Analysis of Scheduling Models Applicable in Referral Health Systems

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Abstract— *Scheduling patient referrals is one of the most important administrative responsibilities performed in the medical office. A referral scheduling algorithm can be a useful tool in the hands of a primary provider. Primary providers are lacking knowledge regarding the care and treatment of chronic diseases and are not familiar with the current status of available resources (consultant doctors) for patient referrals. During patient referral there is a need to know of the availability of the consultant doctor and his/her status in terms of the patient workload. Referring a patient to a doctor with many patients on the waiting queue might delay the treatment. This can results in "added healing time, pain, and even death. This paper investigates the scheduling models applicable in referral health systems and hence proposes a suitable scheduling optimization model.*

Keywords— Dynamic, Static, Scheduling, Referral, Model.

I. INTRODUCTION

The main objective of scheduling is an efficient allocation of shared resources over time to competing activities. Emphasis has been on investigating machine scheduling problems where jobs represent activities and machines represent resources. The problem is not only NP-hard, but also has a well-earned reputation of being one of the most computationally difficult combinatorial optimization problems considered to date. This intractability is one of the reasons why the problem has been so widely studied.

The problem of scheduling is concerned with searching for optimal (or near-optimal) schedules subject to a number of constraints. A variety of approaches have been developed to solve the problem of scheduling

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According to a Baseline Study on the Functionality of the Health Referral System conducted between June and July 2013 in eight counties: Garissa, Kakamega, Kilifi, Kirinyaga, Machakos, Nairobi, Nakuru, and Siaya, indicates that the health referral system in Kenya is less than optimal by 60% and the system needs immediate strengthening. (MoH – Kenya, 2014).

II. LITERATURE REVIEW

2.1 Health referral systems

According to (Mehrotra, Christopher, & Caroline, 2011), the current state of the specialty-referral process in the United States provides substantial opportunities for improvement, as there are break downs and inefficiencies in all its components. Despite the frequency of referrals and the importance of the specialty-referral process, the process itself has been a long-standing source of frustration among both primary care physicians (PCPs) and specialists

In England, the implementation of the NHS e- Referral is still undergoing. According to (A Vision for new patient electronic referral service, 2013, June 12) there is a need for a new, re invigorated Vision for an NHS e-Referral Service, which supports a paperless NHS.

The current healthcare system in Scotland does not manage referrals from Primary to Secondary care in the best way possible. There is a need for a framework to help plan and deliver this change. (Patient Pathway management & Referral Facilitation, (2007, March 19))

The current state of health information systems in Phillippines: The national and local health information systems are poorly integrated and are weakly governed (Alberto et al., 2011). These negative conditions create information gaps at the national and local levels.

Armenia's overall healthcare referral system is not well structured: it does not clearly delineate functions, reporting or referral patterns nor does it address instances where the patient should be referred with certain conditions. Providers in Armenia are frustrated with the lack of communication between referral facilities, mainly in regards to the lack of referral and counter referral systems. (Gohar & Karina, 2009).

The Johns Hopkins University and the Basic Support for Institutionalizing Child Survival (BASICS II) Project conducted a study in Imbabura, Ecuador from September 1999 to April 2000 looking at barriers and constraints to referral in a province with 100% IMCI (Integrated Management of childhood illness) coverage. They looked at demographics and socio economic status, family dynamics, caregivers' perceived problems, access, and health system-caretaker interaction. This study found that health worker behavior, namely providing a written referral slip and counseling the caretaker to "immediately seek referral care," was the most important factor in predicting accessed referral. In addition, risk factors of needing to stay overnight and particularly with a child less than two months of age, interaction with each other were important constraints to compliance with referral. Transportation costs and households in which the mother was not the decision-maker were also important factors (Kalter, Salgado, Moulton, Nieto, Contreras, Egas, & Black, 2003)

A referral assessment in Eritrea found that only 38% of referrals found through record review made it to the next level of care (Cervantes, Salgado, Choi, &Kalter, 2003). Very little is known about what happens to severely ill children who do not comply with referral. Among a sample of 81 caretakers in Nepal who were told to seek care at the nearest health facility, but who chose not to do so, 77 sought care at alternative sources, primarily medical shops (75%) and hospitals (22%). The majority (53%) felt that better care was available elsewhere, and 65% felt the recommended facility was too far, closed, or would not have medicine available.

