IOSR Journal of Dental and Medical Sciences (IOSR-JDMS)
e-ISSN: 2279-0853, p-ISSN: 2279-0861.Volume 17, Issue 2 Ver. 15 February. (2018), PP 61-66
www.iosrjournals.org

Applying Operations Research Techniques to Minimize Delays in Hospital Operations

Mobin Ahmad
Department of Mathematics, Faculty of Science, Jazan University, Jazan 45142, Saudi Arabia
Corresponding Author: Mobin Ahmad

Abstract: *Operations research (OR) focus on the application of analytical methods to facilitate better decision-making. Regardless of its convenience and multiplication of papers in the scholarly writing, there are as yet significant issues around getting OR models generally acknowledged and utilized as a component of standard basic leadership by clinicians, wellbeing supervisors and approach producers. This paper expects to raise the attention to medicinal services administrators concerning handy OR applications.*
Keywords: *Healthcare; delays; queuing*

Date of Submission: 17-02-2018 Date of acceptance: 03-03-2018

I. Introduction:

Healthcare is riddled with delays. The Institute of Medicine (IOM), the major advisory body to the government and the private sector on health-related issues, identified timeliness as one of the six key aims for improvement in its major report on quality of healthcare in 2001. This was in response to the growing evidence of significant delays across the healthcare industry and the impact of these delays on clinical outcomes.

All of us have sat tight for a considerable length of time or weeks to get a meeting with a doctor or timetable a system, and upon entry we hold up some more until being seen. In healing centres, it isn't unordinary to discover patients accumulated in the crisis division holding up room and on stretchers in corridors sitting tight for beds. Inpatient falls, which frequently result in broken bones and genuine difficulties, are known to be more common when medical attendants are deferred in noting call catches. Albeit sitting tight for benefit is badly arranged and irritating in different circumstances, in medicinal services, postponements can be risky or even savage.

This paper describes some of the major types and sources of delay for healthcare, why they exist, and how an operations research (OR) approaches can help provide insights and guidance for reducing delays, often with little or no increase in costs. In presenting specific examples, this tutorial will focus more on the contextual issues that are important to consider in developing, implementing, and interpreting the results of models than on the technical details of the models themselves. I will also discuss the regulatory, institutional, and systemic obstacles to using these methodologies to improve patient access to healthcare and look at efforts to reduce or eliminate these obstacles in the future.

Notwithstanding its value and expansion of papers in the scholastic writing, there are as yet real issues around getting OR models broadly acknowledged and utilized as a major aspect of standard basic leadership by clinicians, wellbeing administrators and approach producers. This paper expects to raise the attention to social insurance directors as to down to earth OR applications

All of us have sat tight for a considerable length of time or weeks to get a meeting with a doctor or calendar a strategy, and upon entry we hold up some more until being seen. In healing centres, it isn't irregular to discover patients multiplied in the crisis division holding up room and on stretchers in passages sitting tight for beds. Inpatient falls, which regularly result in broken bones and genuine entanglements, are known to be more pervasive when medical caretakers are deferred in noting call catches. Albeit sitting tight for benefit is badly designed and irritating in different circumstances, in social insurance, postponements can be hazardous or even fatal.

Some possible reasons for this include,

i) Low levels of engineering/mathematical background in the healthcare sector
ii) OR scholarly papers written for OR professionals, focusing on specialised and technical topics, and not reaching healthcare professionals
iii) Lack of process-related data for modelling
iv) Lack of in-house OR expertise
v) High cost of engaging external OR consultants Translation from theory to practice is never easy. In our local context, based on the published work, we feel that the awareness and usage of healthcare OR is

probably lower compared to other developed countries. In addition, while OR may require a fair bit of mathematical background, OR is also about using 'common sense'.12 Hence we suggest starting with low-hanging fruits: practical yet simple applications

II. Review of Literature:

The provision of high quality health care at an affordable cost is a major challenge for health care systems all over the world. Figure 1 compares the total expenditure on health care among several countries, as a percentage of the gross domestic product (GDP), [1]. In recent years, health care spending has been rising faster than economic growth in most of the countries depicted in the figure. In many countries, the bulk of annual spending growth is due to increases in the prices of health care goods and services, and the availability of ever more new, often high-cost medical products and treatments. As a result, health care providers are facing ever greater pressure to reduce operational costs without affecting the level and quality of their services.

