CHAPTER 4

ECONOMIC ANALYSIS
AND
COST EFFECTIVENESS TECHNIQUE
Chapter 4

Economic Analysis and Cost Effectiveness Technique

4.1] Introduction

Now-a-day; resource allocation decisions in health care increasingly based on
cost-effectiveness analysis. In the severely ill patient, there is little time for delay, and an
error in choice of antibiotics may well cost the patient his/her life. As per the Doctor’s
opinion, it happens that the given treatment should be treating a known organism with an
appropriate dose of antibiotic to which that organism is likely to respond, based on
sensitivity testing. This idea will often not be met. Sometimes one will obtain an organism
and its sensitivity on routine microbiological surveillance and then the patient will show
features of infection likely to be due to that organism.

Therefore the aim of the study is to compare the cost and effectiveness of two
types of treatments with and without prophylactic antibiotics given to the patients admitted
in intensive care unit (ICU). To prevent them from the infections, generally prophylactic
type of antibiotics treatment given to the patients.

The information gathered from the website of Health Ministry of Indian
Government [45] it is observed that the Indian Government has undertaken several health
projects but the work on the cost effectiveness analysis has not much as other. The
Government has just completed one project related to the cancer diseases, which is based
on cost effectiveness technique.

The dose of prophylactic antibiotics may have clinical benefits for patients by
reducing infections and at the same time produce cost savings [60]. Economic evaluation is
a useful tool to help determine whether it is worthwhile to give prophylactic antibiotics in
terms of cost, and benefits to patients and to the health care system.

Randomized trials generate data about relative treatment efficacy. As with other
integrative studies such as decision analyses, [13] and practice guidelines, economic
analyses may use estimates of cost and effectiveness from summaries of several studies of
therapy, diagnosis, and prognosis. Either way, the main distinction between economic analyses
and other studies is to explicit measurement and valuation of resource consumption or
cost data often involves placing values on the health outcomes so that they can be related to the costs of alternative treatment strategies.

We performed a cost-effectiveness analysis from the societal perspective. The method according to the reference case scenario recommended by the panel of [PCEHM] U.S. Public Health Service on Cost-Effectiveness in Health and Medicine. Cost-effectiveness is estimated for quality-adjusted life expectancy (QALE) outcomes [3]. The PCEHM panel published guidelines and recommendations for the conduct and reporting of cost-effectiveness analyses with the goal of improving and standardizing health economic studies.

Cost-effectiveness analysis is now an integral part of health technology assessment and addresses the question of whether a new treatment or other health care program offers good value for money. In this chapter we introduce the basic framework for decision making with cost-effectiveness data.

Economic analysis in health care is growing in importance, and such studies are emerging in ICU. A valid economic cost-of-illness, cost-minimisation, cost-effectiveness, cost-utility, or cost-benefit analysis can be a powerful tool for making decisions on the allocation of resources in an environment which requires consideration of costs which is already describe in chapter 3. Without an understanding of economic evaluation, physician may be left wondering exactly how this can be applied to clinical practice. Below we describe the different types of economic study and give a summary of the key components of an economic analysis including perspective, measurement of cost and outcomes, time horizon, cost-discounting and computerised decision modelling, with an emphasis on the application of cost-utility analysis to ICU patients.

The major avenues for increasing health benefits from available resources in the hospital are increasing the efficiency using proper allocation of resources so that the programs are cost-effective.

In order to increase the use of scarce resources for more cost-effective and efficient services, this study is undertaken to increase the hospital efficiency by performing cost-effectiveness exercise.
The goal of this chapter is to discuss how to evaluate the economic evaluation and the cost effective technique as a starting point. In the second section of this chapter, reviews the methodology and procedure (for calculating the cost effective ratio) adopt for achieving the goal. The remaining section of this chapter addresses important results and discussion with the analysis. Here we present the results of the economic evaluation of this prospectively randomized trial.

4.2] Importance of Economic Evaluation

Physician makes decisions on the care of their patients and also on hospital and health-care policy. A knowledge of the economic analyses of surgical practices is necessary in order to advise in matters of policy. Two formal reviews on the basic principles of the economics of health-care were published on the orthopaedic [23]. In the first section of the study we have attempted to focus on the different types of economic evaluation and to distinguish the strengths and weaknesses of such studies, with an emphasis on the application of cost-utility analysis to ICU.

4.3] Types of economic evaluation

Several categories of economic analysis are in current use, each differing in the their way as per health benefits and varying with the different conditions being studied [47]. It is important to distinguish the various types of economic analysis because each provides specific information which determines its applicability and usefulness in different types of decision-making.

4.3.1] Cost-of-Illness Analysis (COIA).

This measures only the costs associated with a given disease. The primary objective of a COIA is to calculate the cost of caring for persons with the illness compared with those who are well. A COIA may also report differential costs based on the severity of the disease or other factors, but would say nothing of the relative efficacy of the treatments being considered. [23]

4.3.2] Cost-minimisation Analysis (CMA).

This compares the cost of procedures which yield the same clinical outcome, and identifies the cheapest. [31] A cost-minimisation study would determine all costs
associated with each of the devices in order to determine which is the least expensive.

Even though COIA and CMA are common and important studies in economic evaluations but they are not complete in the sense that they are not comparing the different treatment procedure also the financial costs and the health outcome. Therefore to overcome this there are three main types of full economic evaluation: cost-effectiveness, cost-utility, and cost-benefit analysis.

4.3.3] Cost-effectiveness Analysis (CEA).

This is the most commonly used full economic evaluation and one which we intuitively understand. It compares the outcome of decisions in terms of their monetary value per natural unit of health outcome, such as per life saved, or per year of life gained.

