

RESEARCH ARTICLE

Evaluating demand of High Dependency Unit beds in a hospital with insights on return on capital investment

Sonia Daga¹, Janipalli Lakshmi Prasad², Naveen P. Kumar^{1*}

1. Department of Hospital Administration, Kasturba Medical College, Manipal, Manipal Academy of Higher Education, Manipal, Karnataka, India

2. Department of Hospital Administration, All India Institute of Medical Sciences, Bhopal, Madhya Pradesh, India

Introduction: Hospital administration will have to constantly work around predicting demand of the critical care beds and evaluating the options of expanding the existing capacity. These expansions will be constantly requested by clinicians in private hospitals in India. It becomes imperative to infuse capital into such expansions predicting the utilisation pattern of the new beds. This study concentrates on factors considered for estimating the infrastructure enhancement in step down beds in progression of patient care. **Methodology:** Retrospective measurement of past bed occupancy rates of existing critical care beds, number of patients denied admissions through emergency department due to lack of intensive care beds was counted during previous 1 year. Cost estimates of building, equipment, manpower was collected. The prices that can be charged per rack basis was estimated, for revenue calculation. Return on investment tool using annual revenues divided by annual investment was used to measure the outputs. **Results:** For setting up a 34 bed HDU (High Dependency Unit), 4760 square feet of space was utilised, with USD 594,555 as investment, at a revenue of USD 527,425, which is 75% return in first year, provided occupancy is at 100%. At occupancy of 60%, which was seen within 6 months of commissioning new HDU, the breakeven can be achieved at 450 days. At 100% occupancy breakeven can be achieved in 290 days. **Conclusion:** Demand estimation and Utilisation analysis is valuable tools for administration to make decisions on major capital investments.

Keywords: high dependency unit, return on investment, breakeven point, occupancy rate, progressive patient care

Received 8 July 2023 / Accepted 20 August 2023

Introduction

The limited number of intensive care unit (ICU) beds are under constant demand in hospitals, and the fact is becoming more widely acknowledged throughout the healthcare delivery systems. There are more complicated cases reaching tertiary care hospitals because of introduction of universal health coverage schemes by federal and state governments in India. Centralised free trauma and ambulance services are present at point of incidents, within golden hours. Elective surgery cases, infectious diseases patients with respiratory failure also require intensive care services. Inadequate post-operative care owing to a lack of ICU beds can cause elective procedures to be postponed, or patients to be discharged too soon, and patients to be readmitted to the ICU. Progressive Patient Care concept suggests a step-down pattern of critical care areas, so that concentration of manpower and equipment can be judiciously laid out and utilised well. High Dependency Unit (HDU) is believed to be a lower-cost alternative to ICU in the progressive care of critically ill patients who might not require mechanical ventilation as in ICU.

ICUs are the hospital units that offer the most sophisticated critical care. High-dependency care units (HDUs) are hospital units that offer patient care levels and expenses that are in between those found in the ICU and general ward [1].

A high dependency unit is a section of an intensive care unit where patients can get more comprehensive care than

they would receive in a regular ward, but not as much care as would be offered in an intensive care unit. These facilities will offer patients non-invasive ventilatory assistance. Before being moved to the general ward, people admitted in HDU may need to be moved to the ICU later (step up) or those admitted in the ICU who have improved may be moved to HDU (step down) [2].

As per Indian Public Health Standards 2022 norms, (short form IPHS, is an apex task force document released by Ministry of Health & Family Welfare to govern the district level tertiary care hospitals and secondary level community health centers in India) 8-10% of the total beds should ideally be critical care beds, for a 500 bedded district level hospital. It is recommended to have 45 CCU beds (Critical care unit) out of which there should be 14 HDU beds (including 6 paediatric beds) [2].

Establishing high dependence services in a hospital with the right size gives the possibility of enhanced patient care, training, preservation of knowledge and nursing skills, and effective use of resources [3].

Guidelines for constructing and planning ICUs were initially created in 2001 by the Indian Society of Critical Care Medicine (ISCCM), and they were subsequently modified in 2007. These rules were adopted by India, other developing countries, and prominent bodies like NABH. (National Accreditation board for hospitals and healthcare establishments)

Planning aspects of HDU [4]

This is an area where patient care level is intermediate between ICU and other floors.

