Project

APPLICATION OF LINEAR PROGRAMMING IN MANAGEMENT OF PRIVATE HOSPITAL/CLINIC

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Introduction

What is Linear programming?

- Linear programming is a mathematical modeling technique that maximizes or minimizes a linear function when subjected to various constraints. In other words, linear programming is regarded as an optimization method for maximizing or minimizing the objective function of a given mathematical model with a set of some requirements represented by a linear relationship.

Linear programming for hospitals:

In country like Bangladesh, it is extremely difficult to run a private hospital smoothly while attempting to meet multiple objectives such as profit maximization, service maximization, and cost minimization, among others. As a result, linear programming is a tool that can assist the management committee in dealing with these daily challenges and achieving their diverse goals.

To solve linear programming problems

Steps to be taken:

1. **Identify the variables and the constraints.**
2. **Find the objective function.**
3. **Graph the constraints and identify the vertices of the polygon.**
4. **Test the values of the vertices in the objective function.**

Methodology

Visited hospital's information

Name	**Islami Bank Central Hospital**
Established in	16th January, 2002
Location	VIP road, Kakrail, Dhaka
Hospital type	Privately owned (Non-Governmental)
Motto	" By your side "

Why we choose this hospital?

Larger and fast-growing hospital
Data sources are mostly available
Serves huge amounts of patients daily
Visionary
Patient friendly

Interviewee Details:

Name: Dr. Md Abu Yousuf
Rank: Superintendent
Visit Date: 5th March, 2022
Place: VIP Road, Kakrail, Dhaka

Data Collection Method:

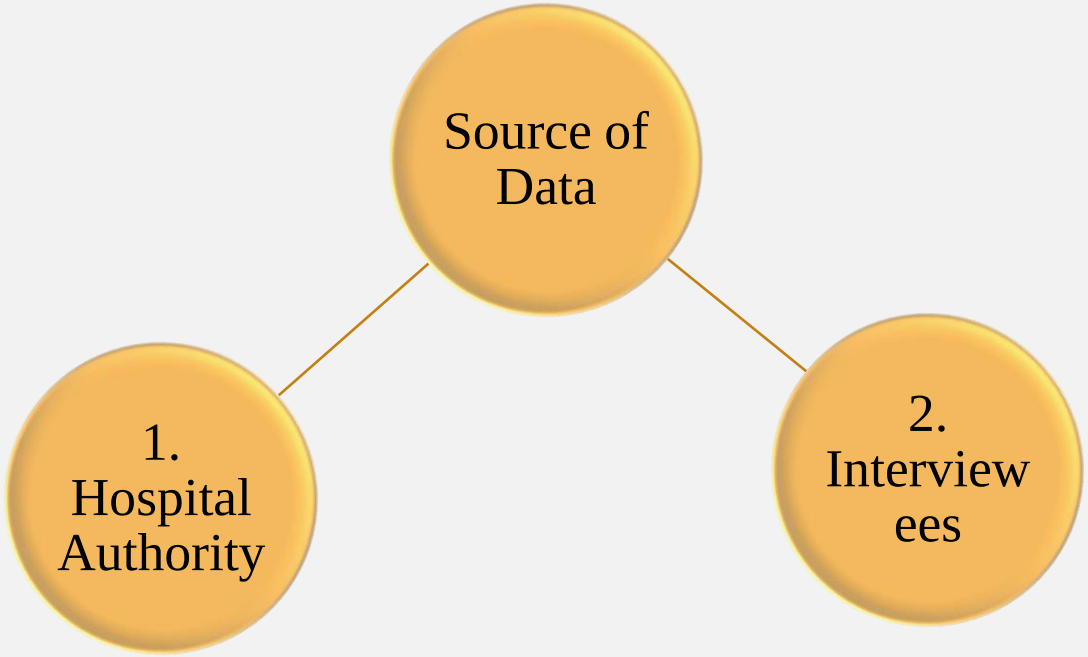
Primary Data

- Filled through a questionnaire
- Data sheet provided by the hospital
- Hospital's website