Application Areas of Operations Research

In the context of material and patient flows, hospital logistics and OM provide a broad range of applications suitable for analysis using OR techniques. An area that has received considerable attention among operations researchers is workforce scheduling, and in particular, nurse rostering.

The issue of building work timetables for attendants to cover fluctuating interest prerequisites is to a great degree troublesome. The programs must fulfill work directions, recognize perpetual and easygoing staff, dole out reasonably qualified medical caretakers, disseminate night and end of the week moves even-handedly among attendants, take into consideration leave and days off, and suit a scope of worker inclinations. Straight, blended whole number and objective programming and also requirement programming strategies have been created to produce nurture lists. Genuine issues are regularly finished compelled so finding a decent quality arrangement requires propelled heuristics inside sensible figuring time. Thus, different metaheuristic methodologies, for example, re-enacted tempering, tabu inquiry, variable neighbourhood seek, scramble look, and hereditary and mimetic calculations have been proposed, and the quantity of utilizations is quickly growing. For surveys of the broad writing on nurture rostering we allude to Burke et al. [5] and Lim et al. [18]. Arrangement planning has additionally been a rich research region over the previous decades, see Gupta and Denton [11]. The way toward appointing availabilities for serving out-and inpatients emerges in demonstrative and treatment units and manages unverifiable administration times, no-shows, cancelations, and walk-ins. A decent arrangement plan keeps quiet holding up times short and limits staff extra minutes considering the patient load and the accessible assets (i.e. staff, rooms, and hardware). Generally utilized methodologies fall into four classifications: scientific programming (deterministic and stochastic), heuristics, lining hypothesis, and reproduction. Working venue arranging and booking (OTPS) has likewise gotten much consideration in the previous 60 years. The vital (long haul) arranging level tends to scope quantification given a figure of patient request. Normally, surgery rooms and square circumstances are doled out to each surgical office over a given day and age. The strategic (mid-term) arranging level manages the production of week after week/month to month (harsh) plans for elective surgeries. At the operational (here and now) arranging level, the following day's surgery plan is created by setting the arrangement of surgeries inside each working room and doling out beginning circumstances to surgeries and also particular assets. At last, the web based arranging level manages rescheduling beforehand arranged surgeries because of unexpected occasions, for example, postponements, crises, and cancelations. The rich and as yet developing writing on OTPS covers an extensive variety of OR philosophies (numerical programming, heuristic methodologies, and re-enactment) for deterministic and stochastic conditions. The intrigued peruse is alluded to the exhaustive survey via Cardoen et al. [8]. The interface between the working theatre and other healing facility units (e.g. serious care, post anaesthesia mind, nursing wards) is step by step getting expanding consideration, see e.g. Hans and Vanberkel [15]. Vital working room arranging has a place with the class of asset designation and scope organization issues.

This class involves decisions concerning the mix and volume of patients treated by a hospital and the amount, capability, and type of resources (i.e. workforce and facilities such as rooms, beds, medical diagnostic and monitoring equipment) for the delivery of health care. Hospital layout planning also arises at the strategic level but has received much less attention.

The point is to plan a healing facility, a center or an office to limit the developments of patients and going with assets, for example, medicinal staff and gear, see Vos et al. [23]. Quadratic whole number programming models were proposed by Butler et al. [6, 7] and Elshafei [10] for issues emerging around there.