* Correspondence to: Naveen P Kumar
E-mail: naveen.kumar@manipal.edu

- It should be located near the ICU or within ICU complex, near emergency or in a ward.
- The nursing and supportive staff should have critical care experience/training.
- Patients after recovery from critical illness, patients of single organ failure and not requiring invasive monitoring or mechanical ventilation but need close observation due to vulnerability for deterioration preferably be admitted in HDU.
- The floor area of the HDU can be up to 50% of the main ICU.
- Doctor/Patient ratio and Nurse/Patient ratio may be relaxed (1:2 and 1:3 respectively).
- It may also be used as palliative unit for patients who are terminally sick and for end-of-life care, if other area is not available for care of such patients in the hospital.

In our institute, to address the issue of excessive refusal of patients requiring ICU care a 34 bedded HDU was commissioned so that ICU patients not on assisted breathing devices can be transferred to a step-down unit. Over a period of previous 6 months, about 100 patients per month could not avail admission due to lack of critical care beds. The study on HDU commissioning was initiated to reduce the strain on the intensive care units and avoid turning away cases from other hospitals because they were at their full capacity. It was observed that during peak timings which is night 8 PM to 12 midnight and early mornings 4 AM to 7 AM, on average around 4-5 cases were turned away every day from the emergency department due to the non-availability of ICU beds. For further management of the patient, ICU occupancy rate has been progressively rising over the past year, and more and more cases have been turned away. There are now 232 ICU and HDU beds at this hospital, the occupancy rate of the 31 ICU beds was taken into account for the study because of their consistent full occupancy.

In the board room meetings of hospital management, the newly planned HDU will cater to all internal medicine speciality units (each department or speciality consisting of 7 Units and each Unit comprising of 3 faculty who are authorised to admit patients), acute dialysis patients, and palliative medicine. It will also act as a step down for post-op surgical patients in case of non-availability of beds in surgical HDU. For institutions which are non-government sponsored, being private not-for-profit tertiary care hospitals, have to consider the revenue losses due to lack of accommodation for patients and if we are planning expansions we have to review the return on investment for every penny spent. When we took into account the bed charge, nursing staff charge, ventilator charge, and monitor charge levied for each patient not getting admitted due to non-availability of ICU bed, on an average we were losing roughly INR 4600 per day (USD 58). With this revenue loss as strategic analysis, we went on to commission an existing ward space into High dependency Unit and

studied its utilisation numbers to generate revenue in next six months after commissioning.

Methodology

The study was observational, conducted over 1-year duration. A cross-sectional, collection of previous year data from medical records department registers on Occupancy rates of intensive care bed units was done. Bed Occupancy Rate (BOR) is an estimation of an inpatient healthcare facility's real usage for a specific time frame. It is stated as a percentage [5]. To calculate occupancy rate, total inpatient days and bed days available was used in the formula, $BOR = (\text{Inpatient Days of Care} / \text{Bed Days Available}) \times 100$. For planning new HDU unit, demand and size was estimated based on number of patients denied admissions into hospital per day.

Return on Capital Investment: A quote of costs involved was obtained from various stakeholders. The total cost of construction, plumbing, electrical alterations, equipment and other capital items was obtained. Fixed cost and operating costs were determined. Daily operating expense and manpower requirement for 100% occupancy was calculated. Breakeven point was used as a tool to understand the returns on capital costs given bed occupancy rates in admissions. The study did not involve biological or health data or financial data from patients or any individuals, hence, ethically it was conducted in sound circumstances, approval was not required.

Results

The monthly and annual bed occupancy rate of ICU beds for 12 months was calculated using the BOR formula as mentioned in the methodology section. ICU-1 and ICU-2 were both closed ICUs managed by the critical care unit consisting of 16 and 15 beds respectively (a total of 31 beds).

The data from Table I shows 2 months in ICU1 and 3 months in ICU2 with around 60% occupancy, rest of all 10 months it is showing above 90% occupancy.

