Research Article

Patient Centered Quality Standards In Pediatric Critical Care: Opportunities And Obstacles

Noran Hazem Hassan[1], Walaa Mahmoud Ali Mohamedien[1*], Hafez Mahmoud Sadek Bazaraa[1], Sally Kamal Ibrahim Ishak[1], Eman Hany Ahmed Elsebaei[2], Maie Abdelshafy Mahmoud Gommaa[1]

[1]Department of Pediatrics, Faculty of Medicine, Cairo University, Egypt
[2]Department of Public Health, Faculty of Medicine, Cairo University, Egypt
Corresponding Author: Walaa Mahmoud Ali Mohamedien,
Email: drwalaapediatric@gmail.com

Abstract

Introduction: Providing medical care to a patient with latest gadgets and the most updated scientific knowledge is the most obvious practice in any pediatric intensive care unit. Quality indicators are crucial to measure various aspects of quality and patient safety in pediatric intensive care.

Aim: To assess the current status of patient centered quality standards in the four general PICUs of Cairo University specialized pediatric hospitals determining the opportunities and the obstacles for quality improvement.

Methods: Our study was a hospital based, quasi-experimental study that was conducted over a nine month period from April 2023 till end of December 2023, adopted baseline assessment, intervention and reassessment design, to evaluate the current status of patient centered quality standards, identifying priority areas, developing action plans to drive improvements in care quality and outcomes in the practice of paediatric critical care. It was conducted within the four general PICUs of Cairo University Specialized Pediatric Hospital. A preformed questionnaire was directed to the healthcare providers working at the four PICUs and interventions including health education and other tools were conducted.

Results: Structure quality indicators showed modest post-intervention improvement (change from 1.5% to 5.2%), while process indicators demonstrated substantial improvement (33.6%–35.1%). Mortality rates decreased from 8%–16.25% to 6.84%–11.74% (reduction: 27%–50.7%). Hand hygiene adherence improved among doctors (69.3% to 79.7%) and nurses (90.3% to 92.7%). Central line-associated bloodstream infection rates improved from 2.77–14.12 to 2.13–8.33 per 1,000 catheter-days (reduction: 23%–58.6%). Catheter-associated urinary tract infection rates changed from 6.47 to 5.39 per 1,000 urinary catheter-days. Length of stay, bed occupancy, and turnover rates showed variable responses across units.

Conclusions: Many of measured quality indicators as process, outcome and accountability indicators showed post-intervention improvement. Such interventions should be applied on a frequent, system embedded and sustainable basis.

Keywords: High quality care, Patient centered-care, Quality improvement, Quality indicators, Quality standards, Outcome.

Introduction

Providing medical care to a patient with latest gadgets and the most updated scientific knowledge is the most obvious practice in any pediatric intensive care unit (PICU). Patient-centered care (P-CC) is a concept that describes organizing healthcare system around the patient [1]. It is a standard of care that ensures that the patient is in the center of healthcare delivery. The P-CC approach emerged in the early 50s of the previous century and became suddenly prevalent in the late 90s to improve quality of care [2].

P-CC is one of the six goals set by the Institution of Medicine, as a measure of quality of care in the healthcare system and working according to P-CC approach leads to better communication between patients and caregivers and improves quality of care, thereby increasing patient satisfaction, care adherence, and care outcomes [3, 4]

The relatively young field of pediatric critical care (PCC) has seen a shift from an approach with little consideration for the complications and adverse effects resulting from the procedures and medications to a more cautious approach with careful concern for the associated risks. In addition to the morbidity and mortality associated with many of the hospital acquired complications (HACs) in children, the attributable cost due to these HACs contributes to the unsustainable health care financial crisis [5].

Quality and patient safety is an integral part of pediatric critical care, however there is a chasm exists between ideal care and actual healthcare delivery globally . In order to care for the growing number of children requiring critical care services, paediatric intensive care units (PICUs) work every day to improve the quality and efficiency of care delivered to children to provide high quality care.

High-quality care is consistent with evidence base and professional knowledge, and it is characterized by an increased likelihood of achieving desired outcomes. The IOM report outlined six dimensions of quality in healthcare: i) Safety (avoiding patient harm), ii) Effectiveness (avoiding overuse and underuse), iii) Patient-centredness (focused on patient needs), iv) Timeliness (avoiding harmful delays), v) Efficiency (avoiding waste, affordability to system), and vi) Equity. The patient perspective is central to this framework, and quality improvement efforts must be focused on patient experience and outcomes during illness [6, 7].

Unfortunately, there are many challenges to quality improvement in the PICU exist, as the PICU environment is characterized by complexity of care, therapeutic choices, time sensitivity for interventions, constantly changing workflow, complicated

interaction between the provider, patient and the healthcare environment, large amounts of visual real-time data that need to be interpreted in the context of changing patient status and the interface with devices, create opportunities for unpredictable errors and harm, also healthcare-associated infections, medication errors, device-related safety issues, and failure to provide timely therapies are some of the events seen in this environment [8].

