Selection of Best Hospital in Mumbai for Tuberculosis Treatment Using AHP Technique

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Abstract

The healthcare sector in India is one of the largest sectors in the Indian economy where private sector dominates. Tuberculosis, commonly known as TB, is seen as one of the major health problems in the Indian health scenario. Treatment for the same has been progressing continuously. Tuberculosis being a bacterial infection requires antibiotics for treatment and prevention. Increasing sophistication of technology has also been playing a huge role in the treatment of tuberculosis. A survey was conducted for three known hospitals in the city of Mumbai, Maharashtra- Fortis Hospital, Apollo Hospital and Nanavati Hospital. A survey was done considering four factors- cost, infrastructure, quality and technology. Reasons for choosing these factors are elaborated upon ahead in the research paper. The data was collected through a primary source where physical papers were circulated and responses collected were then analysed for the further process. Respondents were surveyed and their opinions on various factors as well as priorities of hospitals based on these factors were collected, analysed and processed for further understanding. By the way of conducting Analytic Hierarchy Process Method, it finds out which of these hospitals in Mumbai is preferred the most for its tuberculosis treatment.

Keywords: Healthcare, Tuberculosis, treatment, survey, cost, infrastructure, quality, technology

Introduction

Leaders in healthcare institutions are coming up with novel approaches to improve the quality and efficiency of patient care. The field of operations research (OR) has been used to enhance the efficacy and efficiency of hospital operations. In healthcare settings, it is common for an ongoing health programmer to fall short of its intended goal, leaving programme managers to grapple with causes that are obscure at best. This is the first step in the OR procedure. Organizing a research team with expertise in areas such as epidemiology, biostatistics, health management, etc., is the first step in the conventional OR process.

Due to their other responsibilities and, more likely than not, their own preconceived notions and biases, programme managers may be unable to conduct the research on their own. The success of the research and the shared ownership of its findings, however, requires them to maintain a cooperative relationship with the research team. One cannot overstate the importance of operations research in hospitals and other medical facilities. Family planning, HIV/AIDS, tuberculosis (TB), and malaria control programmes, to name a few, have all benefited from its use. It has been widely recognized for the positive impact it has had on the evolution of health policy and the enhancement of a variety of health programmes.

The Global strategy for control of tuberculosis was developed with the help of operations research efforts that were sustained over several decades. The best-case studies of operation research in this area come from India and Malawi. In India, operation research showed that a drop in TB rates, a decrease in TB-related deaths, and the release of hospital beds previously used by TB patients could be good for the country's economy.

In 2014, an observational study (OR) was performed in the context of the Revised National Tuberculosis Programme on patients with presumptive MDR-TB in North and Central Chennai to identify pre diagnosis attrition, pre-treatment attrition, and factors associated with it. Thus, it can be seen that an important OR application is in the hospital operations.

AHP (Analytical Hierarchy Process) was used to conduct as a technique in operations research to find out which of the hospitals namely: Nanavati, Fortis and Apollo all of which situated in Mumbai, Maharashtra is best for its tuberculosis treatment. The AHP technique is a well-known method used for analyzing and evaluating various options available out there based on pre decided criteria's to eventually help select the best one. The criteria being used here to evaluate the hospitals are cost, infrastructure quality and technology. Further, it uses a combination of math and psychology to get its answer by dividing the process into 3 core parts. First being the issue that needs to be resolved, second the alternate solutions that are at hand and third being the criteria used to evaluate the options. In the final step of the process, numerical priorities are calculated for each of the decision alternatives. These numbers represent the alternatives' relative ability to achieve the decision goal.

Meeting global health challenges through operational research

Notwithstanding the low need that worldwide wellbeing has given functional exploration, some important work has been and is being finished. A few models include: a 32-country program on essential consideration tasks research laid out in 1981 by the US Organization for Worldwide Turn of events; a supported functional exploration exertion north of quite a few years supporting the improvement of a worldwide system on tuberculosis control; and a laid-out group of functional examination around HIV/Helps.

