

Application of Operation Research in Healthcare Industry

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Abstract: This paper represents an overview of Application of Operation Research in Healthcare Industry.

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1. Introduction

According to research, "The healthcare market can triple to \$8.6 trillion (\$133.44 billion) by 2022. India's public health spending was 1.2% of GDP in the 2021 budget". As a result, the use of OR in the field of healthcare is a must to make the industry more efficient and to cope up with the changing technology in the market forces. The industry must move into a more reliable solution and improve hospital's efficiency and level of service, decision support systems, which OR enable to make better decisions. Operations research (OR) methods have been applied to hospital operations to improve effectiveness and efficiency.

The operational techniques used in this report consist of several approaches such as:

- *The queuing theory:* Helps to calculate the expected number of people in the queue, the estimated time, etc. This theory can be applied when decisions need to be made to minimize the length and duration of the lines with minimal investment costs.
- *Simulation model:* A technique that involves building a model of the actual situation and then conducting experiments. Used to know more about the situation
- *Integer programming model:* Used when one or more variables can only accept integer values.

The above techniques help the healthcare industry to apply Operation Research.

Operations Research (OR) focuses on applying analytical methods to enable better decision-making. Hospital managers were giving tasked with developing innovative strategies to deliver high-quality healthcare effectively and efficiently to patients. As a result, Operation Research could apply to many healthcare aspects such as cost and supply, distribution and service, and transportation of ambulances. The report will provide an overview of OR in healthcare to give the reader a global understanding of its application.

The healthcare industry is experiencing tremendous global change as the world's population increases, and medical treatment becomes more sophisticated. These have implications for how healthcare organizations operate. Healthcare organizations were confronted with providing better, more efficient, and more profitable healthcare services. The need to innovate is expected in this field. Healthcare providers must formulate strategies to remain competitive and improve profitability.

2. Literature Review

The healthcare industry is the most critical because it is the question of life and death. Operations Research techniques enable the industry to utilize its resources more efficiently, meet performance targets, manage costs, and find optimum solutions. The efficient functioning of this industry depends on how it allocates resources and addresses the problems faced. The study aims to list the different problems faced by industry and how OR is used to cater to these problems and find optimal solutions. This report will divide the industry into four sub-sections – hospitals, patients' appointments, supply chain management, drug wastage to see the optimal solutions using OR to solve difficulties. Substantial published research evaluates the use of operation research to analyze and design problems in the healthcare industry. Our research is exclusively focused on secondary research; references we have used for our study are:

- Finareli and Johnson (2004)⁵ elaborates a nine-step quantitative demand forecasting technique for the availability of healthcare services within right time and place.
- Patrick et al. (2008) gave a model of patient scheduling, and Turhan et el. (2013) used a heretic model called the fix and optimize for patient scheduling which helped in the appointments of patients and their cancellations.
- Gavin and savin (2008) gave a single server queue model to deal with the last-minute cancellations of orders and appointments.
- Mohanty and Chakravarty⁴ found uncertainty and imbalance between the number of patients and the

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availability of medicines in hospitals during epidemic disasters. These findings suggest the need for more serious attention to the supply of medical conditions in situations of natural disasters, especially drugs, which helps in the inventory control of medicine in hospitals.

There are also some of the other studies present, and which also provides an overview of the Operation Research, its problems, and the techniques to solve those problems to improve the productivity of the companies.

3. Or Model to Support Healthcare Management

In healthcare operations management, the purpose of an OR model is to persuade the appropriate stakeholders to make modifications in systems for better efficiency.

1) *Making an outpatient appointment*

The fundamental problem is when patients have been given an appointment to see one or more doctors. The patient may arrive on time, early, late, or not at all and was seen by a doctor in order of arrival. We want to avoid the healthcare staff being idle because patients did not show up or took less than the allotted time. In 2003 an outpatient clinic in Royal Lancaster Infirmary in England. A study was undertaken to investigate the potential in re-organizing scheduling in these clinics.

2) *Modeling Approaches*

Process Mapping and Bottleneck Analysis: This method has been recommended by the NHS Modernization Agency and encourages its facilitation. The first three guides look at how departments can identify areas for change by using Process Mapping Analysis and Redesign, Measurement for Improvement, Matching Capacity, and Demand. For this example, Clinic Capacity = Clinic Duration/ doctors*mean consultation time. This type of modeling helps stakeholders appreciate the problem and enables them to identify a solution improving efficiency. However, it gives no guidance on the precise form of explanation, and in addition, the approach tends to be naive.

