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# Scheduling Patients in Emergency Department by Considering Material Resources

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**Abstract**

Health organizations are complex to manage due to their dynamic processes and distributed hospital organization. It is therefore necessary for healthcare institutions to focus on this issue to deal with patients' requirements. Preparing a schedule for patients in the emergency department is a complex task, which requires taking into account numerous rules, related to various aspects: respect the triage process (emergency degrees of patients), respect the availability of resources, etc. In this paper, we present a mixed integer linear programming (MILP) approach to facilitate this task. The objective is to minimize the total waiting time of patient's in the emergency department. We consider simultaneously four patients' process: registration and triage, consultation, treatment and hospitalization. The model is characterized by the availability of both human (triage staff, physician, nurse) and material resources (bed) in each process through the stay of patient in the ED except for triage and registration which does not require a bed. To solve this model, we used the commercial solver IBM ILOG CPLEX Optimization Studio. The program has been tested on a set of instances. Numerical results show that the proposed approach can significantly improve the efficiency of emergency department by reducing the total waiting time of patients.


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*Keywords:* Emergency department, mixed integer linear programming, optimization, waiting time, scheduling, patients, material resources.

## 1. Introduction

Nowadays, there are many challenges facing healthcare systems, such as the limited resources, the high cost of medical technology and medication, the high demand, the high customer expectations and the shortage in planning and management decision support tools especially with the complexity of healthcare systems (Feili, H.R [6]). In addition to these challenges, hospitals in developing countries are facing more challenges as the limited government support. Consequently, hospitals are more and more aware of the need to use their resources as efficiently as possible, which urges healthcare organizations to increase emphasis on process optimization in order to control and minimize operating costs and improve the provided services levels. The emergency department (ED) is a complex unit of the

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hospital where the fight between life and death is always a hair's breadth away, requiring a high degree of coordination and inter-relations between human and material elements. According to (Ahmed. M and Alkhamis. T[3] and Dorsaf et al.[5]), emergency department present the crux of hospitals as they serve as a center for medical treatment and as a continuously operating portal for inpatient admissions. In recent years, problems relating to the emergency department has caught a great deal of attention from the operations management community. Previous research published in the literature that adress emergency department problems in healthcare hospital can be divided into three different and related sub-problems, namely (i) sizing of human and material resources, (ii) scheduling of the medical staff, and (iii) scheduling and assignment of patients. Most authors focus on scheduling and assigning of patients (Azadeh et al.[1], Gasmi et al.[2] and Safak Kiris et al.[8]). Some other authors, were interested in scheduling of medical staff (Omar EL-Rifa et al.[7] and H. Feili[6]) and others are interested in sizing of human and material resources (Ahmed. M and Alkhamis. T[3], E. Carbera et al.[4] and Dorsaf et al.[5]).
Patient scheduling is recognized to have a major role on the performance of the health care system. In this context, we propose the scheduling of patients in emergency department by reducing the waiting time of the patients from the arriving until the hospitalization.

The remainder of this paper is structured as follows. The related literature review is provided in Section 2. Section 3 presents a brief description of the problem tackled in this paper. Sections 4 describe the proposed mixed integer linear programming. In section 5, the efficiency of the proposed approach is investigated with the experimental results. And in the final section 6, we close with some concluding remarks and future works.

## 2. Litterature Review

In recent years, health care systems scheduling has caught a great deal of attention. Previous research in this area can be categorized into three main groups: sizing of sizing of human and material resources, scheduling of the medical staff, and scheduling and assignment of patients. In this paper, we are interesting about scheduling patients problem. In France, a recent report of the first national ED conference which gathered health practitioners and government officials decreed the urgency of the problem of long waiting times (Belorgey. N[10]). The report describes several strategies to reduce the potential bottlenecks that cause overcrowding which can also be found in the literature (Akkerman. R and Knip. M[13] , Bruin. AM et al.[14] and Sven. O et al.[15]). Among the recommendations, the authors mention the need to improve patient flow, the need to organize inpatients bed resources and the need to make a better use of available resources.
Azadeh et al.[1] have focuses on scheduling patients in emergency department laboratories (Hematology, CT scan, Radiology, Urinalysis and stool, MRI, ECG) according to the priority of patients' treatments, determined by the triage factor. The scheduling of patients has been modeled as a flexible open shop scheduling problem and a mixed integer programming model has been developed with the objective of minimizing the total weighted completion time of patients. A genetic algorithm is developed for solving the problem. The algorithm is tested on a set of real data from an emergency department.
Gasmi et al.[2] Addresses the problem of overcrowding and waiting time of patients in the ED. Three improvement approaches are proposed to reduce the waiting time: the separation of the flow of incoming patients according to their emergency level, the instalation of an independent medical structure that ensures the continuity of care during the overcrowding of the ED and defining a mechanism for regulating the flow of non-urgent patients to ensurea a good occupancy of consulting box.
Safak Kiris et al.[8], have developed a knowledge-based reactive scheduling system for emergency departments, considering patients priorities, arrival times, flow time, and doctors work load, for the aim of determining the patients who higher priorities initially, and then minimizing their waiting times.
Omar EL-Rifa et al.[7], focus on human resources organization in the ED. They address the personnel scheduling problem (schedule simultaneously physicians and nurses) that depends on an uncertain number of patients and the functional interaction that exists between the different resources of the ED. The objective is to minimize the total expected patients' waiting time. The authors propose a stochastic mixed-integer linear programming solved by an average approximation (SAA) approach. The scheduling of the human resources is then evaluated using a discrete-event simulation model. This approach considers three queues: two assessment queues (patients before and after having auxiliary exams) assured by physicians. The third one is assured by nurses for the treatment of patients.