OPTIMIZING MANPOWER ALLOCATION FOR DIAGNOSTIC IMAGING DEPARTMENT IN NUH

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National University Hospital is a tertiary referral hospital established in 1985, it is also a referral centre for a wide range of medical, surgical & dental specialties.
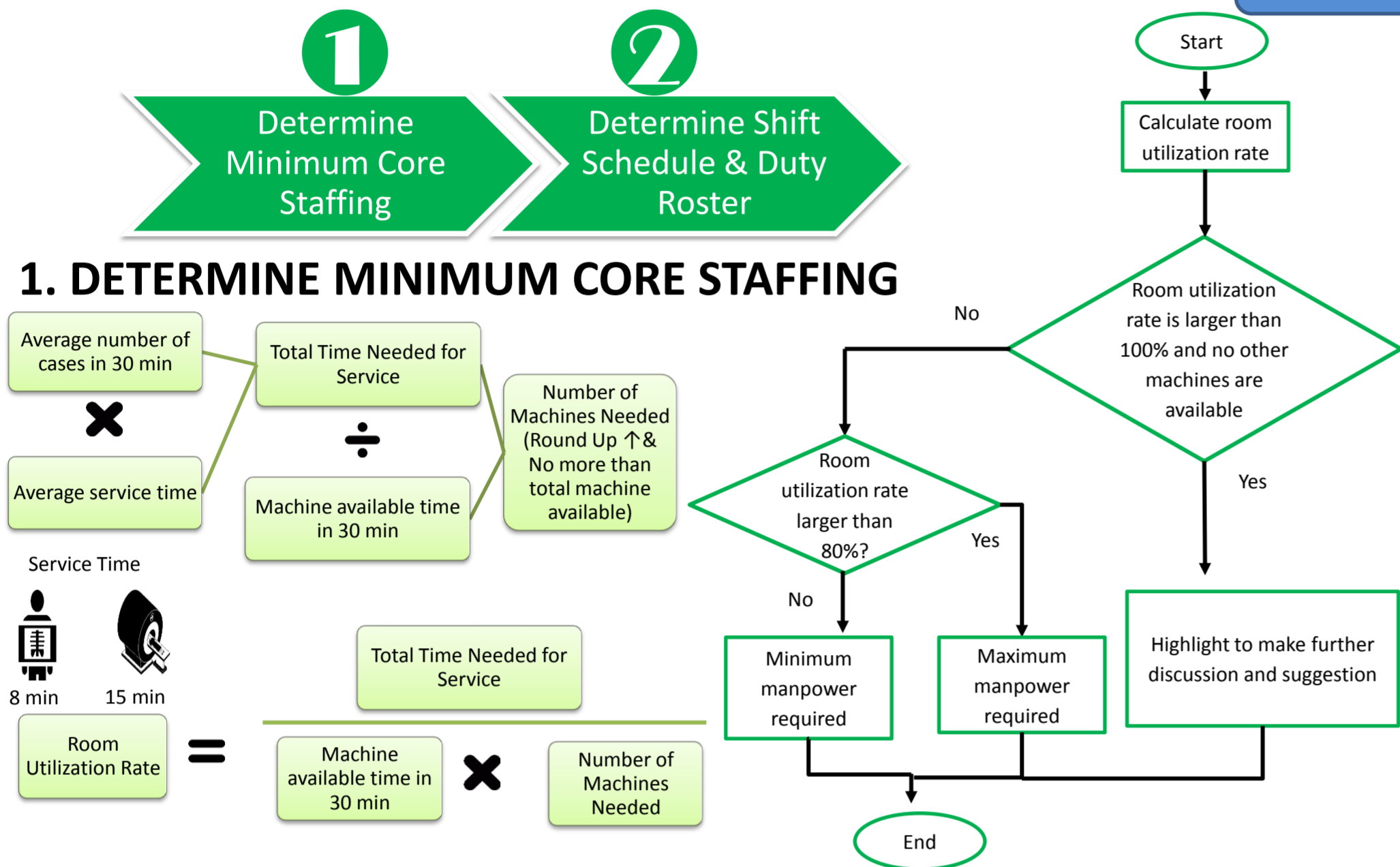
Problem Definition

