

Cost Analysis of Pediatric Intensive Care: A Low-Middle Income Country Perspective

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Abstract

Background: Globally, Pediatric Intensive Care Unit (PICU) admissions are amongst the most expensive. This makes it important to gain insights into the cost of pediatric intensive care units. We undertook this study to calculate the health system cost and out of pocket expenditure incurred per patient during Pediatric Intensive Care Unit (PICU) stay

Methods: Prospective study conducted in a state of art tertiary level PICU of a teaching and referral hospital. Bottom-up micro costing methods were used to assess the health system cost. Annual data regarding hospital resources used for PICU care was collected from January 2018 to December 2018. Data regarding out of pocket expenditure (OOP) was collected from 299 patients who were admitted from July 2017 to December 2018. The study period was divided into four intervals, each of 4 and a half months duration and data was collected for 1 month in each interval. Per patient and per bed day costs for treatment were estimated both from health system and patient's perspective.

Results: The median (inter-quartile range, IQR) length of PICU stay was 5(3–8) days. Mean \pm SD PRISM score of the study cohort was 22.23 ± 7.3 . Of the total patients, 55.9% (167) were ventilated. Mean cost per patient treated was US\$ 2,078 (₹ 144,566). Of this, health system cost and OOP expenditure per patient were US\$ 1,731 (₹ 120,425) and 352 (₹ 24,535) respectively. OOP expenditure of a ventilated child was twice that of a non-ventilated child.

Conclusions: The fixed cost of PICU care were 3.5 times more than variable costs. Major portion of cost is borne by hospital. Severe illness, longer ICU stay and ventilation were associated with increased costs. This study can be used to set the reimbursement package rates under Ayushman Bharat – *Pradhan Mantri Jan Arogya Yojana* (AB-PMJAY). Tertiary care state of art intensive care in a public sector teaching hospital in India is far less expensive than developed countries.

Background

Globally, Pediatric Intensive Care Unit (PICU) admissions are amongst the most expensive. They significantly impact the financial dynamics of patient families. Although intensive care beds comprise of only about 10 % of hospital beds, they account for 20- 40 % of all hospital costs especially in the high income countries[1]. However, health insurance coverage and availability of drugs and consumables from hospital supplies eases financial burden for patient families. The scenario in low middle-income countries like India is different; lack of health care insurance, and absence of uniform governmental health care support contribute majorly to the financial burden. The out of pocket expenditure (OOP) for families whose children are admitted to intensive care units is very high. Although there have been few studies from India on cost analysis in neonatal intensive care units, similar cost analysis of PICU care and the financial impact on the families of children receiving such care in India is limited.

Our PICU is a large public sector Level III, Intensive Care Unit that caters to a significant burden of patient referrals coming from 5-6 north-western states of India viz Haryana, Punjab, Himachal Pradesh, Uttar

Pradesh, Jammu & Kashmir and Rajasthan. Cost analysis from such a set up would provide insight into the financial burden and its impact on hospital and communities. Although the Indian government launched the Ayushman Bharat – *Pradhan Mantri Jan Arogya Yojana* (AB-PMJAY), a health insurance scheme based on economic criteria in September 2018, there is a dearth of evidence on cost of health care to help set the provider payment or package rates. The data generated through this study will help in budget planning, allocation, and effective utilisation. This model can then serve as a benchmark for other similar ICUs.

Methods

Study setting. We undertook a prospective observational cross-sectional study in a Level III PICU of a tertiary care teaching and referral hospital in North India. The PICU is a 15 bedded unit, with an annual admission average of 900 to 1000 patients. It has state of art respiratory, hemodynamic and multimodal neuromonitoring facilities. Diagnostics such as echocardiography, X-ray, ultra-sonography, and arterial blood gas monitoring are available round the clock. While provisions for haemodialysis and continuous renal replacement therapy exist, ECMO is not available. A total of 912 patients were admitted in the PICU during 2018.