Despite the vast body of literature on production planning and inventory control, the translation of well-known practices into the hospital environment is not as widespread as might be hoped. Purchasing, distribution, and inventory management of medical supplies could greatly benefit from OR. Rossetti et al. [21] describe in their recent review the main aspects of inventory management within health care and present techniques and technologies for medical supply logistics. In the context of patient logistics, planning transports

for inpatients among health care units within the hospital has received increasing attention in recent years. Patient transportation is a variant of the dial-a-ride problem (DARP) and concerns finding a set of minimum-cost routes and schedules for a fleet of ambulances (or hospital staff) to transport (or escort) inpatients between nursing wards and diagnostic units. Hospital-specific constraints (e.g. different priorities of requests, need for special equipment and assistance of medical staff during transportation, and incomplete knowledge of transport bookings in advance) significantly complicate the development of high-quality vehicle routes and schedules. Route quality is measured by two conflicting criteria, namely the minimization of fleet operating costs and the maximization of patient satisfaction. The latter is often controlled by imposing a limit on the ride time of each patient and on minimizing deviations from the desired times for pickup and delivery. Due to its combinatorial nature, the DARP is extremely difficult to solve and this has fostered the development of new OR methodologies, in particular of new (meta-)heuristics. For example, Beaudry et al. [2] and Kergosien et al. [17] proposed tabu search based approaches, while Hanne et al. [14] embedded an evolutionary algorithm in a software application designed to support all phases of the transportation flow including request booking, scheduling, dispatching, monitoring, and reporting. While the above list of applications of OR in hospital logistics and OM is by no means exhaustive, it illustrates the wide-range opportunities for OR within the hospital environment. For literature describing the state-of-the-art in health care operations management the interested reader is referred to Hall [12, 13]. A recent review of OR contributions in health care is provided by Rais and Viana [20]. Vissers and Bleech [22] introduce a number of concepts relevant to OM in health care and illustrate them through various case studies. Brandeau et al. [4] also describe applications of OR in various health care areas. Finally, ORchestra is an online database of the literature in the field of OR/Management Science in health care, [9, and 19].

III. Three Sources of Dangerous Healthcare Delays

Emergency Department Delays

Arguably, the most critical delays for healthcare are the ones associated with healthcare emergencies. Unfortunately, emergency department (ED) overcrowding is a continuing and growing problem. In a 2007 survey (American Hospital Association [2]), nearly half of all U.S. hospitals and 65% of urban hospitals reported being at or over capacity in their emergency rooms, resulting in long waits before being seen by a physician and delays of many hours or even days in getting a hospital bed. Each of these sources of delay can be life threatening.

Delays for ED Physicians

Deferrals for crisis mind for the most part start with the hold up to be seen by a doctor. Numerous patients who touch base to an ED are "nonurgent" and would not be hurt by critical postponements in observing a doctor. Nonetheless, many, if not most, are either "new" (requiring "prompt" care) or "dire" (requiring care inside a "short" timeframe). However late investigations have uncovered that holds up to see an ED doctor are long and deteriorating. The general middle hold up to see an ED doctor expanded from 22 minutes in 1997 to 30 minutes by 2004. Maybe considerably more alarmingly, the middle sit tight for patients determined to have intense myocardial localized necrosis (AMI) (heart assaults) expanded from 8 minutes in 1997 to 14 minutes in 2004 (Wilper et al.). These figures are extensively higher in urban territories and for showing healing centres, where most crisis mind is conveyed. Given the criticalness of quick treatment for casualties of heart assault (and also for sepsis, stroke, pneumonia, and injury, among others) these figures, and also narrative reports of patient passing in EDs, demonstrate that these postponements are a genuine danger to the wellbeing and prosperity of every one of us. Likewise, past investigations have set up a solid connection between long crisis division delays and the portion of patients who leave without being seen (LWBS) (Green et al. [16], Fernandes et al. [8]). The extent of patients who LWBS is itself a critical measure of crisis office execution and nature of care, A few investigations have reasoned that patients who LWBS are debilitated and do require crisis mind. One examination has demonstrated that up to 11% of patients who leave without being seen are hospitalized inside a week and 46% of patients were judged to require prompt restorative consideration (Baker et al. [5]).