In worldwide wellbeing, functional examination has a very wide translation. The term is utilized for practically any sort of progress situated examination concerning a program's tasks. Where the board science by and large purposes frameworks displaying and related logical procedures, functional exploration in worldwide wellbeing doesn't utilize these apparatuses adequately. Very nearly twenty years prior a survey of this field noticed this hole and expressed those numerous functional explorations concentrates on worldwide wellbeing "don't convey the full kind of functional examination". For certain special cases, for example, for HIV/Helps where there has been a reasonable setup of functional examination demonstrating work, that hole obviously remains, especially for ignored tropical illnesses. For instance, guides on functional examination distributed by WHO and the Worldwide Asset to Battle Helps, TB and Intestinal sickness center mostly around the utilization of meetings, polls and perceptions, with less emphasis on trial and error and no inclusion of demonstrating or other scientific strategies. More grounded joins between the commonsense and scientific methodologies would overcome this issue.

Fortifying the utilization of the board science in worldwide wellbeing would likewise further develop correspondence between functional examination laborers in worldwide wellbeing and improvement. A new survey of functional exploration in non-industrial nations gives helpful detail.

A portion of the more quantitative or computational methodologies can be helpful, even with restricted information, as their key results are much of the time decided more by the design and rationale of a circumstance than exact upsides of boundaries. One such methodology is "framework elements" displaying, a more total demonstrating approach than discrete occasion or specialist reenactment and one that gives specific consideration to criticism impacts. An essential illustration of this is the framework elements epidemiological model utilized in the worldwide mission to kill polio. The model consolidated a criticism circle that addressed how noticed effects of intercessions would impact ensuing mediations. This educated a discussion on the best methodology by showing that destruction was a more viable and less exorbitant long haul procedure than control as the last option approach wouldn't forestall ordinary significant eruptions of the infection.

Functional examination strategies are valuable for the precise ID of issues and the quest for possible arrangements. Organized ways to deal with recognizing choices, for example, the essential decision approach or precise imagination approaches like the Russian-designed system TRIZ (deciphered as "hypothesis of creative critical thinking"), have extraordinary potential for use in low-asset settings. New methodologies are significant for worldwide wellbeing since systems and projects should be intended to manage both ebb and flow and future difficulties - from the worldwide spread of illness to the effect of environmental change. This can once in a while take us past customary determining philosophies to the utilization of situation examination and different prospects thinking techniques. There has been a considerable lot of such work in the wellbeing field and its strategies have been embraced in high-profile drives like by the Public authority Office for Science in the Unified Realm of Extraordinary England and Northern Ireland. Be that as it may, little seems to have been finished on worldwide wellbeing except for situation examinations on pandemic flu and on Helps in Africa up to the year 2025.

With a normal expansion in outrageous occasions connected to environmental change, debacle arranging and philanthropic operations are turning out to be much more significant. Choice help apparatuses explicitly intended for wide-scale crisis circumstances ought to assume a rising part. Creating experience in this kind of planned operations examination will have application in worldwide wellbeing both in and past crisis circumstances.

Pairwise comparison factors

1.   Cost

Another factor that plays an extremely crucial role while deciding the correct hospital is the potential cost a patient might incur in his or her overall treatment. It is not necessary for hospitals and providers to charge the same rates to everyone for the same services. Because of this, a system is created in which certain clients—such as the federal government or Blue Cross Blue Shield insurers—benefit from pricing that is frequently unprofitable while other clients must pay more to make up the difference. Even for regular treatments, the majority of providers—especially hospitals and surgical centers—do not issue pricing quotes in advance. Because of this, even the most knowledgeable customers are unable to make sensible decisions. However, clarity of how much approximately a treatment will charge a particular patient, influences his decision to a large extent. If the cost of a particular hospital is comparatively high, it must justify and back that up by providing services, quality, infrastructure and technology an edge above the other hospitals. There are a lot of patients that are not financially well to do and might prefer a hospital that charges them lesser irrespective of the services provided, hence it is important to find a middle ground that provides optimum cost for the optimum attributes of the hospital.