Study design

Health system cost: Bottom - up micro methodology was used to estimate health system costs[2]. Annual data regarding hospital resources utilized for the PICU care was collected from January 2018 to December 2018. The methodology for data collection included reviewing records, staff interviews and physical inspection of facility. The data were classified as recurrent or non-recurrent resources. Human resources, diagnostics, consumables and overhead costs (i.e. water consumption, electricity and dietetics etc.) comprised recurrent costs. Costs of building or space, medical and non - medical equipment and furniture was the part of non-recurrent costs. Staff members were interviewed to obtain information on the time spent by them in PICU and further annual salary was apportioned to number of working days in PICU. Pretested questionnaires used in previous Indian studies were used[3-6]. Stock registers of PICU were the major source of data regarding quantities consumables and non-consumables. Data regarding diagnostic tests was collected and cost of diagnostics was calculated by multiplying

each investigation charge by a factor (3.04), (derived from previous costing studies done in PGI), thereby converting the user fee into total cost of diagnostics[7]. Data for the overhead costs was collected by record review of electricity bills and water bills. Hospital's procurement branch had provided the data regarding capital costs, including the year of purchase and price of medical and non-medical equipment[3]. Technical officer in – charge of PICU was interviewed to elicit information regarding average life of the equipment. Apart from this, literature was reviewed to cross validate for the life of capital items[3,7]. The health system costs were summated and calculated as Annual Health System Cost and then divided by the total number of patients admitted in the study year to calculate the mean health system cost per patient. Sources of data are described in Table 1.

Out of pocket expenditure: Out of pocket expenditure is the expenditure borne by the patient families for their ward's treatment in PICU. For the same, the study period of one and a half years from July 2017 to December 2018, was divided into four intervals, each of 4 and a half months duration. Data was collected for 1 month in each interval wherein patients >1 month to 12 years admitted in PICU during that interval were enrolled consecutively.

Written and informed consent was obtained from the parents. OOP expenditure was elicited for bed charges, medicines, investigations, transportation, meals of attendants with patient. The data regarding the same was collected at admission in PICU, followed by a daily interview till the discharge or transfer or final outcome of the patient.

Secondly, we also collected data on socio-demographic characteristics of the families of the patient admitted which included education and occupation of the head of the family and per capita income. Patients were also given questionnaires to obtain information regarding methods to cope with expenses for treatment and salary losses during the hospital stay.

Data Analysis

Health System Costs: Data analysis was done using Statistical Package for Social Sciences (SPSS) version 25 and MS Excel. The cost of the PICU space / building was estimated by applying rental price for the area. Annualized costs of various medical and non-medical equipment in the PICU were estimated based on their average useful life and application of an average discount rate. A discount rate of 3% was used to compute the annualization factor[8]. All the cost estimates were finally converted to 2018 prices to adjust for inflation, applying a discounting factor of 3% per year.

Apportioning Statistics: Appropriate apportioning statistics were used to allot shared or joint resources to the PICU. Firstly, for the human resources, we interviewed people involved in PICU services, which mainly included consultants, residents, nursing officers and technical staff to obtain data on patterns of work flow and time devoted to PICU. Proportion of time spent in PICU care was used to apportionate the shared human resource costs.

Secondly, costs of shared building/space (i.e. waiting hall, discussion room, resident's room, nursing station, laboratory etc.), overheads and equipment were apportioned on the basis of bed-days of PICU patients in a year. Costs of consumables could not be apportioned on the basis of based on bed-days of admission in the PICU, as these are dependent on the severity of illness of the patients.

Unit Costs: Per-patient and per-bed-day costs of treatment were estimated for PICU patients.

Out of Pocket Expenditure: We estimated the mean and standard error of OOP expenditure from the data collected from the patients. Descriptive statistics [frequencies and proportions, mean ± standard deviation (SD) and Median (IQR)] are used for baseline data analysis. Chi Square test, Fisher exact test, Mann – Whitney test and Wilcoxon Whitney test were used to calculate relation between relevant parameters.