High Dependency Unit Costs

Fixed cost and variable cost involved in setting up a 34 bedded HDU was collected. Fixed cost elements included cost heads mentioned in the Table II. Cost of construction, plumbing, electrical and HVAC (Heating, Ventilation and Air-conditioning) system was calculated for 1 square foot and multiplied into 4670 square feet. List of capital items purchased is mentioned in the table III with their purchase cost. The planning of these items requires historical experience of managing critical care units. The researcher collected this data based on suggestions from clinical units and registers of consumption from the central stores of the hospital.

After gaining the above costs, we computed further fixed costs that would be required by collecting the cost heads as shown in Table IV. The manpower of 2 resident

Table I. Annual occupancy rates of Intensive Care Units ICU-1 and ICU-2

ICU 1				ICU 2				Average
Month	In-patient days	Bed days	BOR (%)	Month	In-patient days	Bed days	BOR (%)	BOR of ICUs (%)
May	423	496	85.28	May	465	465	100	92.64
June	256	480	53.33	June	353	450	78.44	65.89
July	414	496	83.47	July	273	465	58.71	71.09
August	463	480	96.46	August	265	450	58.89	77.67
September	441	496	88.91	September	260	465	55.91	72.41
October	488	480	100.00	October	433	450	96.22	98.11
November	410	496	82.66	November	427	465	91.83	87.24
December	436	480	90.83	December	450	450	100	95.42
January	310	496	62.50	January	467	465	100	81.47
February	413	448	92.19	February	351	420	83.57	87.88
March	437	496	88.10	March	491	465	100	94.05
April	438	480	91.25	April	424	450	94.22	92.74
								84

Table II. Fixed Costs involved in renovating the High Dependency Unit

S. No	Cost head	Cost (in USD)
1	Civil	70,450
2	Plumbing	4575
3	Electrical	194440
4	HVAC	45490
5	Capital items	47270
Total fixed cost		362,225

*INR = Indian Rupee (1 USD = 80 INR and 1 EUR = 87 INR)

Table IV. Fixed costs for operating 34 bed high dependency unit

S. No.	Operating Fixed Costs	Per Annum (in USD)	Per day per bed (in USD)
1	Total staffing cost	120600	10
2	Electricity cost	28750	2
3	Monitor rental cost	35700	3
Total operating cost		185,050	15

Table V Selling Price components per patient per bed

S. No.	Revenue	Per day (in USD)	Per year (in USD)
1	Bed charge	7	85319
2	Doctor & Nurse charge	15	186,150
3	Monitor	10	116344
4	Oxygen	11	139612
Total revenue (1 year)		33	527,425

doctors and 12 nurses, 2 respiratory therapists were considered into HDU, as per the suggested norms, and their salaries were taken. Cardiac and Pulse oximetry monitors were hired from an out sourced company on annual basis. 34 of them were planned as required for next one year.

By adding the values from Table II, III, & IV, the total fixed costs and capital item costs of commissioning the new HDU would amount to USD 594,555.

Selling price that can be charged to each patient and its components are mentioned in Table V. Selling price in our study was calculated based on the historical costs that were levied by the hospital in existing areas. Most of the private hospitals put their charges on bed, doctor consultation, nurse, diet, ventilator, oxygen charges are major resources that need to be billed to patients, other consumable items like medicines, surgical items costs go as per consignment price basis offered by manufacturers. These can be called as

Table III. Capital items required for 34 bed High Dependency Unit

S. No	List of capital items	No of units	Total cost (in USD)
1	Shifting trolleys and wheelchairs	2 +2	775
2	Oxygen cylinder trolley	1	25
3	Bedside locker	34	3382
4	Storage cupboards	4	432
5	Hamper stand	5	440
6	Infusion pump	10	3630
7	Syringe pump	10	5110
8	Ophthalmoscope	1	322
9	Refrigerator	1	157
10	Examination light	1	196
11	Stainless steel table	6	196
12	Water purifier	1	402
13	Computer and visitor chair	4+10	623
14	Staff bed	2	607
15	Shifting monitor	5	6500
16	Defibrillator	1	2500
17	Crash cart	2	695
18	Dressing trolley	12	1950
19	Fowlers cot	34	16492
20	Myostand cost	34	2846
Total			47,280

variable costs in the study, but, as they have not yet been accrued, they were not considered in the study.