2.   Infrastructure

Infrastructure is a crucial pillar in supporting and enhancing the overall experience in a particular hospital. A clean and modern environment is crucial for the treatment of any identified illness and for the patient's continued rehabilitation. The seven quality domains—patient experience, effectiveness, efficiency, timeliness, safety, equity, and sustainability—should be supported by infrastructure. Infrastructure comprises the physical surroundings as well as its auxiliary components, such as personnel, systems and procedures, IT, equipment, access, sustainability projects, and IT. All in all, these interconnected elements ought to allow patients to relocate with ease while always retaining their dignity and privacy. Throughout the course of the patient's therapy, the infrastructure will only provide a smooth and complete experience if it is selected correctly in every way.

Importantly, neither patients nor services should be constrained by the physical environment, but the environment should be configured to be fit-for- purpose, with a high degree of cleanliness, and should be sufficiently flexible to serve all patients, including both the physically and mentally disabled.

3.   Quality

Quality improvement is a general term that can apply from everything from small locally developed systems to standardized systems such as Continuous Quality Improvement. Quality as a whole affects the patients experience in more than multiple ways hence when choosing a hospital, quality plays an important factor. When quality is talked about, it means everything that comes under the umbrella for enhancing a patient's experience. It includes quality of the treatment provided, quality of the service provided, quality of the tools used, machines used, overall equipment etc. Poor quality degrades the hospital on various levels, it affects the recovery of the patients as well as well-being of the people working at the hospital. Further, quality of a healthcare center is a holistic expression that includes a wide range of features like, physical ambience of the hospital, clinical competence of the healthcare staff, in patient experience, amenities provided by the hospital, all of them can jointly be assessed for under the factor, quality.

4.   Technology

Technology has played a very important role in the healthcare system both in India and around the world. There has been new innovation in technology for treatment of tuberculosis like virtually meeting patients for the treatment. This has specifically increased more during Covid. There is use of teleradiology for remote analysis of imaging studies. There is another method called the SMS (text) based technology method where the patient is reminded to take his medicines. They can also use this method to take daily updates from their patients. The 99DOTS system involves the use of blister packs and a specially designed envelope to transport and deliver TB drugs to patients. When a dose is dispensed, the patient is prompted to call a toll-free number printed on the inside flap of the envelope.

Video DOT (VDOT) utilizes synchronous (in real time) or asynchronous (at a later time) video conferencing via smartphone or computer to allow HCPs to observe patients taking drugs (at a different time using recorded video). Digital pillboxes incorporate audio, visual reminders within the pillbox itself and can be configured in advance. The act of opening and closing the box to retrieve medication is tracked as a stand-in for a dose being consumed. Microchips can be placed in tuberculosis drugs to act as ingestible sensors. Upon coming into contact with the patient's stomach acid following consumption, an adhesive monitor on the patient's body receives a signal. Dosing histories are then accessible by HCPs from a server after being sent to the patient's smartphone. Another method is using a smart pill box which basically reminds the patients to take their prescribed medicines on time. It also sends notification to the

respective health care workerswhether the patient has taken their medicines or not.

Steps to find best hospital for tuberculosis treatment using AHP

Step 1: Identifying the criteria for deciding best hospital for cancer treatment using AHP

The first step is to identify the success factors in the healthcare industry for determining the best hospital for treatment of tuberculosis. These criteria directly affect the performance and preferability of the hospitals. The criteria chosen are:

(i)Cost (ii)Infrastructure(iii)Quality (iv)Technology
Step 2: Conduct pairwise comparison

First determine the scale for comparison and then allot numerical rating for that. In this case 8 scales are taken and according to the preference rating is given from 1-9. Then a comparison matrixis done.