Delays for Inpatient Beds

Though inadequate ED doctor levels are in charge of huge and genuine deferrals in crisis mind, the single greatest reason for ED packing is an absence of inpatient beds (American Hospital Association [2]). Around 25% of ED patients are admitted to the doctor's facility and roughly 40% of inpatients get through the ED. For healing centers detailing ED limit issues, the normal time to move a patient from the ED to an inpatient bed once the choice to concede has been made is more than 4.5 hours, and bed postponements of more than 24 hours are normal (McCaig and Burt [21]). These postpones prompt substantial quantities of patients in the ED who strain the capacity of the doctors and medical attendants to nurture them. This ED packing likewise bargains the capacity of ED doctors to treat fresh debuts to the ED. At the point when this sort of circumstance

ends up plainly untenable, a healing facility will for the most part go on rescue vehicle preoccupation—suspending new emergency vehicle landings to the ED. In a 2007 review, over portion of all urban and showing healing facilities announced being on redirection in the previous a year (American Hospital Association [2]). At the point when healing centers are on preoccupation, genuinely sick patients need to head out further to get to the closest clinic, expanding their hazard for unfriendly results. Also, because of the expanded travel time, sits tight for ambulances increment, additionally jeopardizing patients. An examination in light of information from New York City demonstrated that when there are critical levels of emergency vehicle redirection in a precinct, the quantity of passings because of AMI increments by 44% (Yankovic et al. [37]). Bed postponements can happen notwithstanding when inpatient beds are accessible. This is on account of patients and beds are not all indistinguishable. Doctor's facilities are partitioned into nursing units, which regularly comprise of in the vicinity of 20 and 50 beds. Each nursing unit is utilized for at least one clinical administrations (i.e., therapeutic, surgical, pediatric, obstetrics, cardiology, neurology). So a patient with coronary illness who is sitting tight in the ED for a bed may encounter a huge postponement if all the cardiology beds are possessed, despite the fact that beds might be accessible in another clinical unit. Likewise, a few patients require telemetry beds, which, in numerous healing centers, are not accessible in all nursing units. At long last, most doctor's facility rooms have at least two beds that can be utilized just by patients of a similar sexual orientation. So it is workable for, e.g., a female patient to be postponed in getting an inpatient bed if the main beds that are accessible are in rooms involved by male patients. The most well-known deferrals for inpatient beds are for basic care beds (American Hospital Association [2]). Serious care units (ICUs) are generally the most costly units in the doctor's facility because of both the innovation used and the abnormal state of staffing required. The full per-day cost in an ICU is around three to five fold the amount of as in a customary inpatient unit (Groeger et al. [17]), and in this manner, healing facility executives trust that these beds ought to be profoundly used keeping in mind the end goal to be "cost productive." Consequently, delays for these beds, which are utilized for the most truly sick and harmed patients, are frequently the longest.

Delays for Medical Appointments

Difficulty in getting a timely appointment to see a physician is a very common problem. In one study, 33% of patients cited inability to get an appointment soon as a significant obstacle to care (Strunk and Cunningham [32]). For most patients, their primary care physician is their major access point into the healthcare system. Yet primary care practices often have long waits for appointments. The average wait for a primary care appointment in the United States in 2001 was over three weeks (Murray and Berwick [25]). A more recent survey in Massachusetts found that the average delay was over six weeks (Mishra [24]). Long appointment backlogs result in difficulty in accommodating patients who have potentially urgent problems. As a result, patients experience delays in treatment that may result in adverse clinical consequences and patient dissatisfaction. Two-thirds of all primary care physicians work in group practices, so patients who cannot get an appointment with their own physician may instead be seen by another physician in the practice. However, continuity of care has been identified as an important factor in accurate diagnosis and appropriate treatment (Smoller [30]). Another adverse consequence of long waits for appointments is the use of the ED for primary care, contributing to the overcrowding mentioned above. From the physician practice perspective, large backlogs may require additional staff and resources to deal with patients trying to get appointments for the same day, and are often correlated with a high rate of cancellations, resulting in a loss of revenue for the practice.