New HDU bed utilization analysis

After 34 bedded HDU was commissioned, we observed for next 6 months the occupancy rates. It started with 15% in first month and then occupancy increased to 60% and it averaged around 62% over a 6-month duration of observation. The 62% occupancy rates suggests 22 beds being occupied on any day.

Discussion

High cost of managing intensive care beds and higher rate of penetration of insurance coverage in population in India, will continue to produce strain on secondary and tertiary care hospitals managers. For an ordinary bed in hospital, there are alternative strategies like increasing home

care services, improving cost effective services at the community level [6]. The alternative strategies to reduce higher length of stay on intensive beds can be clinicians reducing inappropriate admissions in to critical care beds, facilitate faster discharge, using standard treatment guidelines, standard antibiotic usage policy across all units. These are difficult to implement in private hospitals in India where clinicians are working on fee for service or consultant basis. Each clinician will vary in opinions on treatment guidelines and on antibiotic usage regimens, competition among doctors in private practise, sub optimal inter-departmental co-ordination, dysfunctional regulatory system, and unreliability of antibiograms [7]. The presence of HDU as a step down unit for an ICU patient has reduced hospital mortality by 2.5% and remaining length of stay by 1.1 day [8]. Every ICU patient is potentially classified as deemed fit to HDU, if 12-24 hours of monitoring is required in the patient. Reference to data from Table I, ICU bed occupancy rates have consistently exceeded 85% during the previous six months, sometimes even exceeding 97% in spite of reserving a code blue emergency bed for in-hospital Code blues. This points to the demand of critical beds in this hospital. At least 1—2 beds should be kept vacant for code blue situations. Added to this, emergency department records showed everyday 4 to 5 patients outpatient registration numbers not getting converted into inpatient registration numbers, though their diagnosis falls within admissible category. Many clinical department consultants in committee meetings were requesting to enhance critical care beds in previous 1 year. This prompted us to plan for a 34 bedded mid-level care unit. The requirement for more critical care beds was requested by the critical care team.

A 34 bedded HDU was constructed in an area of 4670 square feet which equates to 137 square feet per bed, complying with statutory standards. The infrastructure and the equipment required for each bed has been described here, which matches with statutory guidelines specified in Indian Public Health Standards documents. The cardiac monitors were not purchased in our model, to avoid higher costs in equipment. The equipment costs in hospital will reach up to 40% of the capital investment in hospitals in India [9]. Fowler's cots would be having highest spend on the equipment in a critical care area. The study identifies the selling price or the charges that can be levied on each bed high dependency bed. In the revenues side, maximum earnings would be through monitor wherein, we charge an INR 750 (USD 10) to patient, pay INR 250 (USD 3) to the vendor. Manpower charges we can earn 40% more than we pay. Medical gases revenue would be the highest in a critical care area. A study done on ICU care and econometric analysis of ICU beds, to avoid bed shortage crisis during short terms physicians can be asked to use early discharge strategy, but, authors suggest that there was higher re-admission rate into the ICU [10]. In a step down pattern of progressive patient care, female patients have a higher risk of re-admission into ICU / HDU within 72

hours. [11] The predictions of top management on utilisation have been met as expected before planning to have a HDU. As per Table VI, current utilization of 62% would take around 450 days to breakeven the fixed and operating cost. At a 100% occupancy rate it would take around 290 days to breakeven. But, this cannot be possible in real-time hospital scenario, it can reach 95% by next six months.

Table VI. Utilisation of High Dependency beds during a 6—month after commissioning

Month	In-patient days	Bed days	BOR (in %)
June	119	840	14.17
July	543	868	62.56
August	656	840	78.10
September	673	868	77.53
October	639	840	76.07
November	560	868	64.52
Average	3190	5124	62.26

Limitations of study

The study is single center study and the hospital belongs to private category. There is no uniform pricing regulations in hospitals, across the globe. The selling price and revenue modelling between two private hospitals will vary in India, so utilisation data will vary. The study will be very relevant to private medical college hospitals in India, regarding planning infrastructure and equipment to a HDU. There are many strategies that have solved problems for easing the “regular hospital bed” crisis like Serman's system dynamic modelling process, but, strategies do not hold good in intensive care area, where patients arrive at a complicated health stage and mortality chances are high. Hence, strategies were not used as research tool. Another limitation of the study is costs from patient's increased length of stay was not considered, as research needs were about commissioning costs and utilisation of the new facility. Another limitation of study was only fixed capital costs were considered and variable costs of patients were measured as, fixed costs have a direct bearing on return on capital costs.