In South Africa, the Government has developed a framework to unify fragmented health services at all levels into a comprehensive and integrated National Health Services (NHS). To achieve the goal, there is a need to reorganize the health care system based on primary health care services, with effective referral systems at the primary, secondary and tertiary care levels (Ministry of Health, South Africa, 2009)

(Atkinson, Ngwengwe, Ngulube, Harpham, & O'Connell,(1999)) study results revealed that in urban Zambia, where people sought care at hospital facilities, not for perceived improved quality services, but because they thought they were less costly and better stocked with drugs

A referral assessment in Ghana showed that with only one out of 34 (3%) caretakers interviewed in the referral sites having been referred. Of the children admitted into the inpatient ward, only 11% had been referred to the hospital (BASICS II and the Ghana Health Service, 2003).

A study in Tanzania where Integrated Management of Childhood Illness (IMCI) strategy was being implemented showed that 91% of sick children and 75% of admissions at the referral hospital came from within a 10-kilometer radius. Only 235 out of the 7,989 children (3%) had been referred to the hospital and the referrals that arrived at the hospital, almost half (48%) delayed by two or more days (Font, Quinto, Masanja, Nathan, Ascaso, Menendez, Tanner, Schellenberg, & Alonso, 2002).

A study in Uganda showed that while health workers perceived that a majority (64%) of children referred complied, the reality was that only 28% actually accessed referral care. Health workers also perceived cost and the availability of transport as the main barriers, although in reality the cost of medical care at the referral hospital was the principal constraint for caretaker's not accessing referral (Ministry of Health Uganda, 2012.).

According to Malgo (2015) research carried out in Uganda on the understanding of the relationship between the state of the referral system and the final delivery of quality care found that the functionality of the referral system changes the level of quality care in the same direction; if the functionality is improved, the quality of care will improve as well.

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2.2 Scheduling models

Previous studies have used analytical and simulation models to explore in detail the scheduling of appointments for outpatient services (Cayirli &Veral, 2003). Applications of the simulation approach have included assessing the impact of alternative appointment schedules on waiting times in a specialty department (Harper & Gamlin, 2003), examining the capacity needed to reduce access times in outpatient departments (Elkhuizen, Das, Bakker, & Hontelez, 2007), evaluating scheduling rules in terms of physicians' idle time when the type of patient requesting an appointment at a later time is unknown (Klassen & Rohleder, 2004), comparing appointment systems for patients with different needs in a multi-facility internal medicine department (Wijewickrama & Takakuwa, 2008), and assessing the impact of operating conditions on the performance of rules for scheduling appointments (Ho & Lau, 1999). Other authors have described the use of computer simulation to support decision-making in outpatient clinics (Erdem et al., 2002), to improve utilization of resources, and to reduce physicians' overtime.

Other investigators have established that the length of time a patient has to wait between referral and consultation depends not only on the method for scheduling appointments and the number and type of referrals, but also on the availability of surgeons for appointments, as these physicians may have administrative, educational, or research commitments in addition to their clinical practices (Harper & Gamlin, 2003).

(Hadwan, Ayob, Sabar, & Qu, 2013) investigated how to minimize the penalty cost of a nurse schedule. (Aickelin and Dowsland, 2004) applied a genetic algorithm to solve the nurse shift schedule problem in hospitals with the aim to minimize the penalty cost for not fulfilling the preferences of the nursing staff. (Maenhout and Vanhoucke, 2013) studied the penalty costs with multiple constraints (including the nursing staff's preferences and some certain combinations of work shifts and days off). (Topaloglu and Selim ,2010) considered a variety of uncertain factors in nurse schedule to propose a fuzzy multi-objective integer programming model which takes into consideration the fuzziness of the objective and the nursing staff's preferences.