Delays for Nursing Care

In a historic point report entitled "To Err is Human" (Institute of Medicine of the National Academies of Science [19]), the IOM revealed that therapeutic mistakes in doctor's facilities are in charge of in the vicinity of 44,000 and 98,000 passings every year and for more than one million wounds. A later report from Healthgrades [18] gauges the quantity of passings to be 248,000 every year. Indeed, even at the least level, this suggests a bigger number of individuals are murdered by medicinal blunders than bite the dust from auto collisions or most types of disease. Despite the fact that the reasons for these preventable passing are various, late examinations have demonstrated that lacking attendant staffing levels are a central point in the pervasiveness of therapeutic mistakes (Aiken et al. [1], Needleman et al. [28]). This isn't astonishing in light of the fact that many nursing errands are time touchy. These incorporate organization of drugs, reacting to understanding call catches, and managing crisis confirmations. In spite of the fact that nursing workloads have expanded as of late because of a higher level of elderly and more diseased inpatients and shorter clinic lengths of stay, staffing levels in many doctor's facilities have either stayed static or, much of the time, diminished. Nursing costs involve an extremely considerable part of clinic spending plans, and in this manner, cost-effective medical attendant staffing is vital. In many clinics, the quantity of medical caretakers allocated to a unit is controlled by a predefined proportion of patients to attendants.

Albeit most healing facilities buy in to these guidelines, cost weights and a national nursing deficiency have brought about these proportions being surpassed by and large. In some cases, nonetheless, this is the after effect of an inability to sufficiently anticipate the day by day, week after week, and at times occasional varieties in doctor's facility registration that are regular in most clinical units of for all intents and purposes each doctor's facility. Lacking inpatient nursing levels are additionally a main consideration in delays for beds in the ED. For a patient to be exchanged to an inpatient bed from the ED, an attendant should be accessible to deal with the admission to the unit. So if the staffing level in the unit is with the end goal that the medical caretakers are exceptionally used, numerous patients sitting tight for a bed in that unit will keep on waiting notwithstanding when a bed ends up plainly accessible. Nursing levels likewise assume a part in delays for mind inside the ED. As in different parts of the healing center, medical caretakers are the essential directors and overseers of patients. In the event that the quantity of patients in the ED gets too high for the medical attendants to deal with, either fresh introductions won't be taken into the treatment region until the point when a portion of the patients are released or moved to inpatient beds, or, if the ED is extremely congested, the healing center may go on rescue vehicle redirection. Postponements because of absence of nursing faculty are apparently more dangerous in the ED for a few reasons. To begin with, the requirement for expedient treatment is more dire. Second, the fluctuation in the volume and example of patient landings, and in addition their decent variety, make it more hard to anticipate nursing needs. Lastly, the worry of the workplace in the ED makes it harder to draw in and hold medical attendants and the levels of non-attendance are for the most part higher than in whatever is left of the doctor's facility.

IV. Conclusion:

Several practical OR applications have been described in this paper. There are other healthcare domain where OR techniques will be helpful, such as reducing delay in healthcare release, smoothing of elective admission to decrease peak bed occupancy, and optimal deployment of ambulances. Decision-making is composite especially when it involves a group of stakeholders. Using quantitative (OR) techniques and data help to present objective argument. Expert opinions, such as judgement on future healthcare disease burden, could then be used to fine-tune the quantitative models.

References:

