organizations have come to realize that Taylor's argument applies to hiring managers of technically specialized units as well. In addition to being competent in their specialties, technical managers must be capable of fulfilling management responsibilities, such as planning, budgeting, and motivating. Furthermore, a technical

manager's success often depends on the acceptance of the manager's competence and personality by subordinates, peers, and superiors. This realization, combined with the recent movement in the US toward more participative management, indicates the need for a different organizational process for hiring a technical manager and the need for a group decision support system (GDSS) to support that process. This paper presents a framework for assisting groups of subordinates, peers and superiors to participate in hiring a technical manager and discusses its application to the hiring of a technically specialized nurse manager at a hospital in the US.

Over the last decade, rising health care costs and other fundamental changes in the health care delivery system in the US have forced health care providers, purchasers, and insurers to better manage health care costs while maintaining the quality of care. Revisions in reimbursement patterns have forced a reconsideration of existing organizational structures in an attempt to capture market share and to capitalize on economies of scale. Joint ventures, alliances, and multi-hospital systems have begun to dominate the health care landscape. These arrangements have created new hierarchical structures and new challenges for those involved in managing the care of patients [50].

As the largest group of health care workers, nurses are in a unique position to contribute to the new goals of cost-conscious quality health care. Consequently, today's health care environment has significantly expanded the role of nurse managers. In the past, the role of nurse managers was primarily clinical in nature. They supervised the clinical practice of approximately 10 staff nurses and served as the team's clinical experts. Although nurse managers were also responsible for work schedules and staff evaluation, administrative skills were usually seen as secondary. Nurse managers in many newly created health care delivery systems are often responsible for 25–50 full-time-equivalent employees, and their departmental budgets frequently exceed $1,000,000 [33]. Today, nurse managers must possess not only the relevant clinical expertise but also the necessary planning and budgeting skills. They must have the ability to evaluate costs and benefits of alternative nursing practices. In addition, they must be capable of explaining the basis for their decisions within the institutional, divisional, and corporate structure, and they must be able to motivate and train their staff to adhere to protocols and policies that may not appear to be optimal or expeditious to a patient. Although difficult to measure, interpersonal skills are crucial to the performance of today's nurse manager [47]. Thus, over the last decade, the nurse manager's job has become rather complex, and the criteria for hiring a nurse manager have changed considerably.

At the same time, many organizations are changing their hiring processes. Glendon and Ulrich [22] have suggested that organizations are increasingly departing from authoritarian styles of management and developing systems to encourage individuals to participate in the decisions that affect them. This type of transformation is designed to empower employees to become active participants in shaping the environmental context of their organization. Moreover, this process of decision making enables different groups of employees to recognize the significance of their mutually dependent relationships and to value the perspective of others involved in the treatment delivery system.

Because nurse managers report to nursing directors, interact with other nurse managers, and supervise staff nurses, each of these groups should be involved in developing the criteria for hiring a nurse manager. Most health care organizations, however, still neglect to include staff nurses in decisions that influence the nurses' professional practice and ability to deliver patient care [11]. Recognizing the need for nurse participation in these decisions, Dwyer *et al.* [19] have suggested that nurses see the ability to influence decisions that ultimately affect the care of patients as a necessary condition for fulfilling their professional responsibility. Finally, a participative process is particularly desirable in the hiring of nurse managers because their success depends on their acceptance by subordinates, peers, and superiors.

While many hospitals are convinced of the need for such a participative decision process for hiring new nurse managers, they find it difficult to implement the process because staff nurses and nurse managers often lack the necessary training and experience in hiring. Even experienced nursing directors need assist-

ance in considering the multiplicity of criteria relevant to hiring today's nurse managers. A participative process complicates the matter further because one must also decide how to weigh and aggregate the opinions and judgments of so many participants. This paper explains the process, the models, and the principles used in supporting the nurse manager hiring decision at a small privately-owned hospital.

The decision-making group included staff nurses, nurse managers, and nursing directors. The first task was to help them articulate the criteria to be used in hiring a nurse manager. As described in Section 2, a series of questionnaires was used by each group of decision makers (DMs) to develop a set of criteria and subcriteria. Section 3 describes the use of the Analytic Hierarchy Process (AHP), a technique that allows individual DMs to assess the relative importance of the various criteria and subcriteria and to evaluate available candidates on the hierarchy of criteria and subcriteria. AHP helps ensure that individuals are logically consistent in their judgments. Section 4 shows how the Delphi principles of anonymous feedback and iterative revision were employed to help each DM to understand and respond to the judgments of the other DMs. Section 4 further explains how the Maximize Agreement Heuristic (MAH) was used to produce a consensus ranking of the candidates from the individual DM preferences. A review of all these efforts suggests a group decision support framework that can be useful for hiring technical managers in many organizations. Section 5 describes this framework and discusses its strengths and limitations.

2. DEVELOPING THE HIRING CRITERIA HIERARCHY

General Hospital[1] is a small, privately-owned facility, located in Northern New Jersey. The hospital employs approximately 300 nursing professionals in the positions of staff nurse, nurse manager, and nursing director. General Hospital offers an attractive package of employee benefits and a competitive salary to its employees. This policy has promoted low employee turnover, especially in the nursing care positions. It has also resulted in a substantial number of applicants when new nursing positions become available. With many candidates competing for a few available positions, General Hospital management saw the opportunity to establish high employment standards.

Although the current administrative structure is hierarchical, General Hospital recently instituted a practice of shared governance in its daily operations. The hospital has been remarkably successful with nurses participating in decisions affecting hospital operations and in decisions impacting their performance. In 1994, a goal was to apply the concept of shared governance to General Hospital's hiring practices. Prior to this study, at General Hospital the process of selecting a nurse manager was simple, authoritative, and largely subjective. Based on industry practice, the Human Resources (HR) Department had developed a list of minimum requirements in terms of the knowledge, abilities, skills, and other characteristics for a nurse manager's job. The HR Department screened the candidates by requiring and reviewing an application form, educational transcripts, and letters of references. Then, HR referred the top candidates' names to the nursing director who had an opening for a nurse manager reporting to her. The director was free to use her own criteria and process for the final selection among these candidates. Although clinical competence was always used as a criterion, other criteria such as administrative experience, friendly personality and appearance, varied from one director to another. Similarly, the selection process varied from one director to another and ranged from very simple to fairly elaborate. One nursing director described his process as a simple personal interview with the top-ranking candidate, then the next, and the next, until a satisfactory one was found. Another director indicated that she always interviewed at least four candidates. In addition, she asked two of her subordinates to interview these candidates and provide her with their assessment of each of the four candidates.

