Cleveland Clinic - Medical Resource Optimization Mathematical Formulation

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Dimensions

$r \in Resources$: set of resources

$f \in Facilities$: set of facilities

$sl \in Servicelines$: set of service lines

$ss \in Sub-services$: set of sub-services

$io \in Inpatient/Outpatient$: set of Inpatient/Outpatient indicator

$ms \in Medical/Surgical$: set of Medical/Surgical indicator

$d \in Days$: set of days

Data Parameters: Model Coefficients

$capacity_{f,sl,ss,r}$ is the capacity of resource r at facility f, service line sl, sub-service ss

$revenue_{f,sl,ss,io,ms}$ is the revenue per patient at facility f, service line sl, sub-service ss, for inpatient/outpatient indicator io, and medical/surgical indicator ms

$margin_{f,sl,ss,io,ms}$ is the margin per patient at facility f, service line sl, sub-service ss, for inpatient/outpatient indicator io, and medical/surgical indicator ms

$demand_{f,sl,ss,io,ms,d}$ is the maximum demand of facility f, service line sl, sub-service ss, and day d, for inpatient/outpatient indicator io, and medical/surgical indicator ms

$losMean_{f,sl,ss,io,ms}$ is the mean hospitalization time of facility f, service line sl, sub-service ss, for inpatient/outpatient indicator io, and medical/surgical indicator ms

$minday$ is the minimum day among the set $d \in Days$, $\min_{d \in Days} d$

Decision Variables

$NewPatients_{f,sl,ss,io,ms,d} \geq 0$ is the number of patients accepted in facility f, service line sl, sub-service ss, on day d, , for inpatient/outpatient indicator io, and medical/surgical indicator ms ms

$OpenFlg_{f,sl,ss} \in \{0,1\}$ is the binary variable indicating if facility f, service line sl, sub-service ss is open

Variables

$TotalPatients_{f,sl,ss,io,ms,d}$ is the total number of patients accepted in facility f,service line sl, subservice ss, cumulative for day d , for inpatient/outpatient indicator io, and medical/surgical indicator ms where,

$$TotalPatients_{f,sl,ss,io,ms,d} = \sum_{\substack{d1 \in d \text{ and} \\ \max\{[d - losMean_{f,sl,ss,io,ms}+1], \\ minday\} \leq d1 \leq d}} NewPatients_{f,sl,ss,io,ms,d1} \quad \forall f, sl, ss, io, ms, d$$

Objective Functions

$max \quad TotalRevenue = \sum_{f,sl,ss,io,ms,d} NewPatients_{f,sl,ss,io,ms,d}\ revenue_{f,sl,ss,io,ms}$

$max \quad TotalMargin = \sum_{f,sl,ss,io,ms,d} NewPatients_{f,sl,ss,io,ms,d}\ margin_{f,sl,ss,io,ms}$

Constraints

Maximum demand constraint: Number of patients accepted for f, sl, ss, io, ms should be less than the maximum demand for day d.

$$NewPatients_{f,sl,ss,io,ms,d} \leq demand_{f,sl,ss,io,ms,d}\ OpenFlg_{f,sl,ss} \quad \forall f, sl, ss, io, ms, d \tag{1}$$

Capacity constraint: Total number of patients for f, sl, ss on day d should be less than equal to available capacity of resource r for f, sl, ss. Capacity of resource r is normalized per patient.

$$\sum_{io,ms} TotalPatients_{f,sl,ss,d} \leq capacity_{f,sl,ss,r} \quad \forall f, sl, ss, d, r \tag{2}$$