Ouelhadj & Petrovic (2009) did a survey research of dynamic scheduling in manufacturing systems. They found that a vast majority of the literature dealing with production scheduling has primarily been focused on finding optimal or near-optimal predictive (static) schedules for simple scheduling models with respect to various criteria assuming that all problem characteristics are known. Such predictive schedules are often produced in advance in order to direct production operations and to support other planning activities. Unfortunately, most manufacturing systems operate in dynamic environments subject to various real-time events, which may render the predictive optimal schedule neither feasible nor optimal. Therefore, dynamic scheduling is of great importance for the successful implementation of real-world scheduling systems.

Apurva, Ketan, & Dipti (2010) developed and simulated Dynamic scheduling for real-time distributed systems using ant colony optimization and found that the proposed algorithm is equally efficient during under-loaded conditions. The performance of Earliest Deadline First decreases as the load increases, but the proposed algorithm works well in overloaded conditions also. Because of this type of property, the proposed algorithm is more suitable for the situation when future workload of the system is unpredictable.

The study by (Liu et al., 2010) focuses on scheduling appointments within the same hospital and not outside. It does not consider expanding the supply to meet the demand

More specifically, the objective of this study is to develop dynamic scheduling algorithm model that explores a wider search space for specialist doctors hence increasing the supply to meet the demand in assigning an appointment date to each patient depending on the clinic's appointment schedule at the time of the patient's need and preferences during referral

Algorithms are used in many health care areas to help clarify treatment guidelines, promote best practices and as an attempt to help non-specialists to properly manage patients with wounds and make appropriate referrals when needed (Alsbjörn, Gilbert, Hartmann, Kaźmierski, Monstrey, Palao, Roberto,Van, & Voinchet, 2007). Wound care algorithms have been used extensively by the Agency for Healthcare and Quality, especially related to guidelines in the treatment of pressure ulcers.

The Veterans Administration podiatry service in Cleveland, Ohio, developed an algorithm to connect the elderly diabetic veteran population with podiatry services and medicine department to facilitate appropriate referral, admission, and management of diabetic foot ulcers (Robbins, Nicklas, & Sarah, 2006).

Whiting and Parnell, (2007) used a referral flowchart to visually describe how referrals are made to the wound care clinic. The referral flow, or algorithm, starts with the ambulant patient with wound acute/chronic/complex being directed to the wound clinic and being examined by wound care experts.

Gottrup (2003) describes the organization of a wound healing center in Denmark, where a multidisciplinary team treats patients with all types of wounds. He describes how referrals are made to the center and the possible treatment course with visual schematics of decision-making trees, or algorithms. This format clearly defines which possibilities the patient with a wound may see for treatment: private practitioner, which in turn refers to the multidisciplinary wound healing team; the multidisciplinary wound healing team directly; or the wound healing center

The use of a referral algorithm is one way to help ensure proper management of patients with wounds, including appropriate referral guidelines (Arntson, 2011)

From the literature, most of the algorithms used in referrals are just mere referral guideline steps in the form of flowcharts. These guideline steps are not able to deal with the emerging issues of constrained resources as well as resources that require mutual exclusion utilization.

2.3 The referral models

2.3.1 The Three Delays framework

The Three Delays framework (Thaddeus and Maine, 1994) is one of the most consulted model in respect of maternal and child health care. The framework is still useful today due to the unfortunate fact that emergency obstetric complications are still one of the largest causes for maternal and neonatal deaths. The framework explains maternal mortality in the context of emergency obstetric complications. This being a major cause for maternal deaths, the author tries to understand what happens in the time span before the eventual complication or death occurs. If a patient receives care on time, the outcome is mostly satisfactory. Therefore Thaddeus and Maine (1994) conclude that a delay in being treated is the biggest reason for maternal deaths. They identify three phases in the decision-making process which can all three lead to a delay in receiving the necessary care as shown in Fig 2.1.