Human behavioral factors, such as knowledge gap, fixation, alarm fatigue and failure to effectively communicate and collaborate are often deemed as causal factors for errors. In addition, lack of engagement from the frontline providers, disruption of autonomy and competing priorities in the unit result in a perception of QI efforts as a burden, also lack of leadership buy-in can be a major factor in the failure to sustain QI efforts in the PICU [9]. So, to achieve a high-quality care in PICUs, this study aimed to assess the current status of patient centered quality standards in the practice of pediatric critical care in Cairo University Specialized Children Hospital and identify strategies for improvement.

Patients and methods

This is a hospital based, quasi-experimental study that adopted an assessment, intervention and reassessment design, in which an initial assessment was done to evaluate the current status of patient centered quality standards, identifying priority areas, developing action plans in order to drive improvements in care quality and outcomes in the practice of pediatric critical care. Then assessing the progress in achieving improvement goals with determining the opportunities and the obstacles for pediatric critical care quality improvement. The study was conducted within the four general PICUs of Cairo University Specialized Pediatric Hospital which all have similar organizational and staffing structures.

Four general PICUs of Cairo University Specialized Pediatric Hospital with a capacity of 52 beds were studied where the patient services were conducted during the study period with a total number of 545 patients' medical records in a pre-assessment and 580 in the post-assessment periods were included in the study. The assessment and reassessment were done through a preformed questionnaire/checklist which were directed to the healthcare providers working at the four general pediatric intensive care units of Cairo university Specialized Pediatric Hospital during the study period. Some parameters as the most recent rates were assessed by referring to the hospital statistics records.

Data collection

Data were collected between April and December 2023, with a total study period of 9 months, the 1st 3 months for assessment, the 2nd 3 months for intervention and the last 3 months for reassessment of previously selected quality indicators.

Step one

At first, a designed questionnaire/checklist was formulated to assess the PICUs' current status of patient centred quality standards based on the Joint Commission International (JCI) Accreditation Standards for Hospitals' patient-centered standards and health care organization management standards (JCIAS 7th edition) **[10]** specifically focused on Patient-Centered Standards and Health Care Organization Management Standards.

The Patient-Centered Standards encompass a comprehensive framework designed to ensure safe, continuous, and respectful care, beginning with the International Patient Safety Goals (IPSG) that mandate correct patient identification, effective communication, the safe use of high-alert medications, infection prevention, and fall reduction. This foundation is supported by the Access to Care and Continuity of Care (ACC) standards, which govern seamless care transitions through discharge planning, referrals, follow-up, and transportation, while the Patient-Centered Care (P-CC) standards uphold patient and family rights and the informed consent process. The Assessment of Patients (AOP) standards require a defined, collaborative, and qualified approach to initial and ongoing assessments, integrating laboratory, blood bank, and radiology services to prioritize care needs. Then, the Care of Patients (COP) standards direct the delivery of routine and high-risk care, including early recognition of patient deterioration, resuscitation, blood administration, nutrition therapy, and pain management. Finally, the Medication Management and Use (MMU) standards provide a closed-loop system from selection and procurement through storage, ordering, preparation, administration, and monitoring, ensuring that every aspect of patient care is systematically addressed to optimize outcomes and minimize harm.

Health Care Organization Management Standards included Quality Improvement and Patient Safety (QPS), Prevention and Control of Infections (PCI), Governance, Leadership and Direction (GLD), Staff Qualifications and Education (SQE), and Management of Information (MOI). These standards were adapted specifically to the PICU environment and used to design a comprehensive assessment tool comprising five key dimensions: structure, process, outcome, improvement-based quality indicators (QIs), and accountability-based quality indicators.

The structure dimension assessed the availability of essential resources and infrastructure through six indicators: PICU bed capacity, nurse-to-patient ratio, availability of an infection control nurse and a clinical pharmacist, availability and maintenance of critical equipment (including ventilators, cardiac monitors, infusion pumps, continuous renal replacement therapy machines, and plasma apheresis therapy devices), and the presence of isolation facilities. The process dimension included 14 indicators evaluating the quality and consistency of care delivery, such as patient identification practices, 24-hour intensivist coverage, pain assessment and management, medication safety, blood product availability, access to laboratory results, infection prevention measures, adherence to standardized clinical protocols, multidisciplinary team involvement

during critical events, communication effectiveness, bed management procedures, staff induction and training programs, and fall prevention practices.