Step 3: Comparison Matrix (for the Criterion Involved in the Decision-Making.
Once the goal hierarchy is recognized, all the criteria must be estimated in pairs, which decide therelative significance between any two criteria, and further to their relative priority to the ultimate (final) goal. The decision-making exercise starts by finding out the relative weight of the initial criteria group

Step 4: Calculate the important weights of each criteria (After normalization)
This is done by finding a normalization table where each element is divided by the total of the column from the pair wise comparison of decision criteria and then the average of each row is found out for criteria weights. This will give the priorities of the decision criteria after normalization.

Step 5: Finding the values of Random index

Once the priorities of the different criteria listed in the AHP issue have been ascertained, it is crucial to determine whether the pairwise comparison under consideration is trustworthy or sufficiently good to move on with in order to ascertain the overall priority of three healthcare units. According to Saaty, the process includes determining the Consistency Ratio (CR), which comes before the Consistency Index (CI). It is challenging to get complete consistency with many pair-wise comparisons. As a matter of fact, it is reasonable to anticipate some degree of inconsistency in practically every pairwise comparison set. AHP offers a way to gauge the level of consistency between the decision maker's pairwise comparisons in order to address the consistency problem. If the degree of consistency is unacceptable, the decision maker should review and revise the pair-wise comparisons before proceeding.

Step 6: Finding pair wise comparison of the three hospitals with respect to respective factorsby normalization

The following stage is to compare each of the three potential hospitals in pairs based on the four case-specific criteria. The opinions of those who have used or are aware of the services provided by the three healthcare facilities described are the basis for the pairwise comparison.

The next stage in the AHP process is to determine the three units' priorities based on the four predetermined criteria in the same way that was previously advised. This involves normalizing the matrix first and then calculating the average of the row components.

Step 7: Final Priorities of the Three Hospitals in Terms of the Criteria

The last step of AHP is to find out the overall priority of three healthcare unitsconsidered in this case.

Goal: Hierarchy of AHP to select the best hospital for tuberculosis treatment

Table 1: Hospitals chosen

Criteria	Cost	Infrastructure	Quality	Technology
Decision alternative	Fortis	Fortis	Fortis	Fortis
	Nanavati	Nanavati	Nanavati	Nanavati
	Apollo	Apollo	Apollo	Apollo

Comparison Scale

The comparison between two elements using AHP can be done in different ways. However, the relative importance scale between two alternatives as suggested by Saaty (2005) is extensively used in the decision-making exercises. The values of various attributes vary from 1 to 9 as per therelative importance of the alternatives provided to the different criteria involved in cases as such.

Table 2: Basis for Pair-wise comparison scale

Scale	Numerical rating
Extremely Preferred	9
Very Strong to Extremely	8

Very Strongly Preferred	7
Strongly to Very Strongly	6
Strongly Preferred	5
Moderately to Strongly	4
Moderately Preferred	3
Equally to Moderately	2
Equally Preferred	1

Comparison Matrix (for the Criterion Involved in the Decision-Making Problem)

Vague approaches give a more accurate picture of the decision-making process since preferences in AHP are fundamentally human evaluations based on human observation—especially when it comes to intangibles. Pairwise comparison was the next step in determining the importance of each crucial success factor. Subfactors were then compared for each significant success factor. Pairwise comparisons between each component set and each element in the higher stratum were used to establish the priorities. A nine-point numerical scale was used for a paired comparison.

Table 3: Pair-Wise Comparison of the Decision Criteria

	Cost	Infrastructure	Quality	Technology
Cost	1	2	1.4	1.2
Infrastructure	0.5	1	0.7	1.3
Quality	0.7	1.4	1	0.8
Technology	0.8	0.8	1.4	1

Table 4: Priorities of the Decision Criteria (After Normalization)

The next step is to divide each element by the total of the column from pair wise comparison of decision criteria to find the normalization table. After this step average of each row is found out. From these priorities can be found out after normalization

	Cost	Infrastructure	Quality	Technology	Priority
Cost	0.3333	0.3846	0.3111	0.2790	0.3270
Infrastructure	0.1666	0.1923	0.1555	0.3023	0.2042
Quality	0.2333	0.2692	0.2222	0.1860	0.2277
Technology	0.2666	0.1538	0.3111	0.2325	0.2410