Secondary Data

- Through talking to superintendent
- Through talking to Accountant officer

Findings Method



Hospital Management Details:

Total Bed	242
Total Cabin	106
Total Ward	92

Related statistics

No. of Doctors	**126**
No. of nurses	208
No. of other staffs	534

Patient Count	**Daily**
Indoor	40-50
Outdoor	800-1000

No. of OT	**07**
No. of ICU	12
No. of NICU	05

No. of Tests & Operations	**Daily**
Tests	400-500
Operations	15-25

Parameter	Ratio
Doctor-patient	1:7.5
Doctor-nurse	3:5
Patient-nurse	9:2

Total no. of Departments	Total no. of Pathological Services
29	19

Covid-19 Related Information

Facilities for covid sample collection	No
No. of Covid test	500-1000
Expenditure on per test	2500 BDT
Total bed for covid patient	14
Incentive in health expenditure for Covid patients	NA
Vaccination program	NA

Financial Information

Financial source during establishment	Islami Bank (Parent organization)
Annual Budget	195 crores BDT
Annual Expenditure	120 crores
Net yearly profit	10 crores
Maintenance Cost (rent of building/machineries cost)	11,975,26 BDT
Doctor's salary	26, 000 BDT
Nurses' salary	16, 200 BDT
Staff's salary	18, 000 BDT
Building Construction	94,16,93,304 BDT

Other services

Tele healthcare	**No**
Regular incentives	**No**

Data Analysis

Based on the collected available data, let us form the linear programming model step-by-step.

Revenue Maximization

Revenue from diagnostics and drug sales:

X_{MR} = Number of MRI Scans

X_{XR} = Number of X-RAYs

X_{EC} = Number of ECG tests

X_{CT}= Number of CT scans

X_{OM} = Number of other medical tests (as a whole)

R_{DS} = Revenue from Drug Sale

The constraints are,

$X_{MR} \leq 20$

$X_{XR} \leq 3600$

$X_{EC} \leq 620$

$X_{CT} \leq 20$

$X_{OS} \leq 16000$

Maximize Revenue = $16000X_{MR} + 300X_{XR} + 300X_{EC} + 11000X_{CT} + 500X_{OS} + R_{DS}$

From the numerical data we have collected:

Revenue from MRI Scan : 16,000 BDT

Revenue from X Rays : 300 BDT

Revenue from ECG : 300 BDT

Revenue from CT Scan : 11000 BDT

Revenue from other medical tests(as a whole) : 600 BDT (Approximate Average)

Total Revenue from Drug Sale : 120000 BDT

Revenue from OT, Admission of Patients and outpatient service:

X_{SU} = Number of Surgery

X_{IC} = Number of ICU (Excluding Covid-19 designated ICUs)

X_{CO} = Number of Covid-19 designated ICU

X_C = Number of Outdoor Patients

X_B = Number of admitted patients in Bed/Cabin (Combination and average of 3 types of accommodation Cabin, Ward and VIP)

The constraints are,

$X_{SU} \leq 200$
$X_{IC} \leq 12$
$X_{CO} \leq 14$
$X_U \leq 60000$
$X_B \leq 67$

From the data we have collected,

Revenue from Surgery = 30000 BDT (Average cost per surgery)

Revenue from ICU (Exc. Covid Desig. ICU) = 110000 BDT (Average cost per admission)

Revenue from Covid-19 designated ICU = 30000 BDT (Average cost per admission)

Revenue from outdoor patient = 600 BDT (Average cost per consultancy/visit)

Revenue from admission of patients = 5000 BDT (Average cost per admission)

Maximize Revenue = $200X_{SU} + 12X_{IC} + 14X_{CO} + 60000X_U + 67X_B$

Hence, the Revenue Maximizing linear programming model/**Objective function** for this hospital would be,

Maximize Revenue = $16000X_{MR} + 300X_{XR} + 300X_{EC} + 11000X_{CT} + 500X_{OS} + 200X_{SU} + 12X_{IC} + 14X_{CO} + 60000X_{U} + 67X_{B} + R_{DS}$