The outcome dimension consisted of 10 indicators measuring both clinical and non-clinical performance. Clinical outcomes included mortality rate, average length of PICU stay. Non-clinical outcomes assessed service utilization and efficiency through monthly admission and discharge rates, bed occupancy, turnover rate, bed turnover interval, and bed availability. The improvement-based quality indicators focused primarily on the rate of PICU readmission within 48 hours, while indicators related to iatrogenic pneumothorax, unplanned extubation, and re-intubation were excluded. Finally, the accountability-based quality indicators evaluated patient safety and infection control performance through rates of central line-associated bloodstream infection (CLABSI), catheter-associated urinary tract infection (CAUTI), compliance with hand hygiene practices, and incidence of falls from bed, while pressure sore incidence was excluded from the final assessment tool.

The preformed questionnaire/checklist was administered to healthcare providers working in the four selected PICUs at Cairo University Children's Hospitals during the study period. Indicators were selected based on their relevance to PICU performance, while some were modified or excluded if they did not directly or indirectly reflect patient outcomes. Each indicator was assessed monthly and scored as achieved (1) or not achieved (0). The study included three phases: baseline assessment (3 months), intervention (3 months), and reassessment (3 months). Accordingly, each indicator could obtain a score ranging from 0 to 3, with total scores ranging from 0–75 for the structure dimension and 0–318 for the process dimension.

Outcome, improvement-based, and accountability-based quality indicators were extracted from hospital statistics, using diverse collection methods such as voluntary reporting, record audits, patient feedback, and managerial reports, then converted into measurable QIs through standardized formulas. These QIs were subsequently evaluated for evidence of compliance (EOC) according to the General Authority for Healthcare Accreditation and Regulation (GAHAR) scoring guide, classifying each indicator as Met (average EOC score ≥80%), Partially Met (50%–79%), or Not Met (<50%). Each dimension was then assigned an overall score based on the average of its applicable indicators, and compared against national benchmarks to assess alignment with desired health outcomes. Certain indicators were excluded due to incomplete documentation during the initial assessment, with a recommendation to reinstate them in future improvement cycles. Finally, indicators classified as Partially Met or Not Met were targeted for corrective intervention, forming the basis of the quality improvement plan.

Step 2

At this moment a quality team and a clear plan for testing a change was determined. The quality team involved the entire team of PICU (doctors, nurses, technicians, housekeeping staff, and administrative staff) specifically the infection control nurse (ICN), the in-charge nurse, the clinical pharmacist and the residents. Then an intervention included a plan of corrective, preventive actions and healthy education was applied in form of Determination of a clear role of each member in the team and Training program.

A multidisciplinary quality team was established, comprising the entire PICU staff—doctors, nurses, technicians, housekeeping, and administrative personnel—with key roles assigned to the infection control nurse (ICN), in-charge nurse, clinical pharmacist, and residents. The ICN was responsible for conducting infection control audits, including hand hygiene and bundle adherence (CLABSI, CAUTI), as well as environmental surveillance of water, air, and swab cultures, while ensuring proper isolation measures and delivering continuous staff training on infection prevention.

Clinical pharmacists performed daily prescription audits, verified proper medication labeling and dilution, prevented inappropriate drug combinations, and maintained crash and medication trolleys with correct segregation of look-alike, sound-alike, high-risk, narcotic, and emergency drugs, while also educating nurses on safe medication practices. A quality executive from the hospital's quality department collected and maintained daily data on structure, process, and outcome parameters, serving as the primary source for QI calculations. The in-charge nurse acted as the central link between physicians, nurses, ICNs, pharmacists, housekeeping, biomedical and maintenance engineering, HR, and hospital operations, ensuring optimal nurse-to-patient ratios, staff training, equipment calibration and availability, and overseeing structured handovers, vital sign documentation, patient consent, pain and sedation monitoring, risk screening (pressure sores, thrombophlebitis, falls), and implementation of patient safety checklists. PICU consultants conducted daily morning rounds to review new admissions, clinical care issues, and significant events, while resident doctors utilized checklists to track patient progress and employed standardized structured hand-off tools during shift changes to ensure effective communication.

Training Program

A three-month training program was delivered to new and existing staff across all four PICUs, covering PICU orientation, critical assessment, glycemic control, sedation, pain management, blood transfusion, infection control bundles (CLABSI, CAUTI), hand hygiene, and management of sepsis, DKA, and ARDS. Sessions were interactive, small-group, and held twice weekly for 30–40 minutes, based on Cairo University Hospitals' 2023 infection control curriculum. Concurrent patient safety education used PowerPoint presentations on safety culture and goals.