Results

Sample characteristics

A total of 299 children were enrolled for the estimation of OOP. The median (IQR) age of the study subjects was 4 (0.8 to 12 years). Of all patients, boys represented 63.5% (190). The median (IQR) length of PICU stay was of 5 days (3–8 days). Nearly half of the parents had completed middle and high school education. Only 21(7%) and 7(2.3%) were graduates and post graduates respectively. Socio economic status classification according to Kuppuswami Scale 2018, showed that 288 (96.5%) of admitted children belonged to the lower middle and upper lower socio-economic strata. Out of them 49.8% were labourers and daily wage workers, 44.8% were self-employed and only 5% were salaried personnel. Around 85% patients were discharged or transferred to wards alive from PICU while forty six patients had died (Table 2). The mean \pm SD PRISM III score was 22.2 ± 7.3 with maximum score being 46. Common indications for PICU admission were respiratory (40.8%), followed by hemodynamic needs (19.7%) and combined in the rest. Among the diagnostic categories, tropical fevers (dengue, scrub typhus, malaria, enteric fever) were the commonest ($n = 47$; 15.8%), followed by acute meningoencephalitis ($n = 43$; 14.7%), community acquired pneumonia ($n = 43$; 14.7%), disseminated staphylococcal sepsis ($n = 23$; 7.7%) acute bronchiolitis ($n = 18$; 6.2%), poisoning and envenomation ($n = 17$; 5.8%), acute meningitis($n = 15$; 5%), acute gastroenteritis($n = 9$; 3.1%) and others ($n = 46$; 15.4%).

Health system costs

The total health system cost incurred to treat 912 children in PICU during the year 2018 was estimated to be US\$ 1,578,900 (₹109,844,073). Share of human resources was the highest (58.5%), followed by Capital space (16%) and Equipments (15.5%). The total mean cost per patient treated and per bed-day in the PICU was found to be US\$ 2,078 (₹144,566) and 415 (₹ 28,871) respectively. Of this, the mean health system cost per patient and per bed day was US\$ 1,731 (₹120,425) and 346 (₹24,071) respectively. Table 3 depicts Annual and unit health system costs and total costs for patients admitted in PICU.

Table 2. Characteristics and out of pocket expenditure of patients admitted to Pediatric Intensive care unit in a tertiary care teaching hospital in India

| Characteristics | US\$ (₹) | | | |
|---------------------|----------|------|--------------|------------|
| | N | % | Mean | SE |
| Gender | 190 | 63.5 | 368 (25,659) | 28 (1,965) |
| Male | 109 | 36.5 | 324 (22,576) | 17 (1,191) |
| Female | 299 | 100 | 352 (24,535) | 19 (1,323) |
| Total | | | | |
| Age group | 172 | 57.5 | 334 (23,260) | 15 (1,087) |
| <5 years | 127 | 42.5 | 377 (26,262) | 39 (2,745) |
| >5 years | 299 | 100 | 353 (24,535) | 19 (1,323) |
| Total | | | | |
| Education | 16 | 5.4 | 444 (30,914) | 44 (3,128) |
| Illiterate | 103 | 34.4 | 335 (23,360) | 19 (1,334) |
| Primary school | 82 | 27.4 | 314 (21,883) | 22 (1,598) |
| Middle school | 68 | 22.7 | 423 (29,430) | 71 (4,957) |
| High school | 2 | 0.7 | 380 (26,450) | 0 |
| Diploma | 21 | 7.0 | 293 (20,453) | 33 (2,298) |
| Graduate | 7 | 2.3 | 322 (22,466) | 49 (3,457) |
| Professor of Honors | 299 | 100 | 352 (24,535) | 19 (1,323) |
| Total | | | | |
| Kuppuswami scale | 11 | 3.7 | 288 (20,096) | 59 (4,138) |
| Upper Middle | 122 | 40.8 | 370 (25,786) | 41 (2,883) |
| Lower Middle | 166 | 55.5 | 343 (23,910) | 15 (1,063) |
| Upper Lower | 299 | 100 | 352 (24,535) | 19 (1,323) |
| Total | | | | |