1 Current scheduling of radiographers is inefficient

2 Difficulty in comparing radiographers' workload across modalities
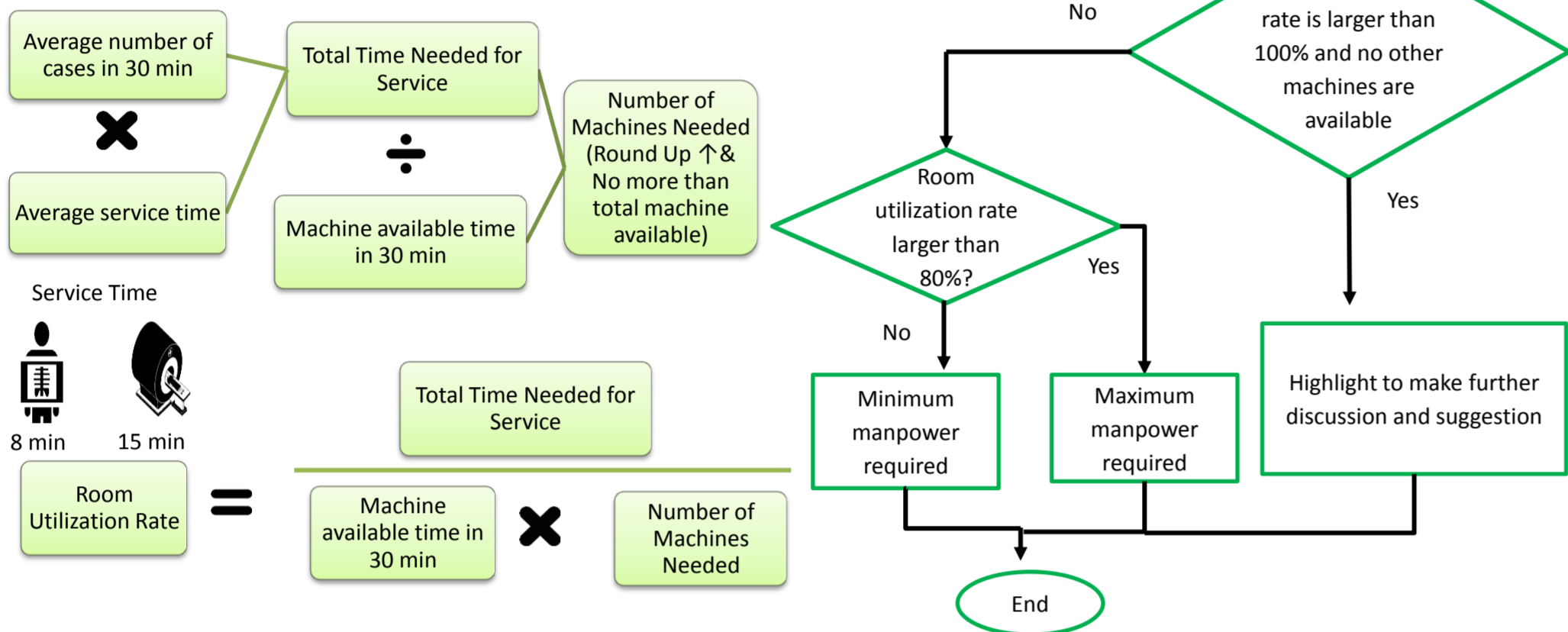
Objectives

Determine Minimum Core Staffing Shift Schedule required to fulfil demand for different modalities

Develop framework for measuring workload of radiographers across modalities

Methodology

1 Determine Minimum Core Staffing → **2** Determine Shift Schedule & Duty Roster

1 Identification of factors → **2** Development of framework → **3** Verification and validation of framework → **4** Workload tracking & benchmarking

1. DETERMINE MINIMUM CORE STAFFING

Average number of cases in 30 min × Average service time

Total Time Needed for Service ÷ Machine available time in 30 min

Number of Machines Needed (Round Up ↑ & No more than total machine available)

Service Time: 8 min, 15 min

Room Utilization Rate = (Total Time Needed for Service) = Machine available time in 30 min × Number of Machines Needed