Patient Medical Record Monitoring

Patients' medical records were closely revised and monitored to ensure complete and consistent documentation throughout the PICU stay. This included full medical history with previous medications and hospital admissions, comprehensive examination findings on admission, primary diagnosis, management plans, prescribed medications, daily progress notes, follow-up sheets, and vital signs checklists. Documentation also covered all investigations performed during admission (laboratory, radiological, and interventional), all communications between doctors and nurses, blood and blood product transfusions with details of any transfusion reactions and their management, full procedural data and attached devices with any complications, daily pain score assessment and management, fall risk assessment and applied interventions, and prescription and administration errors identified by the clinical pharmacist.

Intervention, Observation, and Reassessment

Following the establishment of roles, training, and record monitoring, the improvement plan was implemented with continuous observation of results and iterative adjustments based on lessons learned. After the three-month intervention period, reassessment was conducted, and data were collected and analyzed. The outcomes were presented as the percentage of change from the pre-intervention state, according to the scoring guide.

Step 3

The QIs are then presented in graphical formats for better visual appeal and understanding. And reevaluation was done to correlate the improvement of process/outcome parameter with the improvement activities determining the opportunities for quality improvement and also determining the obstacles preventing that.

Statistical Analysis

Statistical analysis was performed using appropriate descriptive and inferential methods to evaluate the changes in quality indicators pre- and post-intervention. Data were presented as frequencies, percentages, means, and standard deviations where applicable. Comparisons between baseline and post-intervention scores for structure, process, outcome, improvement-based, and accountability-based quality indicators were conducted using paired statistical tests. Percent change from baseline was calculated for each indicator to quantify the magnitude of improvement. All analyses were performed using standard statistical software, with a p-value < 0.05 considered statistically significant.

Results

The average of unoccupied (available) bed days per month had shown increase from (5%-24%) pre-intervention to be (12.34% -15.86%) post-intervention. The average of shifts when nurse: patient ratio not ≥ 1:2 had shown decrease from (3.8% - 31.3%) pre-intervention to be (2.17% - 23.9%) post-intervention. The rest of Structure Quality Indicators in form of availability of equipment and isolation facilities did not show significant improvement. However, the total score of structure QI had increased (still partially met) with percent change from baseline ranging from 1.5% to 5.2%; as shown in table (1).

The following process Quality Indicators among all PICUs didn't show any changes after intervention "Identifying Patients Correctly", "24 hr resident intensivist presence", "Availability of treating team", "a process for handover communication", "Use of standardized methods, forms, or tools to facilitate consistent and complete handovers of patient care", and "Process for management of fall from bed" which all were and still FM, but "24 hr specialist intensivist presence" was and still NM. However, the rest of Process Quality Indicators among all PICUs had shown improvements after intervention with the total score of process QI had increased (however still partially met) with percent change from baseline ranging from 33.6% to 35.1%; as shown in table (2).

Table (1): Structure Quality Indicators Change/ Improvement detected among the four general PICUs of Cairo University specialized pediatric hospital

	PRE				**POST**			
	PICU1	**PICU2**	**PICU3**	**PICU4**	**PICU1**	**PICU2**	**PICU3**	**PICU4**
A1- Available PICU places								
1.a- Available PICU places daily	3/3 (FM)	3/3 (FM)	3/3 (FM)	0/3 (NM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	1/3 (NM)
1.b- Total available bed days /month	1274 (424.7)	1128 (376)	1911 (637)	455 (152)	1288 (429)	1176 (392)	1932 (644)	460 (153)
1.c- Total unoccupied bed days (/month)	305 (101.7)	241 (80.3)	457 (152)	23 (7.7)	204 (68)	245 (81.67)	350 (116.7)	57 (19)
1.d- Average of unoccupied (available) bed days/month	24	18.7	24	5	15.86	14.87	18	12.34
A2- Nurse: patient ratio								