General Hospital wanted to develop a more participative, systematic, and uniform process for hiring nurse managers. Such a hiring process is arduous because the candidates are faced with multiple interviews by peers, supervisors, and

[1]The name of the hospital and selected data have been changed to protect anonymity.

subordinates. In addition, the selection authority is confronted with assimilating each interviewer's opinion into a final hiring decision. General Hospital sought assistance in developing a process for filling the first nurse manager opening in 1994. Management had selected a panel consisting of seven nurses, three nurse managers and two directors to be the DMs, and the HR Department had identified seven candidates who met the desired minimum requirements.

The first task for this group of 12 DMs was the articulation of the relevant criteria for a nurse manager position. All 12 DMs were briefed on the historical processes and criteria used for hiring nurse managers, as well as on the need for a change in these processes and criteria in the 1994 environment. Then the DMs were asked to provide a list of hiring criteria using a questionnaire that assured each respondent confidentiality and anonymity. When this questionnaire was completed by all 12 DMs, the individual responses were aggregated into separate comprehensive lists for the three DM groups: the staff nurses, the nurse managers, and the nursing directors. The lists of hiring criteria are presented in Table 1. While there were many criteria that were common to all three groups, there were also differences between the groups' criteria. For example, staff nurses valued equity and fairness in decision making, and nursing directors emphasized collaboration, while nursing managers did not specifically look for these attributes.

To assess the relative importance of the criteria using AHP, it was important that the criteria at any particular level of aggregation were mutually exclusive and collectively exhaustive. It was also important that the DMs understood the meaning of each criterion. Therefore, in addition to reviewing the criteria traditionally used by the HR Department, the facilitators conducted a substantial literature review and prepared the operational definitions presented in Table 2.

Another set of questionnaires was used to develop a hierarchy of the hiring criteria for each DM group. The questionnaires asked the DMs to consider revising the criteria in Table 1 and the definitions in Table 2. While some wording in Table 2 was modified, overall the DMs endorsed the operational definitions. The DMs also deleted some of the criteria (e.g., Staff Advocate) listed in Table 1, because they were seen as integral parts of other criteria in Table 2 (e.g., Recognition Giving and Facilitation).

Prior to the administration of these questionnaires, the DMs were briefed on the concept of a "hierarchy of criteria". Then, the questionnaires asked the DMs to separate their criteria into related groups, to rank the criteria within each group, and to suggest names for the groups of criteria. At this stage, there were substantial differences among the DMs regarding the ways to group related criteria. Therefore, the facilitators met with each group to synthesize the responses to these questionnaires. In these meetings, there was agreement that the overall categories of managerial skills, personal traits, and experience made sense. The need for mutually exclusive and collectively exhaustive definitions of the criteria was emphasized. Some DMs expressed concerns about, for example, the difficulty of separating managerial experi-

Table 1. Initial list of evaluation criteria

Staff Nurses	Nurse Managers	Nursing Directors
• Financial/Budgeting/Fiscal Skills	• Financial/Budgeting/Fiscal Skills	• Financial/Budgeting/Fiscal Skills
• Communication Skills	• Communication Skills	• Communication Skills
• Creative and Innovative	• Creative and Innovative	• Creative and Innovative
• Clinical Knowledge and Experience	• Clinical Knowledge and Experience	• Clinical Knowledge and Experience
• Flexibility	• Flexibility	• Flexibility
• Leadership Skills/Assertiveness	• Assertiveness Skills	• Leadership Skills
• Managerial Skills and Experience	• Management and Supervisory Experience	• Managerial Experience
• Recognition	• Risk Taker	• Risk Taker
• Interpersonal Skills	• Interpersonal Skills	• Facilitator
• Promote Harmony and Cohesiveness	• Shared Governance Concept	• Cooperative
• Staff Advocate	• Staff Advocate	• Collaborator
• Follows Through/Makes Decisions		• Decision Making Skills
• Equity and Fairness in Decision Making		• Motivator
• Promotes Teamwork		• Promotes Teamwork
• Friendly		• Constructive
• Visible and Accessible		• Consistent
• Continuing Education		• Responsible