Phase 1 Delay: Decision to seek care

Phase 2 Delay: Arriving at health facility

Phase 3 Delay: Provision of adequate care

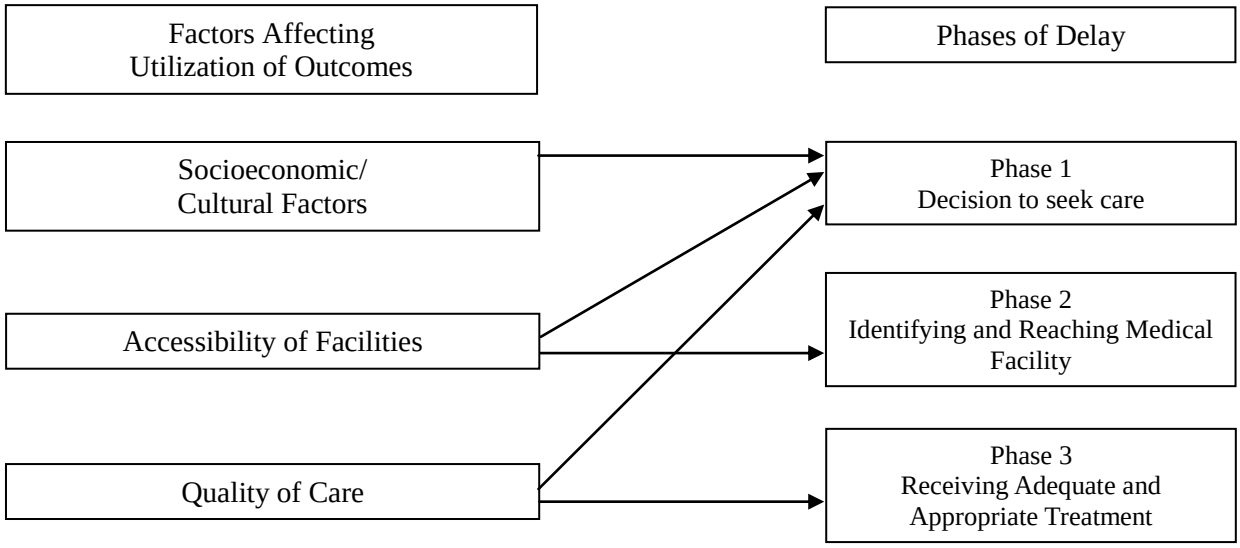

FIGURE 2.1: THREE DELAYS FRAMEWORK
Source: Thaddeus and Maine (1994:1093)

2.3.2 The Access model

(Peters, Garg, Bloom, Walker, Brieger,& Rahman, 2008) designed a conceptual model to assess the access to quality care along four dimensions (Fig. 2.2):