2.a- Nurse: patient ratio ≥1:2 daily	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)
2.b- Total number of shifts (/month)	182 (60.7)	182 (60.7)	182 (60.7)	182 (60.7)	184 (61.3)	184 (61.3)	184 (61.3)	184 (61.3)
2.c- Total number of shifts when nurse: patient ratio not ≥ 1:2 /month	22 (7.3)	9 (3)	57 (19)	7 (2.3)	20 (6.67)	4 (1.3)	44 (14.67)	4 (1.3)
2.d- Average of shifts when nurse: patient ratio not ≥ 1:2 /month	12.08	4.9	31.3	3.8	10.86	2.17	23.9	2.17
A3-Infection control nurse present near daily	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)
A4-Clinical pharmacist present near daily	3/3 (FM)	3/3 (FM)	3/3 (FM)	0/3 (NM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	0/3 (NM)
A5- Availability of equipment								
5.a- Available vital equipment checks daily *6 items	14/18 (PM)	16/18 (PM)	14/18 (PM)	15/18 (PM)	15/18 (PM)	17/18 (FM)	15/18 (PM)	15/18 (PM)
5.b- Available ventilators *3 items	5/9 (PM)	6/9 (PM)	5/9 (PM)	5/9 (PM)	6/9 (PM)	6/9 (PM)	6/9 (PM)	6/9 (PM)
5.c- Available cardiac monitors	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)
5.d- Available infusion pumps	2/3 (PM)	2/3 (PM)	2/3 (PM)	2/3 (PM)	3/3 (FM)	2/3 (FM)	2/3 (FM)	2/3 (FM)
5.e- Available CRRT *3 items	7/9 (PM)	9/9 (FM)	7/9 (PM)	0/9 (NM)	7/9 (PM)	9/9 (FM)	7/9 (PM)	0/9 (NM)
5.f- Available PP procedure *3 items	8/9 (PM)	9/9 (FM)	8/9 (PM)	0/9 (FM)	8/9 (PM)	9/9 (FM)	8/9 (PM)	0/9 (NM)
A6-Available isolation facilities *4 items	12/12 (FM)	9/12 (PM)	12/12 (FM)	9/12 (PM)	12/12 (FM)	9/12 (PM)	12/12 (FM)	9/12 (PM)
Total structure scored items (/75)	60/75	63/75	60/75	37/75	63/75	64/75	62/75	39/75
Total score of structure QI	80% (PM)	84% (PM)	80% (PM)	49.3% (NM)	84% (PM)	85.3% (PM)	82.6% (PM)	52% (PM)
Percent change from baseline	5%	1.5%	3.3%	5.2%				

CRRT: continuous renal replacement therapy. PP: plasmapheresis. Each measurable element (ME) of the standard is scored as (FM): Fully met if ≥90%, or (PM): Partially met if 50% to 89%, or (NM): Not met if <50%. Each ME was measured in a numerical value expressed in form of: Sum of total values measured during both pre-intervention/post-intervention periods at the top of each cell, and in form of mean value in round brackets at the bottom of each cell.

Table (2): Process Quality Indicators Change/ Improvement detected among the four general PICUs of Cairo University specialized pediatric hospital

	PRE				**POST**			
	PICU1	PICU2	PICU3	PICU4	PICU1	PICU2	PICU3	PICU4
B1- Identifying Patients Correctly								
a- At least two patient identifiers	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)

b- Patients are identified before performing diagnostic procedures and providing treatments	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)
B2-24 hr intensivist presence								
a- Resident	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)
b- Specialist	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)
B3-Pain assessment and management daily *3 items	6/9 (PM)	6/9 (PM)	6/9 (PM)	6/9 (PM)	9/9 (FM)	9/9 (FM)	9/9 (FM)	9/9 (FM)
B4-Prescription and administration errors *21 items	33/63 (PM)	33/63 (PM)	33/63 (PM)	33/63 (PM)	51/63 (PM)	51/63 (PM)	51/63 (PM)	51/63 (PM)
B5-Available blood products and administration of Blood and Blood Products (Whole blood, PRBCs, plasma, platelets, cryoprecipitate) *6 items	15/18 (PM)	15/18 (PM)	15/18 (PM)	15/18 (PM)	18/18 (FM)	18/18 (FM)	18/18 (FM)	18/18 (FM)
B6-Available important lab results *3 items	3/9 (NM)	3/9 (NM)	3/9 (NM)	3/9 (NM)	6/9 (PM)	6/9 (PM)	6/9 (PM)	6/9 (PM)
B7-a-Adherence to various infection control activities as hand hygiene *3 items	6/9 (PM)	6/9 (PM)	6/9 (PM)	6/9 (PM)	9/9 (FM)	9/9 (FM)	9/9 (FM)	9/9 (FM)
B7-b-Adherence to various infection control activities as bundle approach to prevent certain infections *3 items	0/9 (NM)	0/9 (NM)	0/9 (NM)	0/9 (NM)	9/9 (FM)	9/9 (FM)	9/9 (FM)	9/9 (FM)
B8-Availablility of a routine/written standard protocol to manage various conditions *8 items	15/24 (PM)	15/24 (PM)	15/24 (PM)	15/24 (PM)	21/24 (PM)	21/24 (PM)	21/24 (PM)	21/24 (PM)