It is the most appropriate method of analysis when the goal is to identify the most cost-effective strategy among a set of options which produce a common health outcome. An example would be the comparison of a new prophylactic antibiotic with the standard antibiotic. If a treatment is more effective and less expensive, the choice is obvious, because a physician's main responsibility is to meet the best the needs of each patient and the preferred method of treatment is called the dominant strategy.

If the new treatment is both more effective and more costly. The choice is then a matter of judgement. If one treatment is more effective but more expensive, CEA helps to quantify the clinical and economic consequences of using it. Such therapies are compared on the basis of the cost-effectiveness ratio. A common error is simply to take the ratio of cost and effect of a particular intervention and to compare it with that of a second intervention. Proper cost-effectiveness analysis, however, is always comparative. The average cost-effectiveness ratio is not a useful quantity since it is estimated by dividing the cost of the intervention by a measure of effectiveness without considering the alternatives. However, an incremental cost-effectiveness ratio is an estimate of the additional cost per additional unit of effectiveness of switching from one treatment to another, or the cost of using one treatment in preference to another. In estimating an incremental cost-effectiveness ratio, the numerator and denominator of the ratio both represent differences
between the alternative treatments. When a comparison is made between two interventions, we are interested in determining the extra health benefit which is gained from the extra unit cost. This is measured by the incremental cost-effectiveness ratio. The numerator of the incremental cost-effectiveness ratio is the difference of the mean cost of each intervention, and the denominator is the mean difference of the effectiveness. Thus, the incremental cost-effectiveness ratio, we use CE ratios as a decision rule.

Thus Cost - (CE) Formula:

\[
\text{Incremental Cost-Effectiveness} = \frac{(\text{Costs A} - \text{Costs B})}{(\text{Effectiveness A} - \text{Effectiveness B})}
\]

Alternative Treatments for ICU Patients with prophylactic antibiotics

A = Treatments with prophylactic antibiotics.

B = Treatments without prophylactic antibiotics.

and thus refers to the amount of money needed to produce an additional health benefit [28]

4.3.4] Cost-utility analysis (CUA).

Cost-utility analysis in which health benefits are quantified in terms of quality-adjusted life-years (QALYs) has now become the standard type of cost-effectiveness analysis. These studies are potentially influential in determining the extent of funding for particular pediatric interventions, and so their methodological quality is extremely important.

This is similar to CEA except that it incorporates a measure of quality of life, 'utility', into the outcomes of the procedures. Utility is a concept used to describe individuals' preferences for a health status and not the quality of the health status as such. Including utility in economic evaluations allows for consideration of what is important to individuals, such as increased life expectancy or improved quality of life, or both. Certain treatments may not affect life expectancy, but may greatly improve the quality of the remaining life span.

Health benefit is no longer measured as the number of deaths prevented or years of life gained, but rather as quality-adjusted life-years (QALYs). A QALY is
computed as a year of life gained, multiplied by the utility score during that year, which is expressed on a scale of 0 to 1[23]

In general, CUA is more complicated than CEA because it involves the actual measurement of individuals' preferences, usually by surveys of patients or of healthy people being confronted with written descriptions of ill persons. The various techniques used to capture people's preferences are complicated. [10]

4.3.5] Cost-benefit Analysis (CBA)

Both costs and health outcomes are expressed in monetary units. To compare treatment options, CBA commonly uses two value for comparisons, the net present value and the cost-benefit ratio. The net present value is simply the value of health benefits minus costs, and the cost-benefit ratio is the ratio between these two (benefits and cost). The main advantage of CBA is that it compares the programs directly even though the programs outside the health care. CBA is the least used technique in the economic evaluation of health care. The main difficulty in applying CBA is quantifying health consequences in monetary terms, and the significant number of ethical issues involved in assigning an amount of money to the value of human life, pain, and suffering.

Cost-effectiveness and cost-utility analyses are the preferred approaches to evaluate medical care technologies today.

The goals of many ICU interventions are to stabilize and support the patients (e.g., mechanical ventilation), rather than to cure or improve an underlying condition. In such instances, isolating the clinical and economic consequences of individual interventions can be difficult.

ICU interventions are often applied to heterogeneous patient population with different underlying morbidities and probability of survival. ICU patients have several complications; therefore determining the effect of a particular therapy in such situations is difficult, complicating both clinical trials and CEAs.

4.4] Samples and Methods

Out of 106 patients admitted in the ICU during the study period only 88 patients are met to our objective. Therefore Cost-effectiveness analysis is based on the 88
patients from the Hospitals. Then the patients are divided into two groups as per objective. In the first group, there are 62 patients with prophylactic antibiotics treatments and in another group there are 26 patients who are not received prophylactic antibiotics treatments.

For the Economic Evaluation, we present the measuring cost in all the ways so that the study variable could not be neglected.

4.5] Determining Costs

The main component of CEA is the all-relevant cost items followed by measurement and estimation. The cost in economic evaluation consists of both direct and indirect cost. [9] The direct medical cost of an intervention are those incurred in providing care, such as payments of drugs, medical supplies and professional services from nurses, physicians, or other health care providers associated with interventions. These costs include cost for treating side effect and complications resulting from intervention. Indirect cost or productivity cost includes cost incurred because of illness, transportation and other expenses incurred by patient’s families. The indirect costs are presented in the Appendix C.

A cost is the use of a resource such that it is no longer available for an alternative use (opportunity cost). The incremental, or additional, costs associated with a given intervention are thus the value of all additional resources used [14].