Flowchart: Start → Calculate room utilization rate → Room utilization rate is larger than 100% and no other machines are available → (No) Room utilization rate larger than 80%? → (No) Minimum manpower required / (Yes) Maximum manpower required; (Yes) Highlight to make further discussion and suggestion → End

2. DETERMINE SHIFT SCHEDULE & DUTY ROSTER

Program used: Linear Optimization Software (AIMMS) to **design a shift schedule to try to match allocated manpower to the min manpower required**
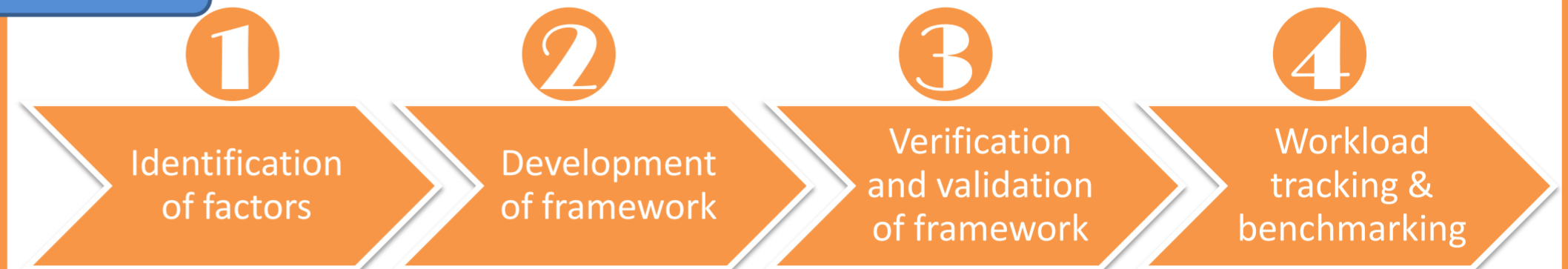
OBJECTIVE FUNCTION:

MIN Overstaffing Cost + Understaffing Cost
Overstaffing Cost: Cost of Hiring Additional Manpower
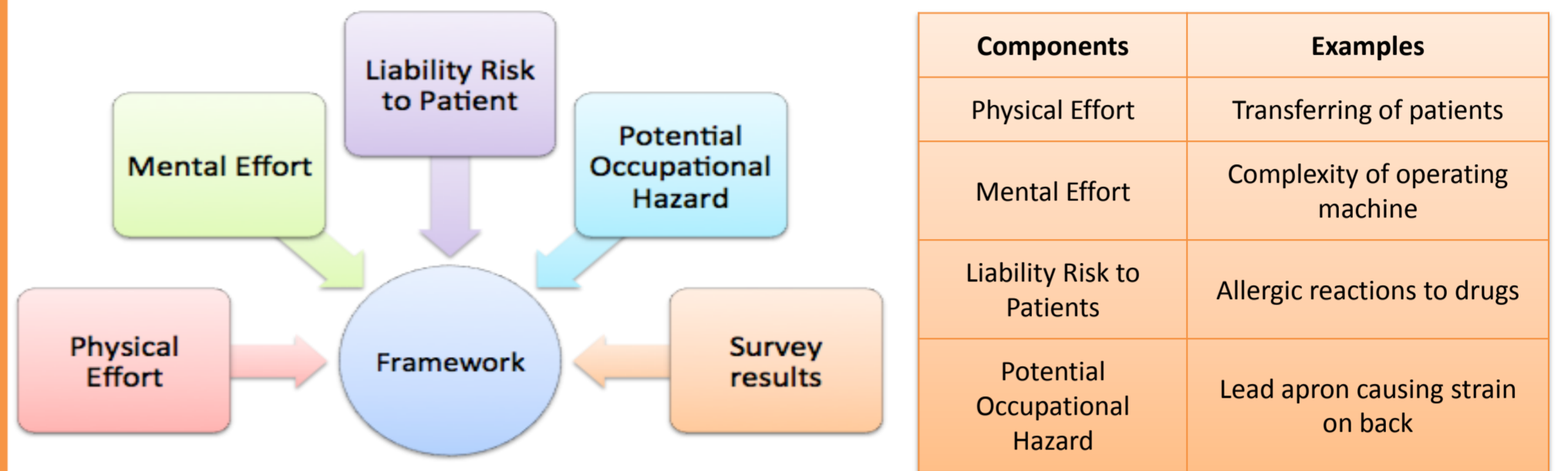Understaffing Cost: Cost of Overtime