B9-Availability of treating team (pediatric critical care resident and nurse ± intensivist) during different situations *4 items	12/12 (FM)	12/12 (FM)	12/12 (FM)	12/12 (FM)	12/12 (FM)	12/12 (FM)	12/12 (FM)	12/12 (FM)
B10-Good communication between doctors and nurses/Effective communication between caregivers								
10.a-The hospital develops and implements a process for handover communication: *4 items	12/12 (FM)	12/12 (FM)	12/12 (FM)	12/12 (FM)	12/12 (FM)	12/12 (FM)	12/12 (FM)	12/12 (FM)
10.b- Use of standardized methods, forms, or tools to facilitate consistent and complete handovers of patient care	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)
10.c- Complete verbal orders are documented and read back by the receiver and confirmed by the individual giving the order	0/3 (NM)	0/3 (NM)	0/3 (NM)	0/3 (NM)	3/3 (FM)	3/3 (FM)	3/3 (FM)	3/3 (FM)
B11-Avilability of process to manage non availability of beds situation *3 items	3/9 (NM)	3/9 (NM)	3/9 (NM)	3/9 (NM)	6/9 (PM)	6/9 (PM)	6/9 (PM)	6/9 (PM)
B12-Process of training and education of newly joined doctors *32 items	62/96 (PM)	64/96 (PM)	64/96 (PM)	60/96 (PM)	80/96 (PM)	80/96 (PM)	80/96 (PM)	76/96 (PM)
B13-Process of training and education of newly joined nurses *8 items	21/24 (PM)	21/24 (PM)	21/24 (PM)	21/24 (PM)	24/24 (FM)	24/24 (FM)	24/24 (FM)	24/24 (FM)
B14-Process for management of fall from bed *2 items	6/6 (FM)	6/6 (FM)	6/6 (FM)	6/6 (FM)	6/6 (FM)	6/6 (FM)	6/6 (FM)	6/6 (FM)
Total process scored items (/318)	(206/318)	(208/318)	(208/318)	(204/318)	(278/318)	(278/318)	(278/318)	(274/318)

Total score of process QI	64.7% (PM)	65.4% (PM)	65.4% (PM)	64.2% (PM)	87.4% (PM)	87.4% (PM)	87.4% (PM)	86.2% (PM)
Percent change from baseline	35.1%	33.6%	33.6%	34.3%				

The Outcome Quality Indicators among all PICUs had shown improvements after intervention, where mortality rate per month was basically reported as ranging from 8% to 16.25%, and have been improved to be ranging from 6.84% to 11.74% with percent change reduction from baseline -27% to -50.7%. Average length of PICU stay was basically reported as ranging from 5.43 to 7.57 days and have been changed to be ranging from 5.37 to 9.26 days with percent change from baseline -1.1% to +22.3%. Number of total admissions per month was basically reported as ranging from 26.7 to 66 patient, and have been increased to be ranging from 25 to 74 patient. Number of new admissions per month was basically reported as ranging from 22 to 50 patient, and have been increased to be ranging from 20.7 to 59.7 patient. Number of discharged patients per month was basically reported as ranging from 21.7 to 52.7 patient, and have been increased to be ranging from 20.7 to 58.7 patient. Average PICU bed occupancy per month was basically reported as ranging from 76% to 95%, and have been changed to be ranging from 79.85% to 87.6% with percent change increase from baseline +1.5% to +10.7%. Rate of turnover per month have been changed from (2.38 - 4.3) to be (2 - 4.13) with percent change from baseline (-3.9 % to +33.3 %). Also bed turnover interval have been changed from (0.35 - 3) to be (0.9 - 2.43) with percent change from baseline (-20.3 % to +162.8 %). Average PICU bed availability per month have been changed from (5%-24%) to be (12.4% - 20%), as shown in table (3).

Table (3): Outcome Quality Indicators Change/ Improvement detected among the four general PICUs of Cairo University specialized pediatric hospital

	PRE				**POST**			
	PICU1	PICU2	PICU3	PICU4	PICU1	PICU2	PICU3	PICU4
C1-Mortality rate monthly								
C1-a- Total number of deaths(/month)	12 (4)	16 (5.3)	16 (5.3)	13 (4.3)	8 (2.67)	13 (4.3)	26 (8.67)	6 (2)
C1-b- Total number of PICU admissions(/month)	128 (42.7)	139 (46.3)	198 (66)	80 (26.7)	117 (39)	166 (55.3)	222 (74)	75 (25)
C1-c- Mortality rate(/month)	9.37	11.5	8	16.25	6.84	7.83	11.74	8
Percent change from baseline	-27%	-31.9%	46.7%	-50.7%				
C2-Average length of PICU stay								
C2-a-Total occupied bed days (/month)	969 (323)	887 (295.7)	1454 (484.7)	432 (144)	1084 (361.3)	939 (313)	1582 (527.3)	403 (134.3)
C2-b-Number of patients (/month)	128 (42.7)	139 (46.3)	198 (66)	80 (26.7)	117 (39)	166 (55.3)	222 (74)	75 (25)
C2-c- Average length of PICU stay (/month)	7.57	6.38	7.34	5.43	9.26	5.65	7.13	5.37
Percent change from baseline	22.3%	-11.4%	-2.8%	-1.1%				
C3-Number of total admissions per month	128 (42.7)	139 (46.3)	198 (66)	80 (26.7)	117 (39)	166 (55.3)	222 (74)	75 (25)
C4-Number of new admissions per month	104 (34.7)	107 (35.7)	150 (50)	66 (22)	83 (27.67)	135 (45)	179 (59.67)	62 (20.67)
C5-Number of discharged patients per month (including deaths)	100 (33.3)	108 (36)	158 (52.7)	65 (21.7)	84 (28)	139 (46.3)	176 (58.67)	62 (20.67)
C6-Average PICU bed occupancy per month								
C6-a-Number of inpatient days (/month)	969 (323)	887 (295.7)	1454 (484.7)	432 (144)	1084 (361.3)	939 (313)	1582 (527.3)	403 (134.3)
C6-b-Number of available bed days (/month)	1274 (424.7)	1128 (376)	1911 (637)	455 (151.7)	1288 (429.3)	1176 (392)	1932 (644)	460 (153.3)
C6-c- Average PICU bed occupancy (/month)	76.04	78.63	76.08	94.95	84.16	79.85	81.9	87.6
Percent change from baseline	10.7%	1.5%	7.6%	7.7%				
C7-Rate of turnover								