There are three general approaches to measuring acute health care costs, ranging in complexity from detailed resource tracking and cost assignment to the use of adjusters, or ratios, with which we multiply health care "prices" (usually referred to as charges) to estimate the actual costs. But here the most common approach is considered and that is by considering the hospital charges.

The hospital's charges for a patient's care by a hospital or department-specific ratio of costs to charges (RCC). RCCs have been shown to be inaccurate for individual patients but accurate to within 10% for groups of patients. As per the American Thoracic Society Workshop on Outcomes Research in 2002 [49] physician costs are generally estimated separately from hospital costs in the United States and included elsewhere. Health care systems outside the United States have generally invested less effort in tracking the resources consumed per patient and there is no international standard for detailed
costing of health care services.

In reference to the physician cost, in this study only other Doctors (experts) charges are subtracted form the total cost so that the hospital cost, hospital cost per patients are calculated properly. The study related to this reference is described in the chapter 3.

Because a CEA is based on incremental costs, the most crucial costs are those that are large and differ significantly between comparison arms. Also Cost of illness studies attempt to quantify the impact of illness on the economy. The original focus of the cost of illness studies was on estimating the medical expenditures and productivity losses due to specific path physiological conditions like as heart diseases, cancer etc. [14]

From the Appendix C we summarize these cost and presented in form of table. The table present estimate of the cost of illness associated with different diseases for all 106 patients. The cost values also presented in the chapter number 2.

Table 29: Economic Cost Related To Health Problem

<table>
<thead>
<tr>
<th>Disease</th>
<th>Number of Patients</th>
<th>Direct cost (In Rs.)</th>
<th>Indirect cost (In Rs.)</th>
<th>Total cost (In Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS</td>
<td>8</td>
<td>234704.36</td>
<td>70411.31</td>
<td>305115.67</td>
</tr>
<tr>
<td>CVS</td>
<td>20</td>
<td>393761.58</td>
<td>118128.47</td>
<td>511890.05</td>
</tr>
<tr>
<td>Poison</td>
<td>11</td>
<td>214241.34</td>
<td>64272.40</td>
<td>278513.74</td>
</tr>
<tr>
<td>RTA</td>
<td>23</td>
<td>533200.28</td>
<td>159960.08</td>
<td>693160.36</td>
</tr>
<tr>
<td>P/A</td>
<td>12</td>
<td>469335.08</td>
<td>140800.52</td>
<td>610135.60</td>
</tr>
<tr>
<td>HI</td>
<td>21</td>
<td>525035.70</td>
<td>157510.71</td>
<td>682546.41</td>
</tr>
<tr>
<td>Other</td>
<td>11</td>
<td>159093.34</td>
<td>47728.00</td>
<td>206821.34</td>
</tr>
<tr>
<td>Total</td>
<td>106</td>
<td>2529371.68</td>
<td>758811.50</td>
<td>3288183.18</td>
</tr>
</tbody>
</table>

In the next two tables we present the Economic cost related to Health Problem, as per the group defined treatments with prophylactic antibiotics and treatments without prophylactic antibiotics are
Table 30: Economic Cost Related To Health Problem, Treatments with Prophylactic Antibiotics

<table>
<thead>
<tr>
<th>Disease</th>
<th>Number of Patients</th>
<th>Number of Deaths</th>
<th>Direct Cost In Rs.</th>
<th>In % as Compared with Table 29</th>
<th>Indirect Cost In Rs.</th>
<th>In % as Compared with Table 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS</td>
<td>4</td>
<td>0</td>
<td>208310.48</td>
<td>89</td>
<td>52077.62</td>
<td>74</td>
</tr>
<tr>
<td>CVS</td>
<td>12</td>
<td>1</td>
<td>289872.20</td>
<td>74</td>
<td>72468.05</td>
<td>61</td>
</tr>
<tr>
<td>Poison</td>
<td>8</td>
<td>3</td>
<td>200355.74</td>
<td>94</td>
<td>50088.94</td>
<td>78</td>
</tr>
<tr>
<td>RTA</td>
<td>14</td>
<td>0</td>
<td>475892.11</td>
<td>89</td>
<td>118973.03</td>
<td>74</td>
</tr>
<tr>
<td>P/A</td>
<td>6</td>
<td>1</td>
<td>269242.68</td>
<td>57</td>
<td>67310.67</td>
<td>48</td>
</tr>
<tr>
<td>HI</td>
<td>13</td>
<td>1</td>
<td>302587.50</td>
<td>58</td>
<td>75646.88</td>
<td>48</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>0</td>
<td>73153.34</td>
<td>46</td>
<td>18288.34</td>
<td>38</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>6</td>
<td>1819414.05</td>
<td></td>
<td>454853.51</td>
<td></td>
</tr>
</tbody>
</table>

Figure 8: Diseasewise Economic Evaluation for Treatment with Prophylactic Antibiotic

From fig. 8, the major cost components in the total economy for the diseases are RTA, CNS, Poison (18%) of treatment with prophylactic antibiotics.
### Table 31: Economic Cost Related To Health Problem, Treatments without prophylactic antibiotics.