Table 2. Evaluation criteria descriptions

Group	Description
Category: *Managerial Skills*	
Nurse Managers	Assertiveness is to express oneself directly and honestly without infringing on the rights of others. The position of the individual is expressed in the first-person. Others are recognized as equals which supports a sense of trust. Assertiveness removes the barriers of traditionally submissive female communication and allows one to exercise power in a constructive manner [16, 32].
Nursing Directors	Collaboration implies a joint effort toward problem solving. It includes the ability to use interdisciplinary teams and joint nurse–physician effort in care giving. Collaboration requires respect for the knowledge and expertise of the other parties involved, and a willingness to work together [32, 33, 46].
Nurse Managers	Communication involves choosing the most appropriate messages and sending them through the most appropriate channels. Successful communication occurs when both the sender and receiver of the message share the same meaning from the message. To communicate successfully, the nurse manager must be able to: determine communication goals, identify the available options, consider the receiver's probable response, and evaluate the options [3, 16, 32, 46].
Nursing Directors, Nurse Managers and Staff Nurses	Decision Making is the process of choosing from two or more alternatives a course of action that is directed toward the resolution of organizational problems and the achievement of organizational goals. It includes the ability to identify the problem, establish the criteria to evaluate potential solutions, identify and evaluate alternative solutions, and select the most desirable alternative [16, 33, 41, 46].
Nursing Directors	Facilitation of the work process (patient care) involves creating an environment in which people (staff nurses) can work up to their full potential. It involves monitoring the workenvironment to identify and overcome barriers to accomplishment. Barriers include conflicts between staff members, inadequate support systems, and inappropriate organizational practices [3].
Staff Nurses	Fiscal Skills involve identifying unit goals and needs, and preparing budgets to acquire the needed resources. They include the capability to forecast fiscal needs, to identify budgetary alternatives, and to implement and control a budget [32, 33, 41].
Nurse Managers	Interpersonal managers understand human needs, group dynamics and corporate acculturation. They maintain close relationships with co-workers but allow them considerable independence. The interpersonal nurse manager helps staff nurses set goals and communicates feedback about their achievement [34, 35].
Nursing Directors	Motivation Skills involve creating and maintaining an environment allowing individuals to expect that: (1) they can use their talents to perform successfully, and (2) desirable outcomes willbe linked equitably to successful performance. To make progress toward such an environment require ideas such as: self-determination, interdependency, open communication, flexibility and concern for the quality of work life [16, 41].
Nursing Directors and Staff Nurses	Organizing Skills involve establishing a formal structure that provides the coordination of resources and human interaction to accomplish common goals. Organizing requires the ability to group the necessary activities into workable units, to determine lines of communication and patterns of coordination, and to develop role structures of superior and subordinate [16, 33, 41, 46].
Category: *Personal Traits*	
Nursing Directors	Consistent nurse managers are dependable within the context of their personal styles and relationships with others. While situations require some variations in response, there is a basic continuity [35].
Nursing Directors	Cooperative nurse managers are able to get along with others and work well as a team member. There is evidence of success in working with administrators, nurse managers, and staff associates [33].
Nursing Directors, Nurse Managers and Staff Nurses	Creative and Innovative problem solvers are motivated by an interest in the problem and its solution so they work longer and harder without external incentives. They spend more time on problem formulation and can move easily from one frame of reference to another. They are enthusiastic about finding new ways to think about things, viewing problems as challenges and opportunities [16, 33, 46].
Nursing Directors, Nurse Managers and Staff Nurses	Flexible managers display an ability to adjust as the needs of staff, patients, or the entire system change. Flexibility means being able to appropriately prioritize and balance a variety of demands, including consultative requests, clinical responsibilities, the requirements of teaching, attending/conducting meetings, participating in clinical inquiry and research, and participating in professional organizations [10, 32].
Staff Nurses	Friendly nurse managers smooth over conflicts in order to return to closer supportive relationships [46].
Staff Nurses	Recognition Giving managers provide positive feedback to staff nurses about the value they contribute to patients and the nursing service. It requires the ability to make candid observations and unbiased evaluations of nurse performance [3, 10].
Nursing Directors	Responsible nurse managers embrace the duties and responsibilities of the position. They accept accountability for the consequences of their decisions and actions [3, 32].
Nursing Directors and Nurse Managers	Risk Taking managers are not afraid to make changes. They challenge the existing process and are willing to step into the unknown. They try different things to discover new ways of accomplishing the task at hand [32, 34].
Nurse Managers	Governance Sharing requires a willingness to allow staff nurses' participation in decisions that affect their practice, work environment, and professional development. An essential underlying belief is that staff nurses will make appropriate and meaningful judgments in providing care and in enacting their role as professionals. Shared governance means sharing power and control [34, 41].
Category: *Experience**	
Nursing Directors, Nurse Managers and Staff Nurses	Managerial Experience means having worked with and through people as individuals and groups to accomplish organizational goals. It includes experience in developing a master staffing pattern; establishing procedures for adjustment of staff; clarifying requirements for each job description; hiring, developing, and firing employees; and defining and controlling the personnel budget [3, 33, 34, 46].

continued overleaf

Table 2. *Continued*

Group	Description
Nursing Directors, Nurse Managers and Staff Nurses	Clinical Experience means effective and caring involvement with patients [10, 16, 41].
Nursing Directors, Nurse Managers, Nurses and Staff Nurses	Financial Experience involves participation in decisions about the allocation of resources and the control for ensuring that results comply with plans. It includes experience in preparing budgets and encompasses forecasting units of service, staffing patterns, salary and non-salary expenses, and revenues [32, 33, 41].

*A candidate's experience should be assessed in terms of both, its quantitative (i.e. number of years of relevant experience) and qualitative (i.e. the types of challenges faced and goals accomplished) dimensions.

Table 3. Synthesized evaluation criteria for each group of DMs

	Criteria		
DM Group	Managerial Skills	Personal Traits	Experience
Staff Nurses	Organizing, Decision Making, Fiscal	Creative and Innovative, Flexible, Recognition Giving, Friendly	Managerial, Clinical, Financial
Nurse Managers	Assertiveness, Interpersonal, Communications	Creative and Innovative, Flexible, Risk Taking, Governance Sharing	Managerial, Clinical, Financial
Nursing Directors	Organizing, Decision Making, Motivation, Facilitation, Collaboration	Creative and Innovative, Flexible, Risk Taking, Consistent, Responsible, Cooperative	Managerial, Clinical, Financial

ence from financial experience. Nevertheless, they agreed to use the criteria descriptions in Table 2 when making the AHP assessments of weights in the next phase of this study.

Table 3 shows the hierarchies of evaluation criteria that were synthesized during the meetings between the facilitators and the DMs. Figure 1 depicts graphically the hierarchy of criteria used by the staff nurses, and illustrates the concept of levels of aggregation within a hierarchy. Figure 1 also shows the relative weights given to the various criteria and subcriteria by the staff nurses. The following section discusses how these weights were developed. Similar hierarchies were developed for the nurse managers and nursing directors.