C7-a-Total number of discharged patients (/month)	100 (33.3)	108 (36)	158 (52.7)	65 (21.7)	84 (28)	139 (46.3)	176 (58.67)	62 (20.67)
C7-b-Total number of available PICU beds / month	42 (14)	36 (12)	63 (21)	15 (5)	42 (14)	36 (12)	63 (21)	15 (5)
C7-c-Rate of turnover (/month)	2.38	3	2.5	4.3	2	3.86	2.79	4.13
Percent change from baseline	-15.9%	33.3%	11.6%	-3.9%				
C8-Bed turnover interval								
C8-a-Total number of unoccupied bed days(/month)	305 (101.7)	241 (80.3)	457 (152.3)	23 (7.7)	204 (68)	237 (79)	350 (116.67)	57 (19)
C8-b-Total number of discharged patients / month	100 (33.3)	108 (36)	158 (52.7)	65 (21.7)	84 (28)	139 (46.3)	176 (58.67)	62 (20.67)
C8-c-Bed turnover interval (/month)	3.05	2.2	2.9	0.35	2.43	1.7	1.99	0.92
Percent change from baseline	-20.3%	-22.7%	-31.4%	162.8%				
C9-Average PICU bed availability (/month) (100-average bed occupancy)	24	21.37	23.9	5.05	15.84	20.15	18.1	12.4

Improvement based Quality Indicators among the PICUs represented by return to PICU within 48 hr was basically reported as zero in the 4 PICUs, and have been increased to be 1 to 2 patients in the 4 PICUs along the post intervention period. Percentage of adherence to hand hygiene for doctors and nurses showed post intervention improvement with percent increase from baseline ranging from 69.3% to 79.7% and from 90.3% to 92.7% respectively. Rates of CLABSI per 1.000 catheter days were basically 2.77 to 14.12 that have been improved to be 2.13 to 8.33, with percent change reduction from baseline 23% to 58.6%. Rates of CAUTI per 1.000 urinary catheter days were basically 6.47 and changed to 5.39 among the four general PICUs. Moreover, 2 PICUs kept their CAUTI rate at zero both before and after intervention, it decreased in 3rd one, while it had increased in the 4th of them, that should be thoroughly investigated; as shown in table (4).

Table (4): Improvement based Quality Indicators Change/ Improvement detected assessment among the four general PICUs of Cairo University specialized pediatric hospital

	PRE				**POST**			
	PICU1	PICU2	PICU3	PICU4	PICU1	PICU2	PICU3	PICU4
D1- Return to PICU within 48 hr								
D1-a-Number of readmitted patients within 48hr/ month	0	0	0	0	2 (0.67)	0	1 (0.33)	0
D1-b-Total number of patients managed (/month)	128 (42.7)	139 (46.3)	198 (66)	80 (26.7)	117 (39)	166 (55.3)	222 (74)	75 (25)
D1-c- Rate of return to PICU within 48 hr (/month)	0	0	0	0	0.017	0	0.0043	0
E2-Rate of central line associated blood stream infection (CLABSI)								
E2-a- Number of CLABSI (/month)	1 (0.3)	5 (1.67)	5 (1.67)	0	1 (0.33)	3 (1)	2 (0.67)	0
E2-b- Number of central line days (/month)	361 (120)	354 (118)	749 (249.7)	343 (114)	470 (156.7	360 (120)	723 (241)	246 (82)
E2-c-Rate of CLABSI / 1000 days	2.77	14.12	6.67	0	2.13	8.33	2.76	0
Percent change from baseline	-23 %	-41%	-58.6%	0%				
E3-Rate of catheter associated urinary tract infection (CAUTI)								
E3-a-Number of patients diagnosed as CAUTI (/month)	0	2 (0.67)	0	0	2 (0.67)	0	0	0
E3-b-Number of catheter days (/month)	293 (97.7)	309 (103)	535 (178)	267 (89)	371 (123.7)	339 (113)	552 (184)	240 (80)