1. Geographic Accessibility (physical distance and possibilities to bridge that distance)

2. Availability (necessary care is present – (human) resources, location, time)

3. Acceptability (relation between social and cultural values of users and of providers)

4. Financial Accessibility (prices of services and the possibility/willingness of users to pay)

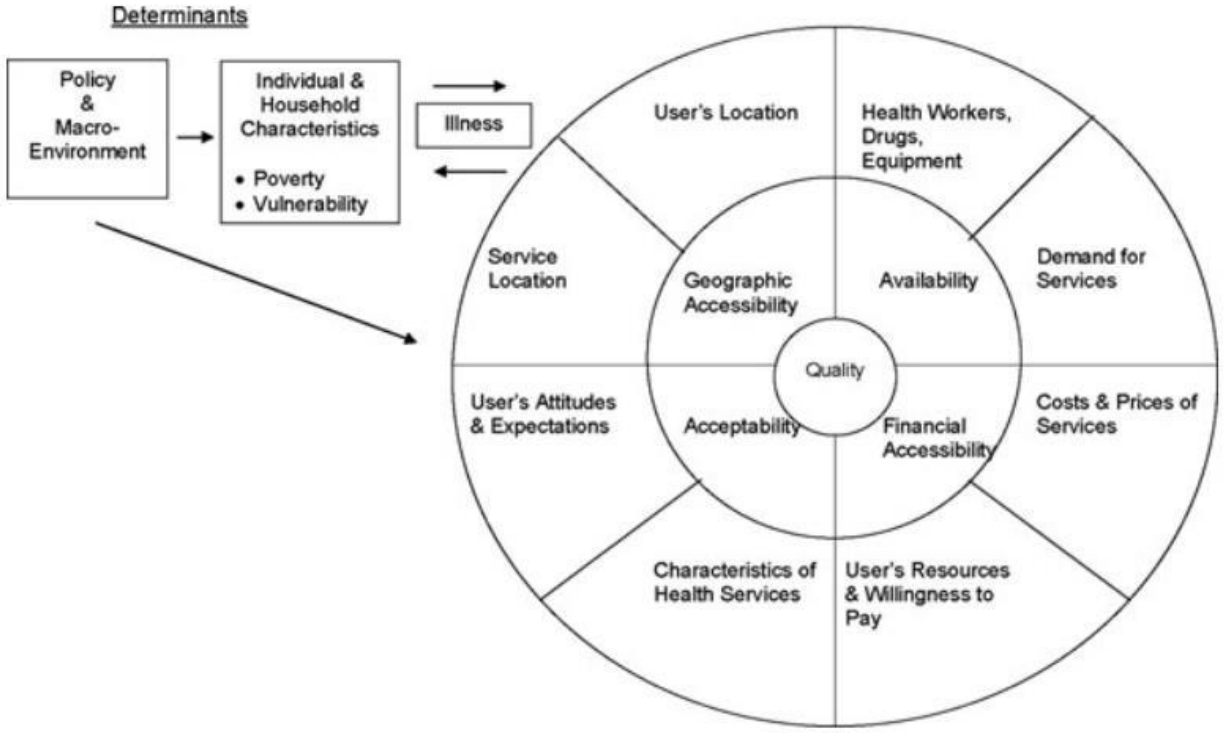

FIGURE 2.2: ACCESS MODEL
Source: Peters et al. (2008:162)

All four dimensions are individually influenced by a factor from the demand side and a factor from the supply side. The policy and macro environmental level and the individual and household level both influence the access to health services and the eventual delivery of overall quality care (Peters et al., 2008). Furthermore it is explained that the poverty level of an individual is an important determinant in establishing that person's health needs, which they describe as 'illnesses. So the level of illness interacts with the level of poverty.

The Access Model is developed in a similar line of thought as the Three Delays Model (Thaddeus and Maine, 1994) so they have some common ground. They both discuss if quality care is within reach for the care seeker and how this influences their decision-making and the eventual care delivery. The Access Model is however applicable to a wider variety of health contexts and does not only focus on maternal health. Also, the Access model tries to explain the relationship between poverty and access to health care, while the Three Delays Model tries to relate the high mortality rates to delays in receiving care.

III. DISCUSSION

Health referral systems are using static scheduling techniques to schedule patients to consultant doctors. Vast majority of the literature dealing with scheduling models have primarily focused on finding optimal or near-optimal predictive (static) schedules for simple scheduling models with respect to various criteria assuming that all problem characteristics are known. Such predictive schedules are often produced in advance in order to direct production operations and to support other planning activities. Unfortunately, most health referral systems operate in dynamic environments subject to various real-time events, which may render the predictive optimal schedule neither feasible nor optimal.

Though the two models (the three delay model and the access model) are both extensively used for analysis and cited in other researches. The models concentrate only on the external influencing factors to access of quality health care but not on how to balance the available resources towards quality health care access. The two models have not considered optimization of available resources which is a very important influencing factor in the referral system as a mean to quality health care access. For the referral system to be successful in delivering quality health care the available resources should be optimized besides influencing factors in the access. Therefore optimization of available resources is a requirement in quality health care delivery.

IV. CONCLUSION

The research proposes a dynamic scheduling optimization model for patient referral system. The model should take into account the influencing factors in the access model.

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