Steady-State Queueing Models: Like bottleneck analysis, this model reinforces those improvements in waiting time can be made by:

- Reducing consultation time
- Growth in the number of doctors
- Modifying arrival rate of patients

However, this method is not capable of making accurate predictions because clinic behavior is typically time-dependent

- **Partial Simulation Modelling:** Here, Simulation addressed two issues: discovering the practical clinic capacity and setting a revised appointment system. Clinic Capacities, a spreadsheet is used to simulate randomly generated consultation times, showing the bottleneck technique as inadequate when calculating actual clinic capacity.
- **Time-Dependent Queue Modelling:** In addition, while the average measures of performance are perhaps the most important, they provide very little insight into the range of clinic performance levels to expect in practice. In contrast, a time-dependent queue

modeling approach can ensure that statistically, the delegate result for the whole clinic duration was obtained efficiently. At a more satisfactory level of detail, it cannot show, for example, the added benefits of scheduling patients with a higher chance of not attending later in the clinic.

4. Application of Operation Research Technique in Healthcare

The report discussed that it has become quite difficult to manage hospitals with the increase in population. Therefore, to provide high-quality medical services, the application of operations research is used in the medical industry for their room planning, emergency department staffing, and long-term planning to provide better treatment.

One of the problems in the healthcare industry is the optimal configuration of their emergency vehicles because this is a life-and-death situation for a person. The fundamental goal of the structure is to cover the most considerable population within a single unit and travel with the smallest distance so that they can reach the hospital faster. So, these researchers used Linear Programming to determine the ambulance location, and to testify its effectiveness, they also used Simulation.

The researchers developed a comprehensive Quantitative Demand Forecasting Model, which is collect historical data, analyze historical trends, identify key demand drivers, recognize relevant benchmarks, prove existing conditions, create core assumptions for population-based needs, create core assumptions for provider-level requirements, make a baseline forecast of future demand, test the validity of predictions against changes in core assumptions. This method helps them analyze market trends and understand the potential future needs to a certain extent. Several OR scholars used the Integer Programming Model to solve the problem of access to health services in rural areas. In hospitals where the number of patient appointments has increased, there are also long waiting times. One of the researchers also used Queueing Theory, which solves the last-minute cancellation of appointments by patients.

5. Operations Research in Nurse Rescheduling

Previous studies have shown that inconsistencies or dissatisfactions between what nurses anticipate of their work schedules and what they experience are solid predictors for their commitment to leave. The Rochester Methodist Hospital was used because many factors showed that the Methodist hospital was well placed to conduct the research and implement its results.

- **The rotation problem:** The planning problem addressed in the research plan was maintaining an efficient workforce. However, the undeniable signs indicated a likely recurrence of a nursing shortage that would last longer than the cyclical shortage of the past.
- **Three Experimental Schedules:** The primary two experimental sets were assigned either conservative shifts or computer-assigned scheduling. The third group designed their program, which was classified as

a selected plan. The second, complex program aimed to give nurses flexibility and the ability to customize their schedules. In the complicated schedule, a computerized arrangement was used to generate a monthly schedule based on a combination of the day-to-day needs of the unit in the unit and the requirements of its employees. Each station selected two RNAs and one LPN to advance the schedule based on group ideas. The guidelines for budget and legal constraints were specified to each workstation, and the nursing administration helped if the treatment groups needed help.

- *Random Sampling:* The data was collected from all nurses and registered nurses who were regularly assigned to nursing wards. Because the primary goal of this intervention was to monitor nurses on a ward, a random sample was used for stations rather than specific people. Type B units were predominately surgical and more frequently circular. Therefore, a fully balanced sample in the 3 stratification variables was not possible.

1) *Immediate Results*

Indicate significant differences in scores between the experimental and control groups after the experimental treatments were administered. In contrast, before the intervention, there was a difference in only one scale. Select-a-plan scheduling group was significantly different from the control in some scale's expectation of a work Schedule that enables communication with the day department, the expectation of being able to control working hours, discrepancies in work schedules that promote an ideal professional care environment, and predictable work differences.

2) *Later Results*

Later The number of turnover cases was insufficient to make statistically significant generalizations. Two years after the experiment was completed, the actual sales figures continued to favour the experimental groups. Again, the numbers were insufficient for statistical analysis. During the third year, the actual turnover rate between the trial and control groups was similar.

6. Using Operations Research to Reduce Delays in Healthcare

Delays plague medical services. There is growing evidence of significant delays in the healthcare industry and the impact of these delays on clinical outcomes. This research paper will describe some of the main types and sources of health care delays, why they exist, and how operations research (OR) methods can help provide information and guidance to reduce delays, usually only adding minimal or minimal costs.

1) *Why are healthcare delays so bad?*

With the advent of price deregulation and increasing pressure from governments, employers, and managed healthcare organizations, hospitals are forced to reduce costs. Also, the demand for medical care is highly concentrated in a small part of the population. Unfortunately, these are not just local

problems, and they are often the result of national shortages.