3. ASSIGNING RELATIVE WEIGHTS TO THE CRITERIA AND PREFERENCE RATINGS TO THE CANDIDATES

The next task was to assist individual DMs in assessing the relative importance of the various criteria and subcriteria, and their relative preferences among available candidates on each subcriterion. Saaty's AHP [44–46] is a useful technique for this purpose. AHP is designed to help DMs structure a problem as a hierarchy of criteria and alternatives, and helps them to use their judgments to make trade-offs among the criteria and prioritize among the alternatives. Although Belton and Gear [7] and Dyer [20] have argued that AHP is inherently flawed

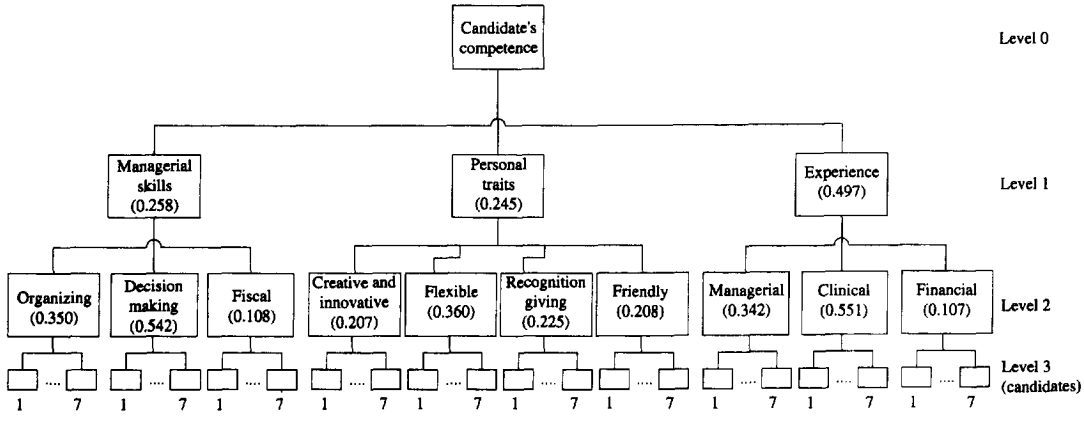

Fig. 1. Staff nurses' hierarchy of criteria and mean group weights for each criterion and subcriterion.

insofar as addition of irrelevant alternatives in AHP can cause a rank reversal, Harker and Vargas [25, 26] and Saaty [44] have noted that this is a flaw with all multi-attribute decision situations. Watson and Freeling [51] have also argued that both AHP and multi-attribute value theory (MAVT) require DMs to answer 'meaningless' (perhaps the correct word is 'ambiguous') questions in assigning criteria weights. Belton [6] has emphasized that an analyst must take great care to ensure that the DMs understand precisely what is meant by a specific 'criterion weight' in either AHP or MAVT assessments. This is because the meaning of that phrase is different from one method to the other. Furthermore, in an AHP application, the meaning of 'criterion weight' is increasingly difficult to conceptualize at higher levels of a hierarchy.

Notwithstanding the above controversies, AHP has been applied to a wide range of practical problems because of its intuitive nature and its power in solving complex problems. These applications include planning information systems [37], selecting licensing candidates in the pharmaceutical industry [42], developing a rating system for the allocation of organ transplants [15], and structuring public debate on nuclear power [24]. While applications of AHP are varied and appear to be unrelated, they all involve judgments concerning qualitative criteria. Saaty [45] and Weiss and Rao [53] provide comprehensive surveys of applications of AHP.

Pairwise comparisons are at the core of the AHP technique. At each level of a hierarchy, a DM is asked to compare each possible pair of factors and to provide judgments on the relative importance of each. While many software products are available, Expert Choice [21] was used to assist the DMs in their pairwise comparisons. To ensure that the DMs understood the concept of pairwise comparisons and were thoroughly familiar with the use of Expert Choice, several group demonstrations, as well as individual hands-on training sessions, were conducted. Comparisons between Level 1 criteria of managerial skills, personal traits, and experience in Fig. 1 were used for these demonstrations, and the comparisons were made on the usual 1–9 scale. For example, each DM was asked to evaluate the relative importance of managerial skills compared with personal traits in selecting the best candidate for the nurse manager position. When a DM considers managerial skills to be substantially more important than personal traits, there may be a rating of "6" in the managerial skills row and personal traits column, and a corresponding inverse "1/6" rating in the personal traits row and managerial skills column. Next, each DM made a similar comparison between managerial skills and experience. Finally, each DM compared personal traits and experience. This completed the pairwise comparison matrix for each DM at Level 1.

Once the pairwise comparison matrix at a given level of hierarchy is completed, Expert Choice computes the relative weights for the various factors for each DM at that level. In addition, Expert Choice computes a consistency ratio (CR) for each DM (see Table 4) and encourages DMs whose CRs exceed 0.10 to reconsider their pairwise judgments. For example, if a DM rates managerial skills as two times more important than personal traits, and two times more important than experience, then logically for that DM, personal traits and experience should be equally important. Suppose, however, that in a pairwise comparison between these two factors, the DM declares personal traits to be three times more important than experience. In this case, a substantial inconsistency has occurred, and the calculated CR would be greater than 0.10. Expert Choice would encourage the DM to reconsider all three of the underlying pairwise comparisons. After a few trials, the DM should arrive at an acceptable level of consistency.

When the DMs were familiar with these intricacies of the Expert Choice software, each DM made the appropriate pairwise comparisons to assess the relative importance of the subcriteria (Level 2) within each major criterion. Once each DM in a group had adequately consistent weights for the criteria hierarchy, each member of that DM group was provided a complete dossier on each of the seven candidates. Then, the group as a whole interviewed each of the seven candidates. At the end of the seven interviews, each DM used the pairwise comparison process separately to indicate his/her relative preferences for each of the candidates (Level 3) on each subcriterion (Level 2) in the group's hierarchy. Expert Choice provided feedback on any significant

inconsistencies. After a few trials, each DM produced acceptable pairwise comparison matrices.

At this point, Expert Choice derived each DM's overall preference rating for a candidate as a linear composite of the DM's hiring subcriteria weights and candidate ratings with respect to each of those subcriteria [45, 46]. Table 4 shows the results of the initial AHP round. For example, Staff Nurse A ranked Candidate 6 with a preference rating of 0.266 as her first choice, while Nurse Manager A ranked Candidate 3 with a preference rating of 0.214 as her first choice. Table 4 also shows that all CR values were less than 0.10. Following the standard practice of AHP, Table 4 reports the overall mean score of each candidate as a linear composite of the scores given to that candidate by all 12 DMs. At this stage, for the DM group as whole, Candidate 6 was ranked first followed by Candidate 3 and Candidate 5.