Conversion rate: US\$1 = ₹ 69.57

| Characteristics | US\$ (₹) | | | |
|----------------------------------|----------|------|--------------|--------------|
| | N | % | Mean | SE |
| Occupation | 149 | 49.8 | 329 (22,926) | 15 (1,068) |
| Labourer | 134 | 44.8 | 342 (23,828) | 18 (1,292) |
| Self-employed | 1 | 0.3 | 788 (54,830) | 0 |
| Unemployed | 15 | 5.0 | 644 (44,819) | 303 (21,114) |
| Salaried | 299 | 100 | 352 (24,535) | 19 (1,323) |
| Total | | | | |
| PRISM SCORE | 148 | 49.5 | 235 (16,376) | 12 (8,30) |
| 11–20 | 100 | 33.4 | 413 (28,765) | 18 (1,307) |
| 21–30 | 48 | 16.1 | 597 (41,552) | 94 (6,599) |
| 31–40 | 3 | 1 | 198 (13,836) | 34 (2,374) |
| >41 | 299 | 100 | 352 (24,535) | 19 (1,323) |
| Total | | | | |
| Ventilated | 167 | 55.9 | 466 (32,482) | 30 (2,118) |
| Non ventilated | 132 | 44.1 | 208 (14,482) | 9 (67,2) |
| Total | 299 | 100 | 352 (24,535) | 19 (1,323) |
| Duration of ventilation | 154 | 51.5 | 210 (14,653) | 8 (5,86) |
| <2 days | 145 | 48.5 | 503 (35,032) | 34 (2,366) |
| >2 days | 299 | 100 | 352 (24,535) | 19 (13,23) |
| Total | | | | |
| Outcome | 253 | 84.6 | 333 (23,208) | 21 (1,511) |
| Alive | 46 | 15.4 | 457 (31,838) | 27 (1,912) |
| Dead | 299 | 100 | 352 (24,535) | 19 (1,323) |
| Total | | | | |
| Conversion rate: US\$1 = ₹ 69.57 | | | | |

SE Standard error of the mean, US\$ United states dollar

Table 3
Health system costs and unit costs of treatment of patients in Pediatric Intensive care unit of a tertiary care teaching hospital in India

| Health system costs | US\$ (₹) | |
|--|-----------------|-------------|
| Annual costs | | |
| Human Resources | 924,479 | (64316004) |
| Physical Space | 253,182 | (17613871) |
| Equipment | 245,519 | (17080756) |
| Diagnostics | 101,710 | (7075964) |
| Drugs and consumables | 34,826 | (2422844) |
| Overheads | 16,965 | (1180255) |
| Non- consumable items | 2,216 | (154167) |
| Total annual cost | 1,578,900 | (109844073) |
| Unit costs | | |
| Average total cost per patient | 2078 | (144566) |
| Average total cost per bed - day | 415 | (28871) |
| Average health system cost per patient | 1731 | (120425) |
| Average health system cost per bed day | 346 | (24071) |
| Conversion rate: US\$ 1 = ₹ 69.57 | | |

US\$ United states dollar

Out of pocket expenditure

The mean OOP expenditures for treatment in PICU was US\$ 352 (95% CI 315–390) as shown in Table 2. Medicines and consumables accounted for a major share of OOP expenditure i.e. 79% (Fig. 1). Mean OOP expenditures per patient and per patient bed day was US\$352 (₹ 24,535) and US\$70 (₹4,897). Mean OOP expenditures for ventilated patient was significantly higher than a non-ventilated [US\$ 466 (₹32,482) vs US\$ 208 (₹14,482); $p < 0.001$]. Similarly, the OOP expenditure in patients with PICU stay of ≤ 2 days was US\$ 210 (₹14,609), which was almost one third of the OOP expenditure among patients with PICU stay of > 2 days i.e. US\$ 503 (₹ 34,993) (Table 2).

We categorised our study patients into 5 groups based on their PRISM III such as 0–10, 11–20, 21 – 30, 31–40, 41 and above. Correlating the severity of illness with OOP, we found that average OOP per patient with PRISM III between '11–20' was US\$ 235 (₹16,376) which was significantly less as compared to patients with PRISM III 21 and above US\$ 413 (₹28,765).