2) *Obstacles to using OR to reduce healthcare delays*

Lack of operational and performance data: Hospitals and other healthcare providers do not collect operational performance data, including delays; however, some hospitals collect delays in hospital beds in emergency rooms. They usually do not collect them by clinical unit or type of service. Therefore, there is no easy way to determine which services have been chronically short of bed capacity. Although hospitals and doctors usually keep certain types of operational data, such as arrival at a facility, hospital stay, appointment time, etc.

Physician resistance: Although hospital resources are controlled primarily by physicians, most physicians are not hospital employees in most hospitals. This makes it difficult for doctors to adopt new practices. Even if doctors are employees, hospital administrators are often unwilling to pressure them to change their behavior. This is because a hospital's reputation mainly depends on the doctors' importance, and the competition for good doctors may be fierce, especially in certain specialties. Estimating demand: One of the biggest obstacles to using OR methods to reduce delays in healthcare is determining the "real" need for healthcare services. First, because most health care costs are paid by third parties rather than by consumers themselves, demand is primarily affected by deductions and copayments. The market has also proven to be highly dependent on supply.

7. Analysis and Findings

1) *Operations research model to support healthcare management*

The issue of model choice is well recognized within the OR literature, and one often proffered guide for OR model building is that the model should be made as simple as possible subject to meeting its purpose. Partial Simulation Modelling Time-Dependent Queue Modelling was the optimal method compared to others.

2) *Application of operation research technique in healthcare*

The use of operations research in the healthcare industry is also used to treat human diseases, such as kidney dialysis therapy, Dynamic Programming, and Simulation used to determine the optimal treatment and provide strategies to maximize patient welfare. In addition, Integer Programming helped the doctors with screening diabetes-related complications. And also, the use of Linear and Non-Linear Programming has come into the picture for the treatment of Intensity Modulated Radiotherapy (IMRT).

3) *Operations research in nurse rescheduling*

Hospitals have many incentives to move to new opening hours. The planning process, readiness assessment, and consensus on what to implement are time-consuming and stressful and compete with other demands. As a result, there is a reluctance to make such efforts. When changes could be implemented along regular channels without creating new or temporary structures, communication and trust are more likely to result. Some changes to the schedule and schedule were not planned and developed by trial and error. And the plan was chosen, and the resort experimented with different programs.

Even if a full-time coordinator is hired, additional time from specific employees may be required for the project to succeed. Third, the diverse mix of facilitator nurses has made it difficult to ensure that scheduling changes are fair.

4) *Using operations research to reduce delays in healthcare*

Effective resource management is essential to achieve this goal and improve the ability of patients to receive the most appropriate care promptly. The increasing capacity and installation of healthcare IT systems in hospitals and doctors' offices have made it increasingly possible to collect and organize the data needed to create and implement OR methods. However, operating room professionals must help guide the development of these systems to determine the appropriate data and develop processes to collect and use this data to advance the methodology. As a result of our research, the hospital implemented a new electronic data collection system to capture doctors' delays. Operations research can and should play a role in these critical discussions and decisions about capacity needs and utilization. To achieve this goal, operational researchers must develop and use models that illustrate the potential adverse consequences of existing or proposed policies, such as hospital closures or mandatory care rates, and publish and promote them in medical journals, newsletters, and newspaper.

8. Advantages and Limitations of or In Healthcare

1) *Advantages*

- It assists the industry with an accurate forecast of volumes of products and services needed for better inventory management.
- It also helps determine what step to be taken at a particular time to improve the output of a process like patient scheduling and appointment times.
- It provides a framework by which the healthcare industry investigates its organization from different perspectives to enhance its management performance and reduce costs.

2) *Limitations*

- It is inflexible for any changes, and in the health scenario, its very risker also as there are many variables involved.
- The constant technology change also made the job difficult for the OR specialist to develop an invariant theory.
- It is also challenging for the scientist to predict the right amount of medicine and inventory. There is also a chance of any natural calamity or any disastrous

situation like Covid-19.

9. Conclusion

Several OR applications have been described in this project. Different healthcare areas where OR techniques will be helpful have been described, such as reducing delay in healthcare delivery, operations research model to support healthcare management, operation research technique in healthcare, operations research in nurse rescheduling, talent management in healthcare organizations. In our view, there is room for more OR work to be done in the healthcare setting. Managers and staff need to be more well-informed on this. Awareness is essential to use different tools and techniques for even better and optimal management. The OR methods used need to be periodically updated for the healthcare system to work swiftly and optimally. Moreover, research has to be continuously funded and encouraged by administrative staff in this area to determine the best practices for management in the industry.

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