Service Maximization

The decision variables are,

X_I = Number of admitted patients who get treated successfully
X_O = Number of out-patients who get treated successfully
X_D =Average visiting hour of the doctor per day
X_N = Average visiting hour of the nurse per day
X_{OS} = Average working hour of other staffs
X_{OT} = Active hour of the OT

Objective function will be,
Maximize Service (Max S) = $X_I + X_O + 145X_D + 208X_N + 534X_{OS} + 3X_{OT}$

Based on collected data

The constrains are:

$X_I \leq 40$
$X_o \leq 800$
$X_D \leq 6$
$X_N \leq 12$
$X_{OS} \leq 12$
$X_{OT} = 24$

Cost Minimization

Decision variables are:

Z_{SP} = Number of Post graduate doctors
Z_{SG} = Number of Graduate doctors
Z_{SN} = Number of nurses
Z_{SO} = Number of other staffs
C_{EQ} = Cost of equipment
C_M = Cost of medicine
C_E = Cost of electricity bill
C_w = Cost of water and gas bill
C_R = Cost of rent

The constraints are,

$Z_{SP} + Z_{SG} \leq 145$
$Z_{SN} \leq 208$
$Z_{OS} \leq 534$
$C_E \leq 30000$
$C_w \leq 15000$
$C_R \leq 800000$
$C_{EQ} \leq 40000$
$C_M \leq 600000$

The data we have are,

S_p = 100000 BDT (Average salary per month)
S_G = 26000 BDT (Average salary per month)
S_N = 16600 BDT (Average salary per month)
S_O = 13600 BDT (Average salary per month)

Objective Function

Minimizing Cost = $100000Z_{SP} + 26000Z_{SG} + 16600Z_{SN} + 13600S_O + C_R + C_W + C_R + C_M + C_{EQ}$

Goal Programming

The hospital has 3 goals:

Maximum Revenue – A unit
Provided service – B unit
Minimum cost – C unit

Goal 1 (For Revenue) : $16000X_{MR} + 300X_{XR} + 300X_{EC} + 11000X_{CT} + 500X_{OS} + 200X_{SU} + 12X_{IC} + 14X_{CO} + 60000X_{U} + 67X_{B} + R_{DS} \geq A$

For Revenue maximization, deviation is considered: Y_R

To make the deviation positive: $Y_R = Y_R^+ - Y_R^-$

So, **Goal 1 with deviation would be** : $16000X_{MR} + 300X_{XR} + 300X_{EC} + 11000X_{CT} + 500X_{OS} + 200X_{SU} + 12X_{IC} + 14X_{CO} + 60000X_{U} + 67X_{B} + R_{DS} - (Y_R^+ - Y_R^-) = A$

Goal 2 (For Service) : $X_I + X_O + 145X_D + 208X_N + 534X_{OS} + 3X_{OT} \geq B$

For Service maximization, deviation is considered: Y_S

To make the deviation positive: $Ys = Y_S^+ - Y_S^-$

So, **Goal 2 with deviation would be** : $X_I + X_O + 145X_D + 208X_N + 534X_{OS} + 3X_{OT} - (Y_S^+ - Y_S^-) = B$

Goal 3 (For Cost) : $100000Z_{SP} + 26000Z_{SG} + 16600Z_{SN} + 13600S_O + C_R + C_W + C_R + C_M + C_{EQ} \leq C$

For Service maximization, deviation is considered: $\mathbf{Y_C}$

To make the deviation positive: $\mathbf{Y_C = Y_C^+ - Y_C^-}$

So, **Goal 3 with deviation would be** : $100000Z_{SP} + 26000Z_{SG} + 16600Z_{SN} + 13600S_O + C_R + C_W + C_R + C_M + C_{EQ} - (Y_C^+ - Y_C^-) = C$

Considering some **hypothetical deviation value** for each goal deviations we considered before:

$\mathbf{Y_R^+} = 1$
$\mathbf{Y_R^-} = 0$
$\mathbf{Y_S^+} = 0$
$\mathbf{Y_S^-} = 0.5$
$\mathbf{Y_C^+} = 2$
$\mathbf{Y_C^-} = 0$