Calculation for value of Random Index values

Find out the λ max with respect to each criterion (cost, surgeon's experience, infrastructure and quality):

$$\begin{vmatrix} 1 & 2 & 1.4 & 1.2 \\ 0.5 & 1 & 0.7 & 1.3 \\ 0.7 & 1.4 & 1 & 0.8 \\ 0.8 & 0.8 & 1.4 & 1 \end{vmatrix} \begin{vmatrix} 0.3270 \\ 0.2042 \\ 0.2277 \\ 0.2410 \end{vmatrix} = \lambda \text{ max} \begin{vmatrix} 0.3270 \\ 0.2042 \\ 0.2277 \\ 0.2410 \end{vmatrix}$$

$$\begin{vmatrix} 1.3435 \\ 0.8404 \\ 0.9353 \\ 0.9848 \end{vmatrix} = \lambda\text{max} \begin{vmatrix} 0.3270 \\ 0.2042 \\ 0.2277 \\ 0.2410 \end{vmatrix}$$

Cost max = 1.343506261/0.32703= **4.108174801**

Infrastructure Max = 0.840484993/0.20421= **4.115709558 Quality Max** = 0.935366726/0.22771=**4.107742668 Technology** =0.984834029/0.24105=**4.085676589**

Computing the average of the values found in Step 2. This average is denoted by λ max: λ max(average)=

4.104325904

Computing CI:

CI= (λmax - n)/n – 1

= (4.104325904-4)/3=0.034775301

Table 5: Value of Random Index

n	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.90	1.12	1.24	1.32	1.41	1.45	1.49

where N = No. of items being compared. CR= Consistency Index/Random Index (R.I.)

=0.034775301/.90

=0.038639223

CR is obtained as 0.039, which is less than 0.1. As per the procedure of AHP, if the CR is less than or equal to 0.1, it can be concluded that the pair-wise comparison considered is appropriate and it is acceptable to move further in the direction of finding out the overall priority in terms of selecting the best possible healthcare unit in the present scenario

After this, the next step involves pair-wise comparison of all the three alternative hospitals with respect to the four criteria chosen for the case. The pair-wise comparison is done based on the opinion of the people who have already availed or known about the services of the three healthcareunits mentioned herein

The next step in AHP is finding out the priority of the three units in terms of the predefined four criteria in the same manner as prescribed earlier, i.e., first normalization of the matrix is to be doneand then the average of the row elements is to be calculated

Table 6: Pair-Wise Comparison of the three hospitalsfor Cost Criterion

Hospital	Fortis	Nanavati	Apollo
Fortis	1	0.40	1.09
Nanavati	2.51	1	1.21
Apollo	0.91	0.83	1

Table 7: Pair-Wise Comparison of the Three hospitalsfor Infrastructure Criterion

Hospital	Fortis	Nanavati	Apollo
Fortis	1	1.34	1.35
Nanavati	0.76	1	1.25
Apollo	0.74	0.80	1

Table 8: Pair-Wise Comparison of the Three hospitalsfor Quality Criterion

Hospital	Fortis	Nanavati	Apollo
Fortis	1	1	0.90
Nanavati	1	1	1.02
Apollo	1.11	0.98	1

Table 9: Pair-Wise Comparison of the Three hospitalsfor Technology Criterion

Hospital	Fortis	Nanavati	Apollo
Fortis	1	0.82	0.93
Nanavati	1.22	1	0.97
Apollo	1.06	1.08	1

Table 10: Pair-Wise Comparison of the Three hospitalsfor Cost Criterion by Normalization

	Fortis	Nanavati	Apollo	Priority
Fortis	0.23	0.18	0.33	0.24
Nanavati	0.57	0.45	0.37	0.46
Apollo	0.21	0.37	0.30	0.29

Table 11: Pair-Wise Comparison of the Three hospitalsfor Infrastructure Criterion by Normalization