The DMs were presented with the results in Table 4 and asked if they had any concerns. The DMs indicated that the questionnaires and AHP had been helpful in enabling them to articulate their criteria and in ensuring that each of their weights and preferences were internally consistent. They were not sure, however, why their individual ratings of the candidates were so different from the ratings of the other DMs. Furthermore, a majority of the DMs did not think that Candidates 6, 3, and 5 would be their first, second, and third choices, respectively. This feedback made the facilitators acutely aware of the limitations of AHP in group decision making. While AHP ensures that each individual DM is internally consistent in making judgments, it does nothing to ensure the sharing of certain judgments, or to ensure a degree of consistency within a group of DMs. Furthermore, AHP does not ensure that group consensus would prevail in the ultimate ranking of the candidates. The following section describes the process that was followed and the principles that were used in response to this awareness.

4. IDENTIFYING THE CONSENSUS RANKINGS OF THE CANDIDATES

The first response was to apply the principle of revision of individual judgments in view of anonymous group feedback from the Delphi technique [16]. While there have been many variations in practice [23, 29, 32, 38, 52], the Delphi method consists of three essential processes to achieve information exchange among a group of DMs without introducing the potential biases of interpersonal interaction. The first process is to collect judgments, along with the underlying rationales, from individuals who are knowledgeable about an issue, by questioning them individually. The next process is to collate and statistically summarize the individual judgments and rationales without revealing the identity of the individuals. The third process is to feed back the collated information to individual DMs and seek a revision in their judgments, if any. This sequence of collating, feedback, and revision is repeated over several rounds until further repetitions produce practically no changes in individual judgments.

Table 4. Initial AHP results

	CANDIDATE							
DM	1	2	3	4	5	6	7	CR
Staff Nurse								
A	0.110	0.081	0.137	0.192	0.081	0.266	0.133	0.06
B	0.129	0.172	0.133	0.056	0.183	0.176	0.151	0.05
C	0.122	0.171	0.112	0.095	0.250	0.102	0.148	0.05
D	0.177	0.205	0.101	0.119	0.142	0.120	0.136	0.04
E	0.066	0.159	0.157	0.089	0.174	0.201	0.154	0.04
F	0.119	0.187	0.123	0.085	0.279	0.083	0.124	0.03
G	0.127	0.064	0.149	0.202	0.099	0.220	0.139	0.03
Nurse Manager								
A	0.091	0.121	0.214	0.071	0.118	0.184	0.201	0.05
B	0.098	0.133	0.178	0.129	0.068	0.114	0.280	0.04
C	0.144	0.068	0.175	0.201	0.089	0.166	0.157	0.04
Nursing Director								
A	0.130	0.138	0.241	0.120	0.147	0.161	0.063	0.03
B	0.202	0.202	0.111	0.141	0.161	0.099	0.084	0.03
Overall Mean Scores								
All 12 DMs	0.126	0.142	0.153	0.125	0.149	0.158	0.148	0.041

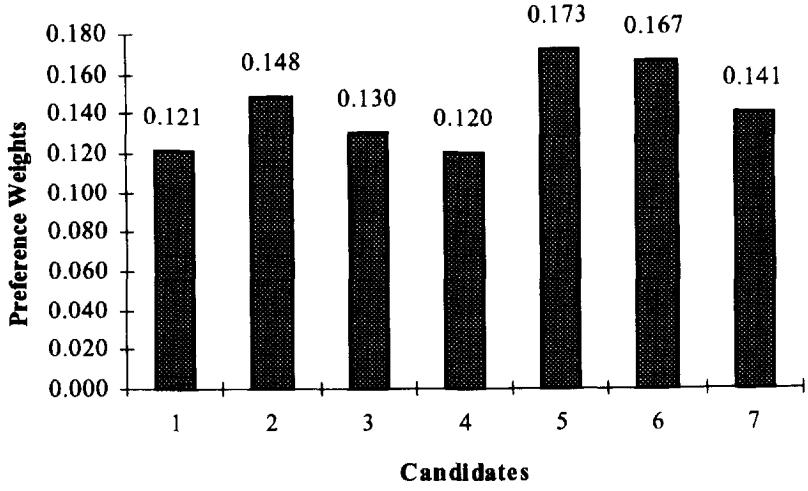

Fig. 2. Initial AHP mean preference weights of the candidates by staff nurses as a group.

In response to the DMs' comments about the results in Table 4, using Delphi principles the judgments of each group of DMs were summarized to provide the DMs with anonymous feedback about the average judgments of the groups. Figures 1 and 2 present the summary prepared from the nursing staffs' judgments. Figure 1 shows the relative weights of the various criteria and subcriteria. Figure 2 shows the initial mean preference weight for each candidate. Similar summaries were developed from the nursing managers' and the nursing directors' judgments. All three feedback summaries were provided to all the DMs. With this impersonal feedback, the DMs were encouraged to reconsider their earlier pairwise comparisons of criteria, and to revise their ratings of the candidates. These revisions constituted the second AHP round.

Table 5 shows the results from the second AHP round. A comparison of Table 4 and Table 5 reveals that a few DMs were influenced by the anonymous feedback, and substantially revised their ratings of some of the candidates. For example, substantial changes occurred in Staff Nurse D's rating of Candidate 6 and Nurse Director A's rating of Candidate 3. Because the number of substantial revisions was small and none of the revisions was dramatic, in this study the Delphi process was stopped after only the second round. We suspect that in other situations, several Delphi rounds may be necessary.

The last tableau in Table 5 shows that, using the standard AHP procedure at this stage, Candidates 6, 2, and 5 were ranked first, second, and third, respectively. To examine the degree to which the standard AHP ranking represented a consensus, each DM's second-round rankings of the candidates were summarized. These rankings are presented in Table 6. Candidate 6 was ranked first by only three DMs, while Candidate 2 was ranked first by four DMs. Furthermore, while Candidate 6 was a second choice for three other DMs, Candidate 2 was a second choice for two DMs. When presented with this analysis, the DMs suggested that the standard AHP procedure did not provide them with the consensus ranking or majority view they were seeking. The DMs asked if there was an alternative method that would more closely represent their consensus view.