CONSTRAINTS:
- Shift Length & Timing
- Break Length & Timing
- Consecutive Working Days & Night Shifts
- Total Working Hours

MODEL ASSUMPTIONS:
- Unit Overstaffing/Understaffing Cost is fixed across department
- No Machine Breakdown
- Radiographers are equally competent at any modality

1. IDENTIFY

Mental Effort, Liability Risk to Patient, Potential Occupational Hazard, Physical Effort, Survey results → Framework

Components	Examples
Physical Effort	Transferring of patients
Mental Effort	Complexity of operating machine
Liability Risk to Patients	Allergic reactions to drugs
Potential Occupational Hazard	Lead apron causing strain on back

Conducted survey to gather perceptions from 72 radiographers on their perceived workload of different modalities.

2. DEVELOP

*Each component has equal weightage with max score of 5

Modality	Physical Effort	Mental Effort	Liability Risk to patient	Potential occupational Hazard	Survey Results
MG	2.02	1.73	1.49	1.67	4
NM	1.25	2.14	3.93	3.15	2
X-RAY	4.17	1.55	2.38	2.92	2.5
US	1.96	3.87	1.61	2.98	4
MR	3.04	4.17	3.15	1.79	3.5
IR	3.04	3.27	3.51	3.63	3.5
CT	4.58	3.27	3.93	3.87	4.5

Modality	Approx. service time (min)
X-Ray	8
CT	20
IR	45
US	30
MR	30
NM	30
MG	15

Develop framework to express workload of different modalities in terms of X-Ray units
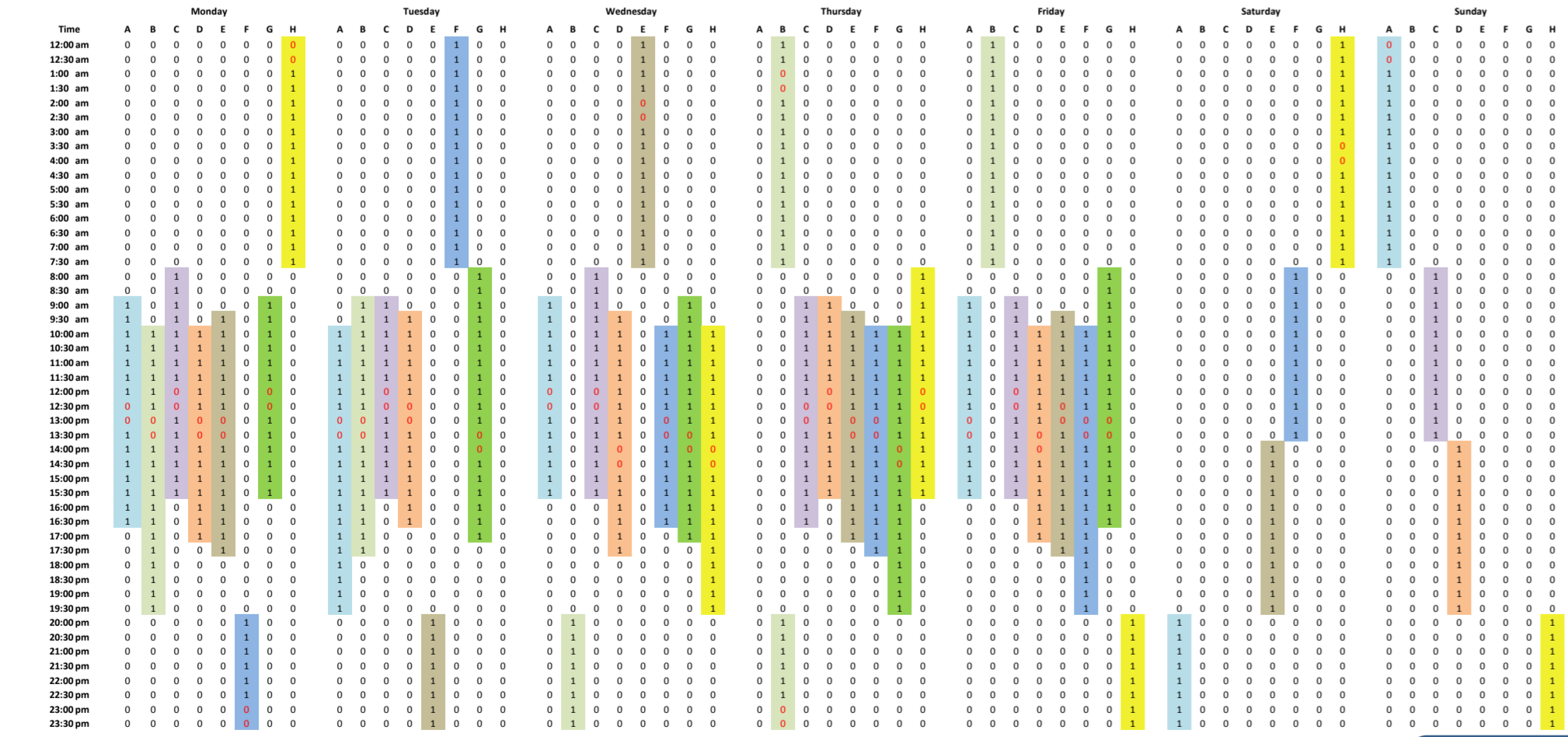
Results