<table>
<thead>
<tr>
<th>Disease</th>
<th>Number of Patients</th>
<th>Number of Deaths</th>
<th>Direct Cost In Rs</th>
<th>In % as Compared with Table 29</th>
<th>Indirect Cost In Rs</th>
<th>In % as Compared with Table 29</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS</td>
<td>2</td>
<td>2</td>
<td>16253.88</td>
<td>7</td>
<td>4063.47</td>
<td>6</td>
</tr>
<tr>
<td>CVS</td>
<td>5</td>
<td>1</td>
<td>63999.38</td>
<td>16</td>
<td>15999.84</td>
<td>13</td>
</tr>
<tr>
<td>Poison</td>
<td>3</td>
<td>0</td>
<td>13885.60</td>
<td>6</td>
<td>3471.40</td>
<td>5</td>
</tr>
<tr>
<td>RTA</td>
<td>6</td>
<td>0</td>
<td>44428.17</td>
<td>8</td>
<td>11107.04</td>
<td>7</td>
</tr>
<tr>
<td>P/A</td>
<td>3</td>
<td>2</td>
<td>29852.40</td>
<td>6</td>
<td>7463.10</td>
<td>5</td>
</tr>
<tr>
<td>HI</td>
<td>5</td>
<td>4</td>
<td>39938.20</td>
<td>8</td>
<td>9984.55</td>
<td>6</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>3</td>
<td>13460.00</td>
<td>8</td>
<td>3365.00</td>
<td>7</td>
</tr>
<tr>
<td>Total</td>
<td>26</td>
<td>12</td>
<td>221817.63</td>
<td>8</td>
<td>55454.41</td>
<td></td>
</tr>
</tbody>
</table>

#### Figure 9: Disease wise Economic Evaluation for Treatment with out Prophylactic Antibiotic

From fig 9, In disease wise economic evaluation for treatment without prophylactic antibiotics the major cost component in the total economy for the diseases is CVS (30%) and RTA (20%), which are very less in numbers.

#### 4.6) Determining Outcomes

Patients are followed up to quantify their use of healthcare services, including hospitalization, physician visits, medications, laboratory tests, and procedures, during the trial. A task force of experts organized by the U.S. Public Health Service (PHS) developed
a standard method of cost-effectiveness analysis. The Task Force recommended that
cost-effectiveness studies use the Quality-Adjusted Life Year (QALY) as the outcome
measure [28].

4.6.1] Quality adjusted life years (QALYs)

The quality-adjusted life-year (QALY) is a measure of the value of health
outcomes. Since health is a function of length of life and quality of life, the QALY was
developed as an attempt to combine the value of these attributes into a single index
number.[24] QALY can be used to compare the cost-effectiveness of any treatment.

The measurement of quality of life, or more specifically, health-related quality of life
(HRQL), plays an important role in the field of health technology assessment (HTA).

Quality of life, the health concept, which it is multidimensional and
theoretically incorporates all aspects of an individual’s life. There is a general interest in
how to achieve the 'goodness' of life, sometimes called life satisfaction or quality of life [6].

Again QALY's are far from perfect as a measure of outcome, with a number of
technical and methodological shortcomings. The use of QALYs in resource allocation
decisions does not mean that choices between patient groups competing for medical care
are made explicit and commissioners are given an insight into the likely benefits from
investing in new technologies and therapies.

A QALY represents a patient’s perception of reduction in value of one year in
perfect health due to pain, disability and suffering caused by illness. It can be viewed as the
proportional decrement in quality of life in the state of ill health, multiplied by years of
expected life. The QALY is an outcome measure that reflects both the quantity and the
quality of life. Quality of life adjustments are based on patient or social ratings of the quality
of life associated with different health states. The ratings, also known as "preferences" or
"utilities," are on a scale of zero (representing death) to one (representing perfect health).

4.6.2] Role of QALY's

In an attempt to integrate the biomedical and psycho-social models, a new
approach has been proposed which can be labeled the bio-psycho-social model [40]
A paradigmatic indicator within this model is the quality-adjusted life-year (QALY), which serves as a composite indicator allowing quality and quantity of life to be combined in a single index [26]. The possibility of combining quantity and quality of life in a single index can be combined is based on the idea that the quality of life can be quantified by applying the concept of "utility."

4.6.3] Measurement Criteria of QALY's

The quantity of life, expressed in terms of survival or life expectancy, is a traditional measure that is widely accepted and has a few problems of comparison, people are either alive or not. Quality of life, provide a whole range of different aspects of people's lives, not just for their health status but also for the characteristics of the people. Even restricting the focus to a person's health-related quality of life will result in a number of dimensions relating to both physical and mental capacity. A number of approaches have been used to generate these quality of life valuations.

QALY combines two distinct variables -

- Quality (health status)
- Quantity (years) of health

There are some methods to measure the quality adjusted life years and they are given below with the descriptions.

4.6.4] QALY's: Methods

There are three common methods for deriving utility-like measures of health status or QALY's:

Health rating method.

This derives health ratings from questionnaires with health experts, potential subjects of treatment, or members of society in general. Individuals are asked to assign values between 0 and 1 to various (well-described) health states.

Time trade-off method.

In this method respondents asked to compare different combinations of length and quality of life. The trade-offs in the responses provide a basis for ranking various states (in quality and years).
Standard gamble method.

In this method respondents are presented with a decision tree with two alternatives like the following: one alternative is impaired health for t years; the other is normal health for n years with probability p or immediate death with probability 1-p. The p at which an individual is indifferent can be interpreted as the respondent's utility of the former alternative.

The decision tree for selecting the optimum strategy with standard gamble method is presented in the form of diagram as below

**Figure : 10 Decision tree by Standard gamble method**

The utilities that are produced represent the valuations attached to each health state between 0 and 1, where 0 is dimensions equivalent to being dead and 1 represents the best possible health state, although some health states are regarded as being worse than death and have negative valuations.[51]

Here the objective is achieved by the method of Standard gamble and the results are presented by the decision tree analysis.