Group decision making processes and optimal aggregation techniques for ordinal individual ranking have been studied by many researchers [4, 8, 9, 14]. Cook and Kress [13] proposed a network model for deriving the optimal consensus ranking that minimizes disagreement among a group of DMs. Ali *et al.* [2] presented an integer programming approach for consensus ranking. While these techniques are complex, Beck and Lin [5] have developed a very simple procedure called the Maximize Agreement Heuristic (MAH) to arrive at a consensus ranking that maximizes agreement among DMs. MAH is distinguished by its simplicity, flexibility, and general performance. Furthermore, empirical tests by Lewis and Butler [31] have demonstrated that, when compared with more sophisticated

Table 5. Round 2 results

DM	CANDIDATE							CR
	1	2	3	4	5	6	7	
Staff Nurse								
A	0.110	0.080	0.136	0.194	0.083	0.272	0.125	0.05
B	0.093	0.105	0.104	0.144	0.281	0.163	0.110	0.04
C	0.150	0.217	0.113	0.120	0.166	0.131	0.103	0.04
D	0.183	0.237	0.079	0.143	0.066	0.228	0.064	0.05
E	0.130	0.098	0.087	0.191	0.125	0.253	0.116	0.04
F	0.097	0.099	0.105	0.119	0.283	0.149	0.148	0.06
G	0.163	0.172	0.081	0.180	0.076	0.217	0.111	0.04
Nurse Manager								
A	0.127	0.197	0.224	0.083	0.163	0.102	0.104	0.07
B	0.125	0.112	0.177	0.151	0.089	0.135	0.211	0.05
C	0.104	0.234	0.217	0.092	0.155	0.108	0.090	0.06
Nursing Director								
A	0.149	0.179	0.137	0.168	0.162	0.124	0.081	0.05
B	0.211	0.194	0.132	0.132	0.151	0.105	0.075	0.05
Overall Mean Scores								
All 12 DMs	0.137	0.160	0.133	0.143	0.150	0.166	0.112	0.050

multiperson/multiobjective frameworks, MAH provides a reasonably good solution to the problem of finding a group consensus ranking.

Given the data in Table 6 and the DM's desire for a consensus ranking, MAH was used to develop the final ranking of candidates. Table 7 illustrates the process and its outcome. Matrix 7.1 shows the number of times each candidate was preferred to other candidates by one of the DMs. For example, using the individual rankings provided in Table 6, four DMs preferred Candidate 1 to Candidate 2, six DMs preferred Candidate 1 to Candidate 3, etc. Then, as required by MAH, the number of preferences in each row were summed to get the total DM agreement (P_i) for each candidate. Similarly, the number of preferences in each column were summed to get the total DM disagreement (N_i) for each candidate. If any entry in the P column or the N row were a zero, the candidate with that entry would have been placed at the top or the bottom of the final consensus ranking, respectively. Given that none of the P_i or N_i entries in Matrix 7.1 was a zero, the difference in total DM agreement and disagreement ($P_i - N_i$) was calculated for each candidate. Then, the greatest positive difference (+ 18) placed Candidate 6 at the top of the final consensus ranking. Following this placement, Candidate 6 was deleted and a new matrix (7.2) was produced. In matrix 7.2, once again there were no zero entries in the P column nor the N row, and the ($P_i - N_i$) column was calculated. Candidates 2 and 4 both showed the greatest positive difference (+ 14) in the ($P_i - N_i$) column. Therefore, Candidates 2 and 4 were both ranked after Candidate 6. Using this procedure, Candidates 6, 2, and 4 were followed by Candidates 5, 1, 3, and 7. The final consensus ranking of candidates is presented in Table 8. Table 8 also presents alternative cases from our sensitivity analysis which is discussed in the next section.

The DMs were satisfied with the logic and the results of MAH. Although this ranking was not dramatically different from the AHP-based ranking in Table 5, this time the DMs agreed that, as a group, they had ranked Candidates 6, 2, and 4 as their top three choices. They felt more comfortable with the decision process because the criteria and weights were made explicit. Nevertheless, they were concerned about the validity of the overall framework in terms of whether it actually enabled them to choose the best candidate. We pointed out that this issue could not be addressed unless organizations were willing to subject alternative group decision practices to randomized trials in which the successes and failures of each practice would be assessed retroactively. The DMs indicated that they could not think of their decisions as experiments for future improve-

Table 6. Round 2 AHP rankings of the candidates by each DM

DM Group	Individual	Rankings
Staff Nurses	A, B, C, D, E, F, G,	6-4-3-7-1-5-2, 5-6-4-7-2-3-1, 2-5-1-6-4-3-7, 2-6-1-4-3-5-7, 6-4-1-5-7-2-3, 5-6-7-4-3-2-1, 6-4-2-1-7-3-5
Nurse Managers	A, B, C,	3-2-5-1-7-6-4, 7-3-4-6-1-2-5, 2-3-5-6-1-4-7
Nursing Directors	A, B,	2-4-5-1-3-6-7, 1-2-5-4-3-6-7

Table 7. Consensus Ranking Calculations Using Maximize Agreement Heuristic

Matrix 7.1

Candidate	1	2	3	4	5	6	7	P_i	P_i-N_i	
1	0	4	6	5	6	4	8	33	−6	
2	8	0	8	6	8	6	7	43	+14	
3	6	4	0	3	6	5	7	31	−10	
4	7	6	9	0	6	3	9	40	+8	
5	6	4	6	6	0	7	9	38	+4	
6	8	6	7	9	5	0	10	45	**+18**	**←Rank 1**
7	4	5	5	3	3	2	0	22	−28	
N_i	39	29	41	32	34	27	50			

Matrix 7.2

Candidate	1	2	3	4	5	7	P_i	P_i-N_i	
1	0	4	6	5	6	8	29	−2	
2	8	0	8	6	8	7	37	**+14**	**←Rank 2**
3	6	4	0	3	6	7	26	−8	
4	7	6	9	0	6	9	37	**+14**	**←Rank 2**
5	6	4	6	6	0	9	31	+2	
7	4	5	5	3	3	0	20	−20	
N_i	31	23	34	23	29	40			

Matrix 7.3

Candidate	1	3	5	7	P_i	P_i-N_i	
1	0	6	6	8	20	+4	
3	6	0	6	7	19	+2	
5	6	6	0	9	21	**+6**	**←Rank 3**
7	4	5	3	0	12	−12	
N_i	16	17	15	24			

Matrix 7.4

Candidate	1	3	7	P_i	P_i-N_i	
1	0	6	8	14	**+4**	**←Rank 4**
3	6	0	7	13	+2	
7	4	5	0	9	−6	
N_i	10	11	15			

Matrix 7.5

Candidate	3	7	P_i	P_i-N_i	
3	0	7	7	**+2**	**←Rank 5**
7	5	0	5	**−2**	**←Rank 6**
N_i	5	7			

ment of a decision-making practice. They had the responsibility to make the best possible decision today. Thus, in view of their comfort level with the AHP-Delphi process and with the rationale underlying MAH, they decided to accept the rank order generated by MAH and proceed with employment offers to candidates in the order indicated by Table 8.