Minimum Deviation: $0\ (16000X_{MR} + 300X_{XR} + 300X_{EC} + 11000X_{CT} + 500X_{OS} + 200X_{SU} + 12X_{IC} + 14X_{CO} + 60000X_U + 67X_B + R_{DS}) + 0\ (X_I + X_O + 145X_D + 208X_N + 534X_{OS} + 3X_{OT}) + 0\ (100000Z_{SP} + 26000Z_{SG} + 16600Z_{SN} + 13600S_O + C_R + C_W + C_R + C_M + C_{EQ}) + 1.Y_R^+ + 0.Y_R^- + 0.Y_S^+ + 0.5Y_S^- + 2Y_C^+ + 0Y_C^-$

Subject to,

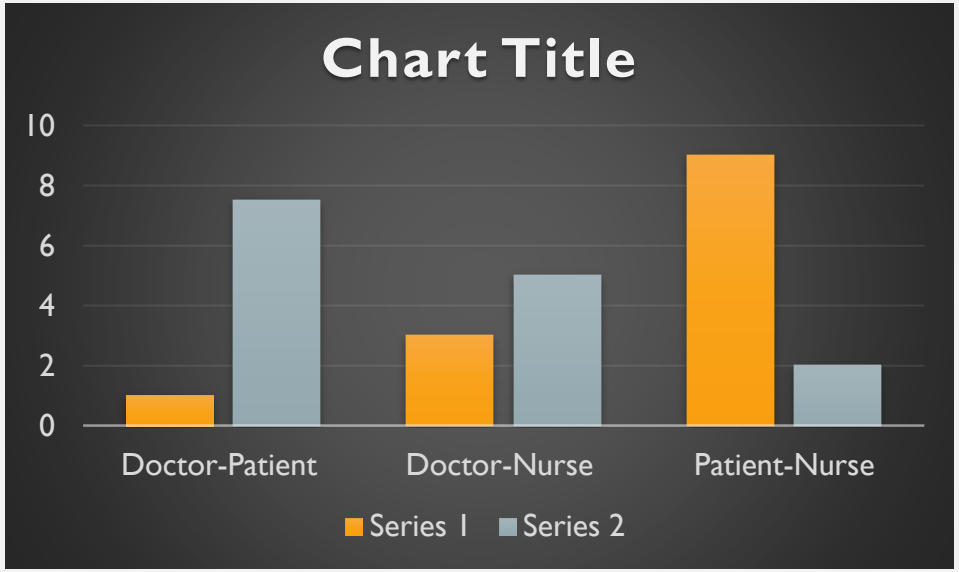
$X_{MR} \leq 20,\ X_{XR} \leq 3600,\ X_{EC} \leq 620$
$X_{CT} \leq 20,\ X_{OS} \leq 16000,\ X_{SU} \leq 200$
$X_{IC} \leq 12,\ X_{CO} \leq 14,\ X_U \leq 60000$
$X_B \leq 67,\ X_I \leq 40,\ X_o \leq 800$
$X_D \leq 6,\ X_N \leq 12,\ X_{OS} \leq 12$

$X_{OT} = 24,\ Z_{SP} + Z_{SG} \leq 145,\ Z_{SN} \leq 208$
$Z_{OS} \leq 534,\ C_E \leq 30000,\ C_w \leq 15000$
$C_R \leq 800000,\ C_{EQ} \leq 40000,\ C_M \leq 600000$

Observation & Limitations

Hospital's overall management was quite good, they have solid future plan, well organized governing body. But there are few points to be raised as concerns:

- Doesn't have a satisfactory doctor-patient ratio
- Situated in one of the busiest roads
- No parking zone
- No incentive for regular/covid
- Very congested, insufficient lifts
- Need to increase more consultants



Conclusion

Covid-19 pandemic has shown us the plight of the healthcare system of Bangladesh. As healthcare is going to be a big market & play an important role - we need to keep focus on it.

3 reasons why linear programming should be used:

1. proper resource allocation
2. To assess health-care policies
3. To operate healthcare management

Thank You!