4.7] Standard Probabilities:

A MEDLINE search of articles published between 1966 and 2001 was conducted to determine relevant probabilities for use in the decision analysis. Table 32 contains the probability with their range values. Table 32 values are use in estimating the cost effectiveness ratio and QALY's too. When the study was used to determine the probability, 95% confidence intervals were calculated from the available data. A weighted
mean was calculated and the minimum and maximum from the studies were taken to represent the range of values.

The prophylactic efficacy of antibiotics in preventing bacteremia was determined from decision analysis. The decision analyses were published in the early 1980s and estimate the value of the effectiveness of antibiotic prophylaxis for patients [11]. On the basis of these studies, the efficacy were estimated to be 89%, with a range of 0% to 100%, reflecting the uncertainty of the value.

**Table 32: Summary of Probabilities Used in the Analysis**

<table>
<thead>
<tr>
<th>Variable</th>
<th>Baseline Value</th>
<th>Range</th>
<th>Source</th>
</tr>
</thead>
<tbody>
<tr>
<td>Prophylactic efficacy of antibiotics in preventing bacteremia</td>
<td>0.890</td>
<td>0.000 to 1.00</td>
<td>Cantor, Coburn H. Allen, and Mark A. Ward [11]</td>
</tr>
<tr>
<td>Stroke, sever, motor deficit, without prophylactic Antibiotic</td>
<td>0.03</td>
<td>0.000 to 1.00</td>
<td>Tengs T. and Wallace [58]</td>
</tr>
</tbody>
</table>

**4.8) Calculation of QALY**

Since QALYs are a vital part of the cost-effectiveness calculation, QALY is supposed to be a composite index that takes into account both the benefit (or harm) supplied by a therapy, and the duration of that benefit (or harm). Using some sort of a "quality of life" scale makes the measurement of benefit or harm. The formula for QALY is:

\[
\text{QALY} = \text{probability} \times \text{duration}
\]

"Probability" is the statistical probability that the health condition related to the Quality of Well-Being (QWB) will occur. For the calculation, in this study the published standardizes probability with prophylactic antibiotics was taken to be 0.89. "Duration" is the expected duration of that health condition.

The values of probability indicate that 89% chance from preventing the patients from infections. This also value also shows the prophylactic efficacy of antibiotics
in preventing infections.

The essential data for calculating an overall QALY for the treatment with prophylactic antibiotics in these patients are given in the following table:

For Disease RTA,

\[
\text{QALY} = \text{probability} \times \text{duration} = 0.89 \times 4 = 3.56 \text{ days}
\]

In the same way, the calculation procedure was applied to other diseases.

**Table 33: QALY for the treatment with Prophylactic Antibiotics**

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Days</th>
<th>Units of utility (p)</th>
<th>QALY's</th>
<th>QALY gain in days</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS</td>
<td>7</td>
<td>0.89</td>
<td>6.23</td>
<td>324.85</td>
</tr>
<tr>
<td>CVS</td>
<td>3</td>
<td>0.89</td>
<td>2.67</td>
<td>324.85</td>
</tr>
<tr>
<td>Poison</td>
<td>3</td>
<td>0.89</td>
<td>3.56</td>
<td>433.13</td>
</tr>
<tr>
<td>RTA</td>
<td>4</td>
<td>0.89</td>
<td>3.56</td>
<td>324.85</td>
</tr>
<tr>
<td>P/A</td>
<td>5</td>
<td>0.89</td>
<td>4.45</td>
<td>324.85</td>
</tr>
<tr>
<td>HI</td>
<td>3</td>
<td>0.89</td>
<td>2.67</td>
<td>324.85</td>
</tr>
<tr>
<td>Other</td>
<td>3</td>
<td>0.89</td>
<td>2.67</td>
<td>324.85</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>28</strong></td>
<td></td>
<td><strong>2382.23</strong></td>
<td></td>
</tr>
<tr>
<td><strong>Mean</strong></td>
<td><strong>4</strong></td>
<td></td>
<td><strong>340.31</strong></td>
<td></td>
</tr>
</tbody>
</table>

In the column of days we take the average length of stay in ICU in days.

This table reflects the fact that the treatment with prophylactic antibiotics is considering for this patient has a 89% chance of preventing them from infections (i.e., the probability of achieving this effect of treatment is 0.89). Further, if the treatment does cure diseases, patient will probably live another 3.56 days for RTA and will have a "normal" quality of life (i.e., the QWB value for the diseases is 1.0). Therefore, contribution to the overall QALY calculation from "RTA cure" (the QALYcure) \(0.89 \times 4 = 3.56\). This means that for every patient like this one who receives the treatment with prophylactic antibiotics, we might expect to gain 324.85 \(=(365 \times 3.56) / 4\) quality - adjusted life years In another
word we can say that RTA, patients living for 4 days in ICU confined to a hospital for treatment was worth only $0.56$ days of regular time ($0.89 \times 4$ days).

Thus, those patients receive the treatment with prophylactic antibiotics in the 4 days of ICU can live approximately 340 days out of 365 days in a year.

$q = 1- p = 1-.89 = 0.11$, the chances of death after receiving the treatment with prophylactic antibiotics is 11% i.e. probability of death (immediate death) those who are received the treatment PA. The average value of stay in days after receiving PA is 4 and QALY's is 0.44 ($=0.11 \times 4$). Therefore QALY’s gain in days $40.15$ $=(365 \times 0.44)/4$.

On the similar ground of descriptions, we may say that the prophylactic antibiotics is more cost effective in the sense that the patients can live approximately 1.2 years with perfect health.