	Fortis	Nanavati	Apollo	Priority
Fortis	0.4001	0.4275	0.374733	0.4007
Nanavati	0.3032	0.3181	0.34743	0.3229
Apollo	0.2966	0.2543	0.277837	0.2762

Table 12: Pair-Wise Comparison of the Three hospitalsfor Quality Criterion by Normalization

	Fortis	Nanavati	Apollo	Priority
Fortis	0.3221	0.3362	0.3088	0.3224
Nanavati	0.3218	0.3359	0.3498	0.3358
Apollo	0.3559	0.3278	0.3413	0.3417

Table 13: Pair-Wise Comparison of the Three hospitalsfor Technology Criterion by Normalization

	Fortis	Nanavati	Apollo	Priority
Fortis	0.3042	0.2821	0.3218	0.3027
Nanavati	0.3721	0.3450	0.3338	0.3503
Apollo	0.3236	0.3728	0.3442	0.3469

Table 14: Final Priorities of the Three Hospitalsin Terms of the Criteria

	Cost	Quality	Infrastructure	Technology
Fortis	0.24	0.3224	0.4007	0.3027
Nanavati	0.46	0.3358	0.3229	0.3503

Apollo	0.29	0.3417	0.2762	0.3469

Overall Priority of All the Three Hospitals

Overall Priority for Fortis
= 0.24*0.3270+0.3224*0.2042+0.4007*0.2277+0.3027*0.2410=**0.3085**

Overall Priority for Nanavati
=0.46*0.3270+0.3358*0.2042+0.3229*0.2277+0.3503*0.2410=**0.3770**

Overall Priority for Apollo
=0.29+0.3270+0.3417*0.2042+0.2762*0.2277+0.3469*0.2410= **0.3111**

Analysis

The above study was conducted using the AHP Method, that is, Analytical Hierarchy Process Method and on the basis of four specific criteriums- cost criterion, infrastructure criterion, qualitycriterion and technology criterion. The main objective of the study was to select the most appropriate and preferred hospital for the treatment of tuberculosis.

The final arrived analysis reveals that the hospital that best delivers to all the criteriums taken is Nanavati. The overall priority figure arrived at for Nanavati is 0.377 making it the most preferredhospital.
The study was done taking into consideration three hospitals- Fortis, Nanavati and Apollo. When comparing with Nanavati that has the highest overall priority, the following observations can be made:

- Nanavati is preferred x times more than Fortis

- Nanavati is preferred y times more than Apollo

Even though, all of the three hospitals considered for the survey are well known in the medical spectrum and conduct their practices in an efficient manner, the study reveals that Nanavati is the best capable of handling the needs of customers.

Conclusion

Tuberculosis affects more than 1 million people in India every year. However, it is treatable by a medical professional. There exist variety of health programs that offer treatment to patients of tuberculosis. Hospitals in Mumbai provide comprehensive programs surrounding the disease taking into consideration and evaluation of health policies. For the purpose of the survey, the respondents were asked for their preferences among three hospitals- Fortis, Nanavati and Apollo.The respondents were asked to list their preferences taking into consideration the listed criteriums-cost criterion, infrastructure criterion, quality criterion and technology criterion.

AHP Method was used to fulfil the objective of finding out the most appropriate and preferred hospital that would meet the needs of the customer in the most efficient manner. The process of the AHP Method was followed to arrive at the end results, that is, the Overall Priority for the three hospitals. Looking at the Overall Priority for the three hospitals, we can conclude that Nanavati is defined as the best hospital as it provides the most satisfaction effectively to the end customer with an overall priority of 0.377. Nanavati is preferred x times more than Fortis whose overall priority is 0.309 and y times more than Apollo whose overall priority is 0.311 also making it the next preferred alternative.

Looking at the results, it can also conclude AHP Method to be an effective form of an operations tool. This framework can be used by tuberculosis patients to find themselves a hospital that is the right fit for them. AHP Method, being a multi criteria solving technique makes it much easier for the end medical customer as the important critical factors are involved in the decision-making process. It is for these reasons; Analytical Hierarchy Process Method was selected as an aid to this study.

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