Conclusion

This study shows High Dependency Unit can be viable option to reduce pressure on intensive care bed shortage crisis in a multi-speciality hospital. Creating a HDU facility will require less capital compared to ICU bed. Utilisation monitoring and costs of a new critical care facility is important for revenue cycle monitoring. Our bed occupancy on new HDU increased from 14% in first month to 60% in 6 months duration. This study reveals that 100% return on capital investment is achievable in a year and first quarter period, 450 days precisely with 60% occupancy rates, given the selling prices and infrastructural costs we had incurred in Indian situation.

Author contributions

SD - Conceptualization, Data curation, Methodology, Resources, Writing – original draft.

JLP - Funding acquisition, Supervision, Validation, Analysis, Editing

PNK - Formal Analysis, Funding acquisition, Supervision, Validation, Visualization, Writing – review & editing, Project administration.

Conflict of Interest

None to declare

References

- Guidelines for developing admission and discharge policies for the Paediatric Intensive Care Unit. Paediatric Clinical Practice Guidelines; Policies. 2018:1246–48.
- Government of India Ministry of health and family welfare. GUIDELINES FOR HIGH DEPENDENCY UNIT (HDU) INTENSIVE CARE UNIT (ICU) Google; [cited 2023Apr13]. Available from: <https://chrome.google.com/webstore/detail/adobe-acrobat-pdf-edit-co/efaidnbnmnnibpcajpcgclefndmkaj?hl=en-GB>
- Boots R, Lipman J. High dependency units: Issues to consider in their planning. *Anaesthesia and Intensive Care*. 2002;30(3):348–54.
- Rao BK, Mittal K, Khilnani GC, Rungta N, Rungta N, Dixit S, et al. Indian Society of Critical Care Medicine Experts Committee Consensus statement on ICU Planning and designing, 2020. *Indian Journal of Critical Care Medicine*. 2019; 24(S1).
- WHO European Health Information at your fingertips. [Internet]. World Health Organization. World Health Organization; [cited 2023Mar31]. Available from: https://gateway.euro.who.int/en/indicators/hfa_542-6210-bed-occupancy-rate-acute-care-hospitals-only/
- Najibi, S.M., Seyedi, S.H., Farhadi, P. et al. Development of a model for predicting hospital beds shortage and optimal policies using system dynamics approach. *BMC Health Serv Res* 22, 1525 (2022).
- Philip Mathew, Jaya Ranjalkar, Sujith John Chandy: Challenges in Implementing Antimicrobial Stewardship Programmes at Secondary Level Hospitals in India: An Exploratory Study: *Front. Public Health*, 18 September 2020, Sec. Infectious Diseases – Surveillance, Prevention and Treatment. Volume 8 - 2020 | <https://doi.org/10.3389/fpubh.2020.493904>
- Lekwijit S, Chan CW, Green LV, Liu VX, Escobar GJ. The Impact of Step-Down Unit Care on Patient Outcomes after ICU Discharge. *Crit Care Explor*. 2020 May 6;2(5):e0114. doi: 10.1097/CCE.000000000000114.
- Naveen PK, Godhia HP, Srinivas NJ et. al. Insights into equipment planning of a 250-bed hospital project. *Int J Health Sci Res*. 2014;4(10):311-321.
- Diwas Singh KC, Christian Terwiesch, (2011) An Econometric Analysis of Patient Flows in the Cardiac Intensive Care Unit. *Manufacturing & Service Operations Management* 14(1):50-65.
- Aishwarya TR, Naveen Kumar P. Relative Risk Analysis of Patient Return within 72 Hours to Emergency Department. *Online J Health Allied Scs*. 2022;21(3):4.