Now for the patients those who did not receive the treatment with no prophylactic antibiotics are given in the following table:

**Table 34 : QALY for the treatment without prophylactic antibiotics**

<table>
<thead>
<tr>
<th>Diseases</th>
<th>Days</th>
<th>Units of utility (p)</th>
<th>QALY's</th>
<th>QALY gain in days</th>
</tr>
</thead>
<tbody>
<tr>
<td>CNS</td>
<td>2</td>
<td>0.03</td>
<td>0.06</td>
<td>10.95</td>
</tr>
<tr>
<td>CVS</td>
<td>1</td>
<td>0.03</td>
<td>0.03</td>
<td>10.95</td>
</tr>
<tr>
<td>Poison</td>
<td>1</td>
<td>0.03</td>
<td>0.03</td>
<td>10.95</td>
</tr>
<tr>
<td>RTA</td>
<td>2</td>
<td>0.03</td>
<td>0.06</td>
<td>10.95</td>
</tr>
<tr>
<td>P/A</td>
<td>2</td>
<td>0.03</td>
<td>0.06</td>
<td>10.95</td>
</tr>
<tr>
<td>HI</td>
<td>2</td>
<td>0.03</td>
<td>0.06</td>
<td>10.95</td>
</tr>
<tr>
<td>Other</td>
<td>2</td>
<td>0.03</td>
<td>0.06</td>
<td>10.95</td>
</tr>
<tr>
<td>Total</td>
<td>12</td>
<td></td>
<td></td>
<td>76.65</td>
</tr>
<tr>
<td>Mean</td>
<td>1.7</td>
<td></td>
<td></td>
<td>10.95</td>
</tr>
</tbody>
</table>

From the table, it may be chance of only 3% of preventing them from infections. On the same line of description we may say that the patients without prophylactic antibiotics can live approximately 11 days $=(365 \times 0.06)/2$ out of 365.
4.9] Application of QALYs in the Economic Analysis of Health-care

QALYs form an integral part of one particular type of economic analysis within health-care, i.e. cost-utility analysis (CUA). Cost-Effectiveness Analysis (CEA), incremental effects are assessed in natural units such as lives saved, years of life gained, like blood pressure measured in milli metre of Mercury (mm Hg).

In the same way CUA the incremental improvements in health are measured using QALYs. A further advantage of QALYs, is that they allow the effectiveness and cost-effectiveness (or cost-utility) of interventions applied in very different disease areas to be compared, even when, because of their different outcomes, they would not be comparable within a CEA.

Table 33, 34 and Table 36 shows the outcomes and cost, expressed in QALYs, generated by two alternative treatments (A and B) for a given medical condition.

The basic idea about the QALY is that a year of life lived in perfect health is worth 1 QALY (1 Year of Life × 1 Utility = 1 QALY) and that a year of life lived in a state of less than this perfect health is worth less than 1. In order to determine the exact QALY value, it is sufficient to multiply the utility value associated with a given state of health by the years lived in that state. QALYs are therefore expressed in terms of "years lived in perfect health": half a year lived in perfect health is equivalent to 0.5 QALYs (0.5 years × 1 Utility), the same as 1 year of life lived in a situation with utility 0.5 (1 year × 0.5 Utility).

4.10] Cost-Effectiveness Analysis (CEA)

We performed a cost-effectiveness analysis from the societal perspective. The model adheres to the reference case scenario recommended by the Panel on Cost-Effectiveness in Health and Medicine. The cost-effectiveness ratio (CER) is computed as the ratio of difference in cost of two interventions relative to the net difference in their effectiveness. The cost-effectiveness ratio represents a measure of how efficiently the proposed intervention can produce an additional QALY. By using this standard method, the cost-effectiveness of alternative innovations may be compared, helping healthcare payers decide what changes they should adopt.
Cost-effectiveness Ratio Calculation

The cost-effectiveness ratio is a statistical parameter. It is estimated from data on costs and health outcomes that are subject to random variation. Thus, assessing the precision of a computed CER is an important aspect of cost-effectiveness analysis. An interval estimate for the CER or the standard error of its point estimate can be used to assess its precision. Several methods for constructing confidence intervals for the CER have been proposed.[42].

We use of CER ratios as a decision rule. For CE ratio was calculated on the basis of treatment cost per patient. Therefore using the APPENDIX C value we calculate the average cost value. Thus the following table gives the treatment cost for both the interventions, i.e. "A" Treatments with prophylactic antibiotics and "B" Treatments without prophylactic antibiotics.

Table represents the treatment cost for all the patients those who meet the objectives in the groups.

**Table 35: Treatment Cost for the Patient.**

<table>
<thead>
<tr>
<th>Diseases</th>
<th>With PA</th>
<th>Without PA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Number of Patients</td>
<td>Treatment cost in Rs</td>
</tr>
<tr>
<td>CNS</td>
<td>4</td>
<td>13437.62</td>
</tr>
<tr>
<td>CVS</td>
<td>12</td>
<td>8615.18</td>
</tr>
<tr>
<td>Poison</td>
<td>8</td>
<td>10199.47</td>
</tr>
<tr>
<td>RTA</td>
<td>14</td>
<td>9800.15</td>
</tr>
<tr>
<td>P/A</td>
<td>6</td>
<td>20535.45</td>
</tr>
<tr>
<td>HI</td>
<td>13</td>
<td>7596.73</td>
</tr>
<tr>
<td>Other</td>
<td>5</td>
<td>6560.67</td>
</tr>
<tr>
<td>Total</td>
<td>62</td>
<td>76745.27</td>
</tr>
<tr>
<td>Mean</td>
<td></td>
<td>1237.82</td>
</tr>
</tbody>
</table>