Discussion

Globally PICU admissions are most expensive and have significant impact on financial dynamics of patient families. India, being a lower middle-income country, financial burden on most of the middle class families is beyond their reach and far more than their family income. Lack of health care insurance and government health care support in most places increases the financial burden further. Our findings revealed that 80% of the total cost incurred to a patient when cared for in PICU was borne by the hospital and only 20% by the patient. This finding is opposite to the general patterns of health care financing wherein nearly 70% of total health care costs are borne by out-of-pocket by patients[9]. Of the health system cost, the major expenditure was towards staff salaries (58%) followed by physical space and infrastructure (16%), equipment (15.6%), diagnostics (6.4%), and the rest by drugs and consumables (hospital supply), non-medical equipment charges and overheads. Staff salaries contribute to the major chunk of expenditure because of the higher number of doctors and nurses deployed in PICU. Study by Moerer et al had also found cost of staffing to be the highest expenditure in intensive care[10]. A study in a neonatal intensive care unit by Narang et al had also shown similar results; personnel salary constituted 55% of the running costs [11]. A French study by Garcia et al, also had shown much higher proportion of salary cost, 82% of ICU budget was consumed by staff cost [12].

The out of pocket expenditure per patient in our study constituted approximately 20% of the total PICU cost per patient. Although a significant proportion of supplies are provided by the hospital, being a public sector hospital and comparatively cheaper, it is overburdened with large volume of patients. Most patients belonged to the lower middle and upper lower socio-economic strata and more than half were daily wage workers who earned about US\$ 100–200 per month. Hence they depend on public sector hospitals for healthcare. Although the OOP, was low compared to international standards, it still translates into significant cost burden for our economically disadvantaged patients.

The OOP in a ventilated patient was double that of a non-ventilated child. Mechanical ventilation requires increased diagnostic and therapeutic procedures, invasive monitoring and drugs and other consumables, thus escalating the cost per patient. Shweta et al had shown that at all levels of care, the most expensive were those requiring mechanical ventilation[13]. Similar findings were reported in the study by Moerer et al[10].

We found that the costs of intensive care in PRISM III group of '11–20' was significantly less as compared to PRISM III group above 20. However, the cost incurred was similar between PRISM III group '21–30', '31–40' and '41 and more'. This is explained by the fact that children with PRISM III score above 20 are all severely sick and hence their intensive care needs and cost involved will be similar. Garcia et al in their study comparing Physiological Stability Index (PSI) with costing had found that increase in PSI on day 1 was associated with increased cost of investigations and treatment[12].

Length of ventilation and PICU stay correlated with the OOP; average OOP in a patient with PICU stay of < 2 days was almost one third the average cost of patients with PICU stay of > 2 days. Similar findings were

reported by Chalom et al where the length of stay had the strongest correlation with the average cost per patient[14].

This study was done in a tertiary level PICU which has one of the best intensive care facilities available at an affordable cost in a public sector hospital. In developing countries, cost of ICU care in public is much less than corporate sector hospitals. A study from another tertiary care teaching hospital in our country had shown similar cost analysis; total cost per

patient and per day cost amounted to US\$ 1,705 and US\$ 229 respectively[15]. However, unlike our hospital, the total cost is completely borne by the patient families.

Compared to the cost of intensive care in developed nations, ICU costs are low in the developing countries. A study done by Children's Hospital of Philadelphia USA, had shown total cost for a patient admitted to PICU amounted to \$12342 while per day per patient cost amounted to \$2264(14). Similarly, a study from a teaching university hospital of Thessaly, Greece showed mean actual cost per ICU patient to be €16516, actual reimbursement from social funds was only €1671[16]. A study by Moran et al in Queen Elizabeth Hospital, Australia, on cost calculation in adult intensive care unit showed that the median cost per patient was AUS\$2534 (range AUS\$106 to AUS\$95602)[17]. This low cost of ICU care in India is partly attributed to low cost of drugs, recycling of consumables and lower staff salaries.

To the best of our knowledge, this is the first study of its kind, to address the detailed cost analysis of a tertiary level PICU care in a public sector hospital. The strength of our study lies in our robust cost calculation that has taken into account all the fixed and variable costs. This study can therefore act as a benchmark for other similar PICU's and for planning cost minimisation trials.

Conclusions

PICU health system costs are 3.8 times more than the Out of Pocket expenditure in a public sector hospital. Severe illness, longer ICU stay, need for ventilation and duration of mechanical ventilation were associated with increased costs of PICU care. This study can be used to set the reimbursement package rates under AB-PMJAY. Tertiary level intensive care in India is far less expensive than developed countries. Intensive care in public sector is affordable compared to corporate sector hospitals[15].