1. DETERMINE MINIMUM CORE STAFFING

Minimum Core Staffing Results for DDI X-Ray

30 min time block	Average no. of cases	Total service time	Number of equipment available	Total available machine time	Current room utilisation	Machines needed	Proposed utilisation	Minimum manpower required	Maximum manpower required	Minimum core staffing
8.0	0.95	7.58	5	150	5.05%	1	25.26%	1	1	1
8.5	3.47	27.74	5	150	18.49%	1	92.46%	1	1	1
9.0	7.61	60.89	5	150	40.60%	3	67.66%	3	3	3
9.5	12.50	100.00	5	150	66.67%	4	83.33%	4	4	4
10.0	17.00	136.00	5	150	90.67%	5	90.67%	5	6	6
10.5	17.77	142.16	5	150	94.77%	5	94.77%	5	6	6
11.0	17.74	141.89	5	150	94.60%	5	94.60%	5	6	6
11.5	15.57	124.53	5	150	83.02%	5	83.02%	5	6	6
12.0	12.93	103.47	5	150	68.98%	4	86.23%	4	4	4
12.5	9.04	72.32	5	150	48.21%	3	80.35%	3	3	3
13.0	6.08	48.63	5	150	32.42%	2	81.05%	2	2	2
13.5	6.64	53.16	5	150	35.44%	2	88.60%	2	2	2
14.0	8.84	70.68	5	150	47.12%	3	78.54%	3	3	3

Approx. service time	No. of equipment available	Min Manpower per machine	Max Manpower per machine
8	5	1	1.2