Treatment cost is nothing but the ratio of total number of patients to the treatment cost. Calculation for RTA patients, Treatment cost/patient in Rs is

For PA, $9800.15/14 = Rs. 700.01$
For without PA, $803.03/6 = Rs. 134.84$
Other calculation as per the above procedure for the remaining diseases are presented in the form of table and they are as below

**Table 36: Treatment cost per Patients**

<table>
<thead>
<tr>
<th>Disease</th>
<th>With PA</th>
<th>Without PA</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Treatment cost / patients in Rs</td>
<td>Treatment cost / patients in Rs</td>
</tr>
<tr>
<td>CNS</td>
<td>3359.41</td>
<td>1850.97</td>
</tr>
<tr>
<td>CVS</td>
<td>717.93</td>
<td>315.58</td>
</tr>
<tr>
<td>Poison</td>
<td>1274.93</td>
<td>242.84</td>
</tr>
<tr>
<td>RTA</td>
<td>700.01</td>
<td>133.84</td>
</tr>
<tr>
<td>P/A</td>
<td>3422.57</td>
<td>304.71</td>
</tr>
<tr>
<td>HI</td>
<td>584.36</td>
<td>403.93</td>
</tr>
<tr>
<td>Other</td>
<td>1312.13</td>
<td>195.00</td>
</tr>
<tr>
<td>Total</td>
<td>11371.34</td>
<td>3446.66</td>
</tr>
</tbody>
</table>

In a cost-utility analysis, costs and outcomes are compared by dividing the incremental cost by the incremental outcome of one treatment over the other, which will indicate how much each additional QALY gained with the new treatment will cost.

For the RTA disease,

\[
\text{Costs A} = \text{Treatments Cost with prophylactic antibiotics} = \text{Rs 700.01} \\
\text{Costs B} = \text{Treatments Cost without prophylactic antibiotics} = \text{Rs 133.84} \\
\text{Effectiveness A} = 3.56 \\
\text{Effectiveness B} = 0.06
\]

**Therefore,**

\[
\text{Incremental CER} = \frac{(\text{Costs A} - \text{Costs B})}{(\text{Effectiveness A} - \text{Effectiveness B})} = \frac{(700.01 - 133.84)}{(3.56 - 0.06)} = 161.76
\]
For the decision-making we prepare the following table, which represents the CER's for different diseases

**Table 37: Cost-Effectiveness Ratio for various diseases.**

<table>
<thead>
<tr>
<th>Disease</th>
<th>Incremental Cost in Rs</th>
<th>Incremental Effectiveness in QALY's</th>
<th>CER Cost / QALY's</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Costs A- Costs B</td>
<td>Effect A - Effect B</td>
<td></td>
</tr>
<tr>
<td>CNS</td>
<td>1508.44</td>
<td>6.17</td>
<td>244.48</td>
</tr>
<tr>
<td>CVS</td>
<td>402.36</td>
<td>2.64</td>
<td>152.41</td>
</tr>
<tr>
<td>Poison</td>
<td>1032.09</td>
<td>3.53</td>
<td>292.38</td>
</tr>
<tr>
<td>RTA</td>
<td>566.17</td>
<td>3.50</td>
<td>161.76</td>
</tr>
<tr>
<td>P/A</td>
<td>3117.86</td>
<td>4.39</td>
<td>710.22</td>
</tr>
<tr>
<td>HI</td>
<td>180.44</td>
<td>2.61</td>
<td>69.13</td>
</tr>
<tr>
<td>Other</td>
<td>1117.13</td>
<td>2.61</td>
<td>428.02</td>
</tr>
<tr>
<td>Total</td>
<td>7924.49</td>
<td></td>
<td>2058.4</td>
</tr>
</tbody>
</table>

In the case of the figures in above Table 37, the cost-utility ratio is 161.76 Rupees per additional QALY gained with treatment A (= Prophylactic antibiotics) for RTA patients. The cost per QALY’s gained for PA treatment as compared to without PA treatment is Rs 2058.4. Incremental QALYs are often pictured as the difference in the rectangular areas resulting from the multiplication of life-years and utility. The QALYs from table 37 are shown graphically in following Figure 14 for RTA.

Similarly we show graphically (pp 97-99) for each disease and the Rupees per additional QALY gained due to treatment A in above table.

The way in which QALYs are calculated can also be understood geometrically. The points in figures indicate two co-ordinates in a Cartesian plane limited by two axes representing years of life along the horizontal axis and utility along the vertical axis. Each of the points or co-ordinates represents the number of years lived in a state of health with a specified utility.
Figure 11: QALY's Picture as a rectangular areas for CNS Disease.

Figure 12: QALY's Picture as a rectangular areas for CVS Disease.
Figure 13: QALY's Picture as a rectangular areas for POISON Disease.

![Diagram showing QALY's as rectangular areas for POISON Disease.]

Figure 14: QALY's Picture as a rectangular areas for RTA Disease.

![Diagram showing QALY's as rectangular areas for RTA Disease.]

Figure 15: QALY's Picture as a rectangular areas for P/A Disease.

Figure 16: QALY's Picture as a rectangular areas for HI and OTHER Disease.
4.11] Technical Efficiency:

Since CEA involves two metrics (cost and an effectiveness measure) one cannot obtain a single measure of social net benefits; one can only compute the ratio of the two. This can be done in two ways:

**Cost per unit of outcome effectiveness (CE)**

\[
CE = \frac{\text{Cost}}{\text{Effectiveness in terms of QALY's}} = \text{Average cost per unit of effectiveness}
\]

This shows the technical efficiency indicator for the hospital. The decision can be taken on the basis of the ratio. Least value of the ratio for particular disease indicates that the hospital provides the perfect treatments as per the diagnosis to the patients and patients has shown good response & recover speedily from the diseases.