4.1. Sensitivity analysis

During our engagement with General Hospital neither we nor the DMs saw the need for any sensitivity analysis. After all, the entire process had been iterative. In retrospect, we recognize that sensitivity analysis would have been very useful. Sensitivity analysis not only enables DMs to check how robust a particular decision is, but also helps them learn which steps and what types of judgments are most critical in a particular decision-making process. The lessons learned from such a sensitivity analysis would have been most useful to the DMs at General Hospital as they implement the GDSS in the future without a facilitator. Thus, the omission of a sensitivity analysis represents a limitation of this study. In our future research, we plan to include a thorough sensitivity analysis and we encourage other researchers to do the same.

Although we did not perform a sensitivity analysis in consultation with the DMs, we have now constructed alternative cases which are summarized in Table 8. In Case 1, we chose six of our 12 DMs and one of our seven candidates at random. We considered what would happen if these six DMs increased their respective ratings of the chosen candidate by 10% each. In other words, this was a test of sensitivity of Level 3 ratings. As can be seen from Table 8, the top three candidates remained unchanged,

Table 8. Final consensus ranking and the results of sensitivity analysis

Ranking	Final Consensus Rankings (Candidate)	Sensitivity Analysis		
		Case 1 (Candidate)	Case 2 (Candidate)	Case 3 (Candidate)
1	6	6	6 and 2	6
2	2 and 4	4	4	4
3	5	2	5	2
4	1	1	1	5
5	3	5	3	1
6	7	3	7	3
7	—	7	—	7

although Candidates 2 and 4 were no longer tied for the same rank. Furthermore, Candidates 1 and 5 showed a rank reversal. Overall, our results are fairly robust.

In Case 2, we chose six DMs and one Level 1 criterion at random. Again, we assumed that the six DMs (not identical to the six in Cases 1 or 3) increased their respective weights for the chosen criterion by 10% each. The results were less sensitive than in Case 1. This time, Candidates 6 and 2 were tied for Rank 1 but they were followed by other candidates in exactly the same order as the original solution.

Finally, in Case 3, we chose six DMs and one Level 2 criterion at random. Again, we assumed that the six DMs increased their respective weights for the chosen criterion by 10% each. Again, the results were less sensitive than in Case 1. This time, all candidates were ranked in exactly the same order as the original solution, except that Candidates 4 and 2 were no longer tied for Rank 2.

The above results of our sensitivity analysis, make us particularly confident of our methodology and our recommendations to General Hospital.

5. THE PROPOSED GDSS

The experience at General Hospital suggests a framework for a GDSS that can be useful for technical manager hiring decisions in many large organizations in developed and developing countries. A GDSS consists of all the hardware, software, databases, people, and procedures needed to provide effective support in group decision situations [1]. The proposed GDSS can be implemented on a local area network (LAN) with the relevant databases and model bases on LAN servers. The hiring criteria definitions such as those in Table 2, the criteria hierarchy such as those in Fig. 1, and the candidate qualifications constitute the relevant databases. The first time a GDSS is built for a particular technical manager hiring decision, these databases need to be carefully constructed with the help of a facilitator. Later, only candidate qualifications would have to be updated at the time of each hiring decision. The criteria definitions and hierarchy should be updated every 3 or 4 years.

AHP and MAH constitute the model base of the proposed GDSS. Given the criteria hierarchy in the database, AHP allows individual DMs to arrive at consistent relative weights for the criteria, and consistent relative preference ratings for the candidates. Criteria definitions and candidate qualifications assist this process. Although procedures for arriving at a summary of a group's quantitative responses to well-structured decisions could be easily computerized, the Delphi iterations require an external facilitator to ensure the necessary anonymity and to provide judgment on terminating these iterations. Finally, the MAH heuristic in the proposed GDSS helps arrive at the consensus ranking.

Together, these components of the proposed GDSS assist DMs in articulating their criteria, in arriving at individually and group-wise consistent weights for the criteria and the candidates, and in arriving at the final consensus ranking of the candidates. While this framework for a GDSS was developed in the context of identifying a consensus ranking of nurse manager candidates at a US hospital, the framework would be equally applicable to many other technical manager hiring decisions that require judgments involving qualitative criteria from a group of DMs. The implementation of the proposed GDSS would be divided into three phases.

5.1. Phase 1

During the first phase, each participating group of DMs articulates the relevant criteria

and develops a hierarchy of those criteria. This phase leads to the development of the relevant database. This phase consists of six distinct steps:

1. Each DM develops a list of criteria;
2. Facilitators aggregate individual lists of criteria and develop a comprehensive list for each distinct group of DMs;
3. In addition to reviewing traditional criteria and processes, facilitators undertake a comprehensive literature search to prepare operational definitions of the various criteria and to obtain agreement among the DMs about the validity of these definitions. These definitions ensure that, at each level of aggregation, the criteria are mutually exclusive and collectively exhaustive;
4. Each DM identifies sets of related criteria and rank orders the criteria within each set;
5. Facilitators collect the rankings and develop a synthesized hierarchy of criteria for each DM group;
6. Facilitators and each group of DMs meet to finalize each group's criteria hierarchy, and to become familiar with the formal definition of each criterion.

This phase needs to be repeated only once every 3 or 4 years for a particular technical manager hiring decision in an organization.

