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Editorial

Managing Patients and Resources in Nuclear Radiology

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Healthcare costs in the U.S. have increased rapidly in recent years and now exceed those in other nations that provide equivalent or better care. Increased demand for specialized services has been identified as one of the causes of this trend in U.S. healthcare costs [1,2]. Machine time, direct labor time, and radiopharmaceuticals contribute the most to the total cost of each procedure in nuclear radiology [3]. The way these resources are managed has a direct impact in the overall cost and the quality of service to the patient. Increased demand for nuclear radiology procedures coupled with the complexity of the procedures, make managing patient service and resources very challenging.

Nuclear radiology procedures involve multiple activities that are performed in multiple sequential steps following a strict protocol. The activities include administration of a radiopharmaceutical, waiting for the radiopharmaceutical to permeate to the target organs in the body, imaging (scanning), waiting, and re-scanning. The radiation from the decay of the radiopharmaceuticals, which have a very short half-life (minutes to hours), allows for the gamma cameras to take images deep within the body. Consequently, each activity has to be done within a specified time window to allow for high quality images. Furthermore, each procedure typically requires several resources: station (room), equipment (e.g. gamma camera, treadmill), radiopharmaceutical, nuclear radiology nurse, EKG technician, technologist, and nuclear radiology physician. Each step in a procedure can only be performed by a qualified technologist or nurse. The nuclear radiology physicians interpret the results of the procedures.

The nature of managing patient service and resources in nuclear radiology has several challenges. For example, radiopharmaceuticals are typically prepared in remote radio-pharmacies far from the clinic. They have to be managed carefully and their delivery requires a well-planned lead time. The short half-life of the radiopharmaceuticals imposes strict time constraints on scheduling patients and resources. To successfully complete a procedure, every step follows and sequence and has to be initiated and completed within a specific time window. If the procedure protocol is not followed, a poor scan can result, causing poor utilization of expensive resources and patient rescheduling. The duration for scans is minutes to hours. A procedure may require multiple scans in a single day or multiple days depending on the procedure. The equipment used in nuclear radiology such as gamma cameras are very expensive and cost up to US $1 million and must be utilized wisely. The resources required to serve a patient must be available at each step of the procedure. Typically, each step of a procedure requires the scheduling of a pair of resources, a qualified human resource and a station.

Another challenge is that patient requests for an appointment in nuclear radiology are highly stochastic. The requests are typically made by the patient's specialist physician and are handled one at a time as they arrive. Therefore, appointments are typically made without taking into account possible future requests. Improving patient service through techniques to hedge against random disruptions is a major concern in radiology [4]. In fact, only a few commercial packages are available and they provide very rudimentary patient scheduling capabilities based on spread sheets.

One of the current open challenges in health care delivery systems is finding better ways to schedule patients and re-

sources in highly constrained environments. Part of my research work has focused in studying nuclear radiology clinics with the objective of improving their operation while providing a better patient quality of service. For this problem a nuclear radiology patient service management simulation model has been develop that considers both patient and management perspectives. The model incorporates patient and resource scheduling algorithms within the simulation framework. This system provides a novel decision support tool that can help managers in assessing their scheduling decisions based on system performance. The results obtained using this new system provided useful insights regarding the management of patient and resources in a real nuclear radiology clinic. This work has been published in [5].

My second work along this line of research consisted in developing new algorithms to assist managers toward scheduling patients and resources more efficiently in nuclear radiology clinics. Several scheduling algorithms have been proposed for this setting. The performance of these algorithms has been compared to an existing scheduling algorithm currently used by a real nuclear radiology clinic and they have showed improvement for several of the system performance measures including patient waiting time and camera utilization rates. A discussion of the results and the tradeoffs between algorithms is provided in [6] and [7].

The models and algorithms developed for this problem can be adapted to be used in other health care settings or in a different application. The successful implementation of these ideas will contribute to the development of new health IT to aid in patient and resource management in radiology clinics across the US. Nuclear medicine clinic managers will have access to a data-driven patient and resource management methodology that combines patient-oriented and manager-oriented real-time management. Significant benefits to society at large will accrue from improving patient service, safety dealing with radioactive isotopes, and flow through the use of the new methodology; and from healthcare providers utilizing costly resources more efficiently to foster competitiveness and contributing to reducing the cost of overtime and healthcare overall.

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