**Outcome effectiveness per unit cost (ES)**

\[
EC = \frac{\text{Effectiveness in terms of QALY's}}{\text{Cost}} = \text{Average effectiveness per unit cost}
\]

In this case the bigger ratio is better for the comparisons. This is another indicator of technical efficiency. Both are the good measures of technical efficiency.

According to our results, hospital is technically efficient for the diseases as per the rank, since it is calculated as average cost per unit of effectiveness. Now it is observed that from the table number 37 (pp.96), the hospital is more technically efficient for the diseases as per the rank HI, CVS, RTA, CNS, Poison, Other and P/A.

In chapter 2, it is observe that the hospital shows good allocative efficiency indicator for the disease RTA and less efficient for CNS. In the above discussion it is notice that the hospital is also less efficient in CNS as compare to RTA as a technical efficiency concerned. For the same disease the hospital shows good allocative and technical efficiency.

4.12] Decision Analysis Model:

In Cost effectiveness studies, the CER is a useful statistical aid in decision-making processes and in the allocation of health care resources. A decision analysis model was developed to represent the choices available to the physician. A
diagram of the decision tree is represented in Figure 17. We considered two strategies treatment with prophylactic antibiotics and treatment without prophylactic antibiotics. Each decision branch includes chance events (Technical efficiency) with their probabilities (QALY weights) for occurrence. The first branch showing the cost for treatment per patients in Rs. using mean value calculated in table 35 (pp. 94).

Figure 17 : Decision Tree Model.

4.13] Discussion: and Outcomes of the study

The economic evaluation estimates the costs of patients by measuring their resource use during their stay in intensive care and hospital wards, their ambulance journey and care after discharge that includes patient's and household's costs, informal care costs and changes in employment [25]. It is observed that direct cost for any disease is always more than indirect cost due to medical, treatment, and hospital resources charges.

From the decision point of view, prophylactic antibiotics with treatment were more effective than without prophylactic antibiotics treatment but the treatment cost is also higher than non-prophylactic antibiotics treatment. The mortality rate, with PA is less than treatment without PA.

The most important challenge for both clinical practice and healthcare policy is to the more definitive definition of the clinical characteristics used to select patients for this new technology versus current alternatives so as to prevent both its overuse and its under use. In the future, such decisions will increasingly depend on the economic as well as the survival implications for these individuals.
Outcomes from Economic Evaluation:

The estimates of the cost of illness in Table 29 help establish an empirical context for a discussion of the economics of health. The approach focuses on the total cost of existing illness, rather than incremental cost or benefits of a given intervention that changes the incidence of future illness. The study of the economic costs provides a template for estimating the economic cost of inadequate diet and inappropriate. From the table 29 the total medical expenditure for 106 patients are in 77 % (Rs 2529371.68) where as for the same patients productivity losses of 23 % (Rs 758811.504) out of total cost in Rs. 3288183.184.

It is also observe that approximately 26-30 % cost will be due to productivity losses out of the total expenditure. The maximum medical expenditure for RTA (21.08 %), HI (20.07 %), P/A (18.55 %) and CVS (15.56 %) out of total medical expenditure. As compared to medical expenditures the productivity losses are very less in percentages. the range percentage of productivity losses is 0.6 to 2.

Results from QALY's:

If we rank the QALY's then it is observed that, for same prophylactic antibiotics patients gains maximum quality-adjusted life years for those patients who suffers from the diseases are CNS, P/A, RTA, Poison, Other, HI and CVS sequentially where-as without prophylactic antibiotics sequence of diseases are RTA, P/A, Other, HI, CNS, Poison and CVS.

Finding from Cost-Effectiveness analysis:

Tables 30 and 31 present the estimated discounted costs and outcomes for alternative strategy. When antibiotic-associated deaths were included in the analysis, the no-antibiotic strategy dominated by the antibiotic strategy. In that case, antibiotics with treatments both are more costly and associated with a lower QALY's as a result of antibiotic-associated deaths. When prophylactic antibiotics associated deaths are included, antibiotic prophylactic with treatment is more effective and more costly than no-prophylactic antibiotics treatment.
The prophylactic antibiotics with treatment strategy would prevent 56 cases (out of 62, 6 are death) of different diseases treated in ICU, with an effect of 3.68 days in average. For 26 patients who do not receive prophylactic antibiotics, only 14 patients survive with an effect 0.05 in average. The total cost would be Rs 3446.66. For patients who receive antibiotics, the total cost would be Rs 11371.34. The incremental cost-effectiveness ratio of treatment with prophylactic antibiotics was Rs 2058.4 per QALY saved and per patients with different cases prevented. The cost per QALY gained for prophylactic antibiotics are more than treatment compared with no prophylactic antibiotics.

After detailed analysis on micro level it was found that the ICU patients at high risk of death who were treated with prophylactic antibiotics had a significantly lower mortality than patients who did not receive prophylactic antibiotics. Thus treatment with prophylactic antibiotics is cost effective technique for ICU patients.

Major Outcomes of the Study:

- From the economic evaluation it is observed that direct cost is always more than that of indirect cost. The observed difference between them is ranges from 17% to 30%. The reasons for that may be severe illness of the patient and that's why the stay is more in the hospital.
- A prophylactic antibiotic is more cost effective than non-prophylactic antibiotics treatment.
- The Quality adjusted life years gain due to prophylactic antibiotic is near about 11 month whereas the treatment those who do not receive this type of treatment are live approximately less than a month.