5.2. Phase 2

After the criteria hierarchies are developed, the second phase involves the individual DM's assessment of the relative importance of the various criteria and the relative preference for the candidates. This phase consists of five steps:

1. The HR Department makes the initial screening and identifies several eligible candidates;
2. The facilitators familiarize DMs with the principles of AHP and a suitable AHP software (e.g., Expert Choice);
3. Each group of DMs interviews each of the candidates with their criteria hierarchy in mind;
4. The DMs use Expert Choice to do the pairwise comparisons among the criteria at each level of the hierarchy, and to do the pairwise comparisons among the candidates on each subcriterion at the lowest level of the hierarchy. These criteria and subcriteria are developed in the first phase;
5. In cases of logical inconsistencies, Expert Choice alerts individual DMs and encourages a repetition of the previous step.

5.3. Phase 3

Once individually consistent pairwise comparisons are complete, the third phase of arriving at the consensus ranking of the candidates begins. This phase consists of the following steps:

1. Expert Choice computes the relative weights for various criteria and the preference ratings for each candidate;
2. Using the output from Expert Choice, facilitators provide anonymous feedback about each group's average weights and preferences to all the DMs. If the DMs are satisfied that there is adequate consistency within the group, the process proceeds to Step 3 below. Otherwise, the facilitators ask the DMs to go back to Step 4 of Phase 2;
3. Facilitators input the final data from Step 2 to MAH and obtain a consensus ranking of the candidates;
4. We recommend a sensitivity analysis at this point, not only to enable the DMs to check how robust their decision is, but also to help them learn which steps and what judgments, are most critical to their decision-making process;
5. Facilitators hold a final meeting with the DMs. Unless there are unforeseen dissatisfactions, the process of rank ordering candidates ends. Then, the process of employment offers and negotiations begins in the order prescribed by MAH.

5.4. Strengths and limitations of the proposed GDSS

Overall, the experiences in this study are consistent with the previous research on AHP-Delphi, MAH, and GDSS. Specifically, the proposed framework has the potential to increase the quality of group decision making because it affects a group process in four important ways.

First, the use of AHP-Delphi encourages DMs to focus on explicit and functional criteria, rather than to use implicit, biased, or inappropriate criteria such as sex, sexual orientation, or race. These techniques also provide a systematic approach to relatively unstructured problems.

AHP enables DMs to evaluate both qualitative and quantitative criteria by making pairwise comparisons [26]. While AHP recognizes the preferences given individually by each DM and evaluates their internal consistency, Delphi provides feedback about inconsistencies among several DMs. Implementing this framework as a GDSS would provide more immediate feedback to the DMs about their choices and would enhance the integration of various DMs' judgments. Together, these attributes of the proposed GDSS increase the depth of the analysis and contribute to providing a higher-quality decision [1].

Second, in a group setting status differences can reduce the willingness of group members to participate, and a few individuals can dominate the decision process. In AHP-Delphi, DMs are questioned systematically, and feedback is provided anonymously. The logical structure of AHP and the impersonal feedback of Delphi reduce the inhibitory effects of status differences and the potential for domination of the group by a few individuals [30]. Because AHP-Delphi contributes to more equitable participation, DMs are more likely to be satisfied with the process and confident about the outcome [39]. An argument, however, can be made that a DM's judgments may deserve to be weighted differentially depending on the individual's expertise. Otherwise, the judgments of the group's best members may be undervalued. In the available literature, AHP has been adapted to allow for such a differential weighting scheme [44], and some organizations may want to incorporate that adaptation in their GDSS. In any case, an advantage of AHP is that it makes the weighting scheme fully explicit. Consequently, participating DMs are generally satisfied with the process and confident of the outcome, unless the weighting scheme is unreasonable.

Third, group decisions are frequently a source of considerable conflict among DMs, because different individuals typically approach a decision with different sets of criteria and preferences. AHP-Delphi can be viewed as both a conflict generating and a conflict management procedure. In the initial phases of this GDSS, DMs with different organizational perspectives contribute a diversity of viewpoints to the development of the relevant criteria. This kind of conflict generation is seen as productive, because it inhibits the 'groupthink phenomenon' [27]. At the same time, the anonymous feedback of the Delphi technique provides members of each group an incentive to rethink the issues and reconsider their judgments in view of the judgments of other DM groups. Furthermore, the structured and anonymous interaction of AHP-Delphi minimizes the potential for negative conflict among personalities with competing ideas.

Fourth, in today's participative organizations, selecting the best candidate may not be the responsibility of a single DM. Multiple individual rank orderings must be combined into a single group rank ordering. This is a particularly difficult task when the group seeks to reflect a consensus. MAH is a simple and intuitive technique for arriving at a consensus ranking.

To use the proposed GDSS framework effectively, several issues, detailed below, need to be addressed.

First, the procedure assumes knowledgeable DMs [17]. Therefore, careful selection of the participants for the DM group is important. This issue is discussed by Brockhoff [10] and by Preble [41]. In addition, our experience at General Hospital suggests that the process becomes difficult when the total number of DMs involved is as large as 12. In the forecasting context, Winkler [54] and Winkler and Clemen [55] have found that once the number of experts gets into double digits, adding one more expert produces a negligible improvement in resulting forecasts. In the context of sample sizes, Horowitz [28] had made a similar observation much earlier. In view of these observations and our own experience, we believe that the number of DMs should be limited to seven or eight. Similarly, we believe that the number of candidates should be restricted to four or five.

Second, some leading by the facilitators is inevitable in the collating and editing phase of this GDSS as facilitators synthesize the responses of the DMs and restructure the questions. Thus, facilitators must be chosen with care. They must have a commitment to avoid distorting the intent of the DMs' responses.

Third, it is always possible that an individual with formal authority could override the recommendation of a GDSS. AHP-Delphi in combination with MAH minimizes the risks of such an override by making the perspectives of all knowledgeable individuals explicit. That risk

would be completely eliminated only if top management commits itself to the GDSS.

Finally, it would be useful to evaluate the recommended selections of the proposed GDSS in comparison to those of alternative decision-making methods, in terms of the candidates' long-run performance. Unfortunately, DMs in most organizations, like those at General Hospital, do not want to subject their decisions to such true but morally hazardous tests of validity. As one DM at General Hospital said, "We don't want to be evaluated by Monday-morning quarterbacks; we must do what we believe is the best today." We believe that the proposed GDSS provides the DMs with a process for doing their best.

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