Abbreviations

PICU

Pediatric intensive care unit

OOP

Out of pocket expenditure

IQR

inter quartile range

PRISM

Pediatric risk of mortality score

AB-PMJAY

Ayushman Bharat–Pradhan Mantri Jan Arogya Yojana

ECMO

Extra corporeal membrane oxygenation

SPSS

Statistical Package for Social Sciences

PSI

Physiological Stability Index

Declarations

Ethics approval and consent to participate - Ethics approval was taken from the Ethics Committee of the Post Graduate Institute of Medical Education and Research, Chandigarh India

A written consent was taken from parents. The Ethics Committee had given approval as per the requirements in the protocol.

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All authors have read and approved the manuscript

Declaration of competing interests: The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Tables

Due to technical limitations, table 1 is only available as a download in the Supplemental Files section.

Figures

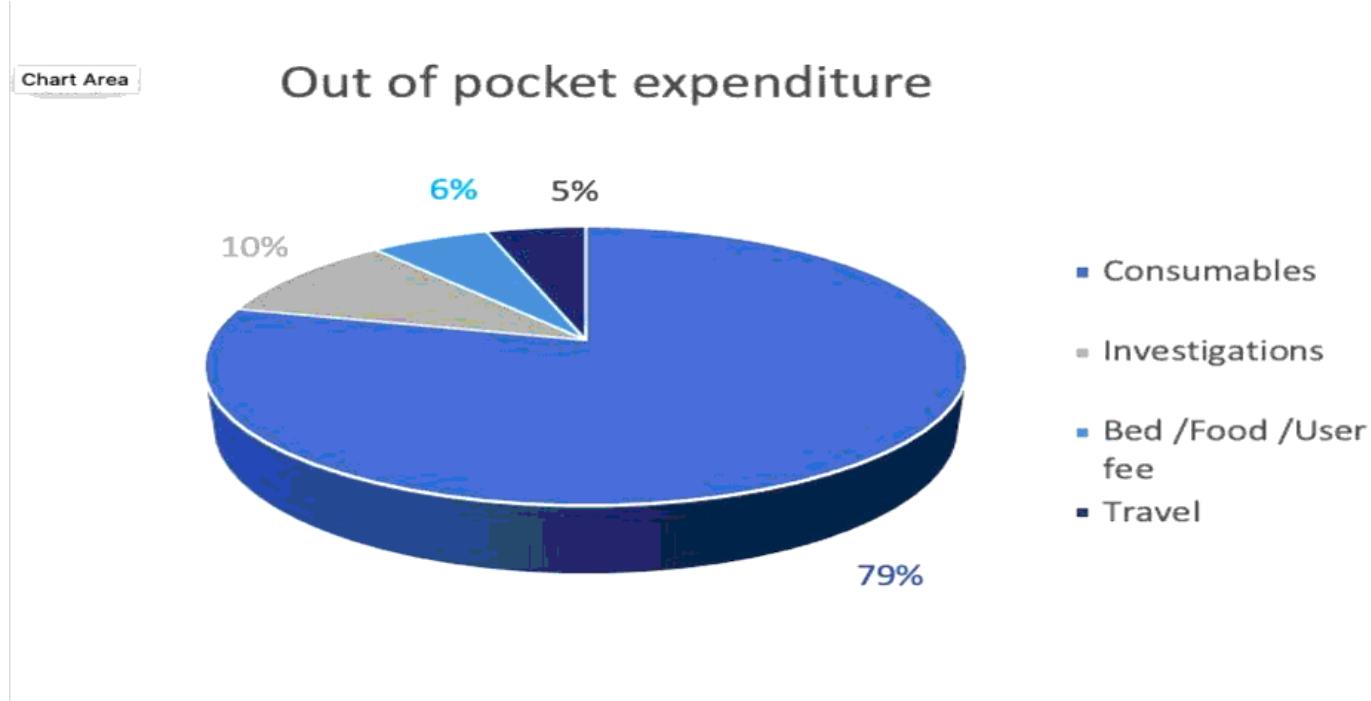


Figure 1

Determinants (%) of out of pocket expenditure of patients admitted in PICU of a tertiary care teaching hospital in India

Supplementary Files

This is a list of supplementary files associated with this preprint. Click to download.

- [Table1.docx](#)