2. DETERMINE SHIFT SCHEDULE & DUTY ROSTER

3. VERIFY & VALIDATE

Results are verified and validated by consulting the Management of NUH.
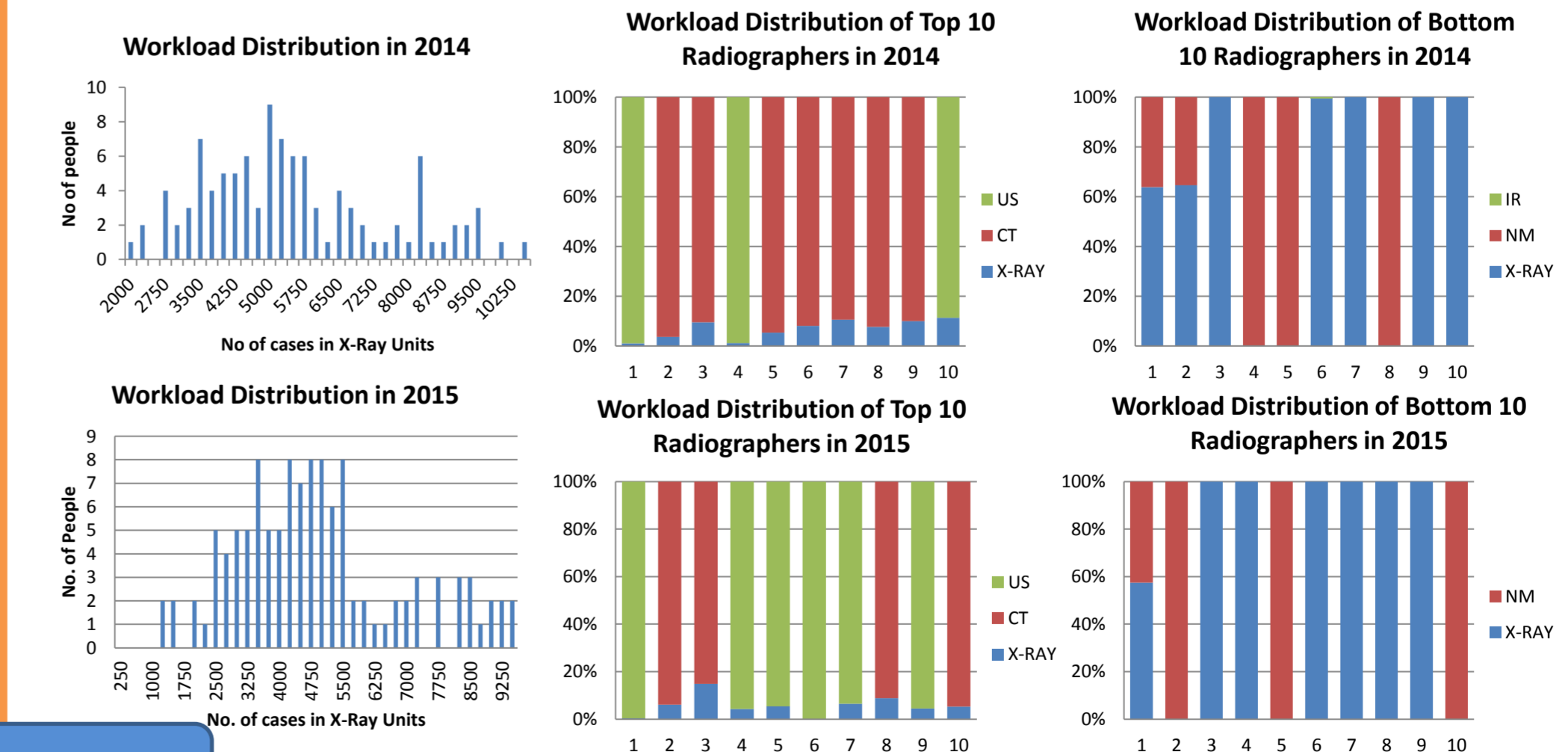
Modality	Score based on Components	Score of Modality/Score of X-Ray	No of scans per hour	Workload in X-Rays units	No of scans to achieve workload equivalent to 1 X-RAY	No of workload in X-Rays units per hour	Ranking
MG	10.90	0.807	4	1.513	0.661	6.053	7
NM	12.48	0.923	2	3.463	0.289	6.925	6
X-RAY	13.51	1.000	7.5	1.000	1.000	7.500	5
US	14.42	1.067	2	4.001	0.250	8.002	4
MR	15.64	1.158	2	4.341	0.230	8.683	3
IR	16.95	1.255	1.3	7.057	0.142	9.410	2
CT	20.15	1.492	3	3.729	0.268	11.187	1

Example for Calculation of CT Workload in X-Ray units:

Formula developed:
$$\frac{n_1 (Modality\ Workload)}{7.5 \times X-Ray\ Workload} = \frac{Score\ of\ Modality}{Score\ of\ X-Ray}$$