[1]. World Bank. Health expenditure. Available at http://data.worldbank.org/ indicator/SH.XPD.TOTL.ZS (accessed on May 15, 2012), 2012.
[2]. A. Beaudry, G. Laporte, T. Melo, and S. Nickel. Dynamic transportation of patients in hospitals. OR Spectrum, 32:77–107, 2010.
[3]. M. Beaulieu, S. Landry, and J. Roy. The productivity of hospital logistics operations. Technical report, Centre sur la productivit´e et la prosp´erit´e, HEC Montr´eal, available at http://cpp.hec.ca/cms/assets/documents/recherches_publiees/CE_2011_06.pdf (accessed on May 15, 2012), 2012 (in French).
[4]. M.L. Brandeau, F. Sainfort, and W.P. Pierskalla, editors. Operations Research and Health Care. A Handbook of Methods and Applications, Kluwer's International Series. Springer, Dordrecht, 2004.
[5]. E.K. Burke, P. De Causmaecker, G. Vanden Berghe, and H. Van Landeghem. The state of the art of nurse rostering. Journal of Scheduling, 7:441–499, 2004.
[6]. T.W. Butler, K.R. Karwan, and J.R. Sweigart. Multi-level strategic evaluation of hospital plans and decisions. Journal of the Operational Research Society, 43:665–675, 1992.
[7]. T.W. Butler, K.R. Karwan, J.R. Sweigart, and G.R. Reeves. An integrative model-based approach to hospital layout. IIE Transactions, 24:144–152, 1992.
[8]. B. Cardoen, E. Demeulemeester, and J. Beli¨en. Operating room planning and scheduling: A literature review. European Journal of Operational Research, 201:921–932, 2010.
[9]. F. Dexter. Bibliography of operating room management articles. Department of Anesthesia, University of Iowa, USA, http://www.franklindexter.net/bibliography_TOC. htm, 2012.
[10]. A.N. Elshafei. Hospital layout as a quadratic assignment problem. Operational Research Quarterly, 28:167–179, 1977.
[11]. D. Gupta and B. Denton. Appointment scheduling in health care: Challenges and opportunities. IIE Transactions, 40:800–819, 2008.
[12]. R. Hall, editor. Patient flow: Reducing Delay in Healthcare Delivery, volume 91 of Springer International Series in Operations Research & Management Science. Springer, New York, 2006.
[13]. R. Hall, editor. Handbook of Health Care System Scheduling, volume 168 of Springer International Series in Operations Research & Management Science. Springer, New York, 2012.
[14]. T. Hanne, T. Melo, and S. Nickel. Bringing robustness to patient flow management through optimized patient transports in nospitals. Interfaces, 39:241–255, 2009.
[15]. E. Hans and P. Vanberkel. Operating theatre planning and scheduling. In R. Hall, editor, Handbook of Health Care System Scheduling, Springer International Series in Operations Research & Management Science, chapter 5, pages 105–130. Springer, New York, 2012.
[16]. S.H. Jacobson, S.N. Hall, and J.R. Swisher. Discrete-event simulation of health care systems. In R. Hall, editor, Patient flow: Reducing Delay in Healthcare Delivery, Springer International Series in Operations Research & Management Science, chapter 8, pages 211–252. Springer, New York, 2006.
[17]. Y. Kergosien, Ch. Lente, D. Piton, and J.-C. Billaut. A tabu search heuristic for the dynamic transportation of patients between care units. European Journal of Operational Research, 214:442–452, 2011.
[18]. G. Lim, A. Mobasher, L. Kardar, and M.J. Cole. Nurse scheduling. In R. Hall, editor, Handbook of Health Care System Scheduling, Springer International Series in Operations Research & Management Science, chapter 3, pages 31–64. Springer, New York, 2012.

[19]. ORchestra. An online reference database of OR/MS literature in health care. Centre for Healthcare Operations Improvement & Research, University of Twente, The Netherlands, http://www.utwente.nl/choir/orchestra, 2012.
[20]. A. Rais and A. Viana. Operations research in healthcare: A survey. International Transactions in Operational Research, 18:1–31, 2010.
[21]. M.D. Rossetti, N. Buyurgan, and E. Pohl. Medical supply logistics. In R. Hall, editor, Handbook of Health Care System Scheduling, Springer International Series in Operations Research & Management Science, chapter 10, pages 245–280. Springer, New York, 2012.
[22]. J. Vissers and R. Beech, editors. Health Operations Management: Patient Flow Logistics in Health Care. Routledge Health Management Series. Routledge, New York, 2005.
[23]. L. Vos, S. Groothuis, and G.G. van Merode. Evaluating hospital design from an operations management perspective. Health Care Management Science, 10:357–364, 2007.
[24]. Ernst & Young. Health barometer 2010: Survey on the quality of health care in Germany. Technical report, available at http://www.ey.com/Publication/vwLUAssets/ Gesundheitsbarometer_2010/$FILE/Gesundheitsbarometer%202010.pdf (accessed on May 15, 2012), 2011 (in German).

Mobin Ahmad "Applying Operations Research Techniques to Minimize Delays in Hospital Operations.". "IOSR Journal of Dental and Medical Sciences (IOSR-JDMS), Volume 17, Issue 2 (2018), PP 61-66.