Calculating workload for CT:
$$\frac{3 \times (CT\ Workload)}{7.5 \times X-Ray\ Workload} = 1.5 \Rightarrow \frac{(CT\ Workload)}{(X-Ray\ Workload)} = 3.75$$

4. WORKLOAD TRACKING & BENCHMARKING

Workload Distribution in 2014

Workload Distribution in 2015

Workload Distribution of Top 10 Radiographers in 2014

Workload Distribution of Top 10 Radiographers in 2015

Workload Distribution of Bottom 10 Radiographers in 2014

Workload Distribution of Bottom 10 Radiographers in 2015

Suggestions

The comparison diagram clearly demonstrates that the new manpower allocation follows closely to the demand pattern and minimizes overstaffing during non-peak hours. The new design not only saves manpower costs but also allows the radiographers to have more time to carry out their non-clinical duties.

Comparison between Manpower Allocation and Demand (Demand, Optimal, Current)
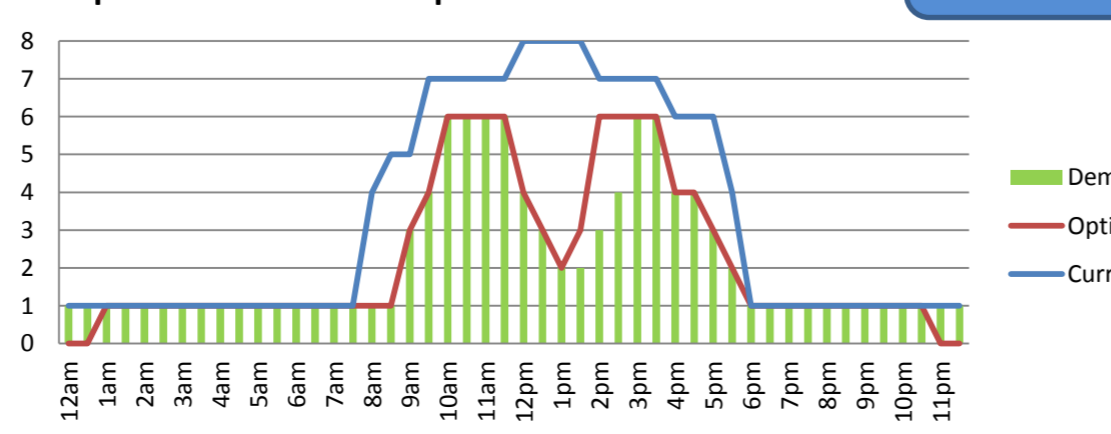
Projected Manpower Allocation for 98 Staff (Current Allocation, 2015 Projected Allocation, 2014 Projected Allocation)
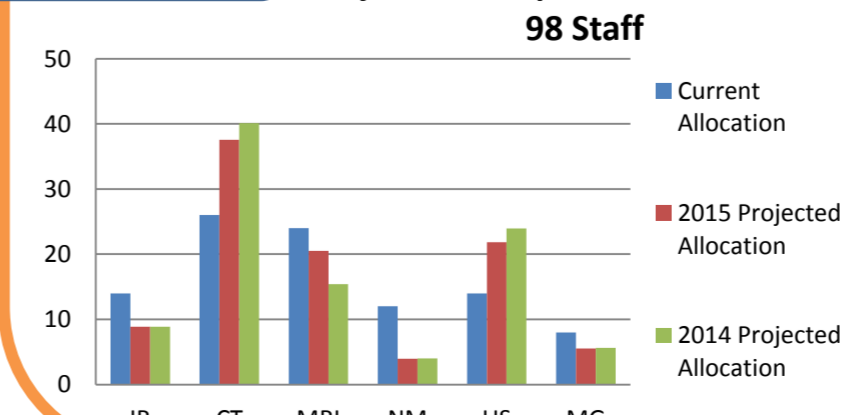
Analysis of workload in 2014 and 2015 gives consistent results which reflects that radiographers with high workload are mainly doing Ultrasound (US) and CT scans while radiographers with low workload are mainly doing X-Rays and Nuclear Medicine (NM) scans. The projected manpower allocation for the various modalities indicates that there is a lack of manpower in CT and US. Thus, more radiographers should be trained to be competent in US and CT.