E3-c-Rate of CAUTI/1000 days	0	6.47	0	0	5.39	0	0	0
E4-Percentage of adherence to hand hygiene monthly								
E4-a-For doctors	69.3	69.3	69.3	69.3	79.67	79.67	79.67	79.67
E4-b-For nurses	90.3	90.3	90.3	90.3	92.67	92.67	92.67	92.67
E5-Rate of fall from bed								
E5-a-Number of patient falls	0	0	0	0	0	0	0	0
E5-b-Rate of patient falls	0	0	0	0	0	0	0	0

Comparisons were conducted between improvement in structure and process QIs and improvement in outcome and accountability and improvement based QIs. Upon post intervention increase of both structure and process QIs, mortality rate "MR" showed parallel reduction in all PICUs, except in PICU3 which could be explained by usage of mortality rate instead of standardized MR (Fig. 1). Upon post intervention increase of both structure and process QIs, Rate of return to PICU showed slight increase in PICU1&3 but remained as zero in PICU 2&4, (Fig. 2).

Figure (3) shows that length of stay decreased in PICU2, PICU3, and PICU4 (by -11.4%, -2.8%, and -1.1% respectively), yet paradoxically increased in PICU1 by +22.3%, suggesting that factors beyond structure and process improvements—such as patient acuity and case mix—influence this metric. Figure (4) demonstrates mixed results for turnover rate, with PICU2 and PICU3 showing improved turnover (+33.3% and +11.6%), while PICU1 and PICU4 showed decreased rates (-15.9% and -3.9%). These findings indicate that quality improvement interventions do not uniformly impact all outcome measures across units, emphasizing the need for unit-specific contextual evaluation.

Figure (1): Comparison between the changes in structure, process interventions and the outcome as MR in the 4 PICUs

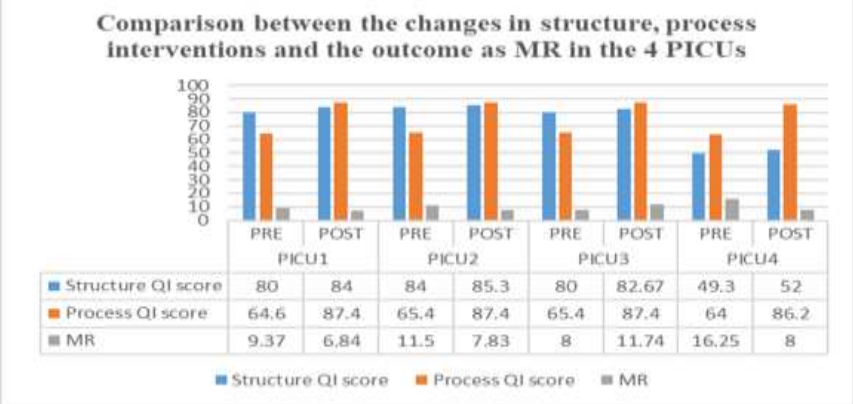


Figure (2): Comparison between the changes in structure, process interventions and the improvement as Rate of return to PICU in the 4 PICUs

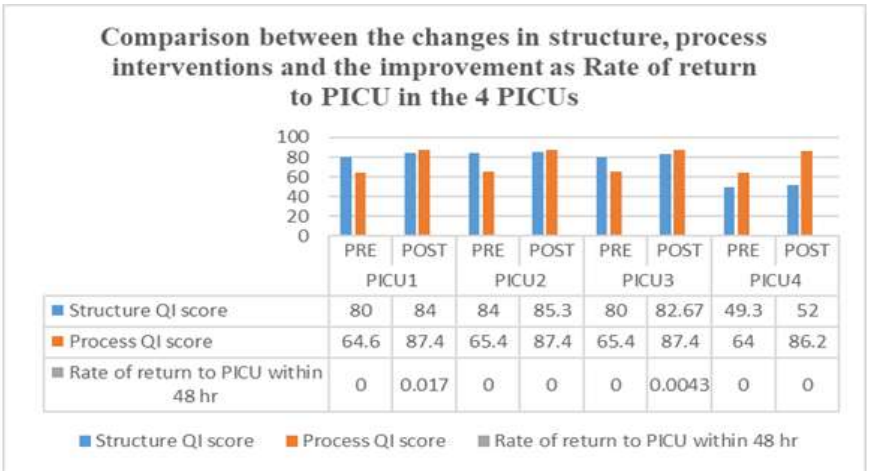


Figure (3): Comparison between the changes in structure & process interventions and Length of stay in the 4 PICUs

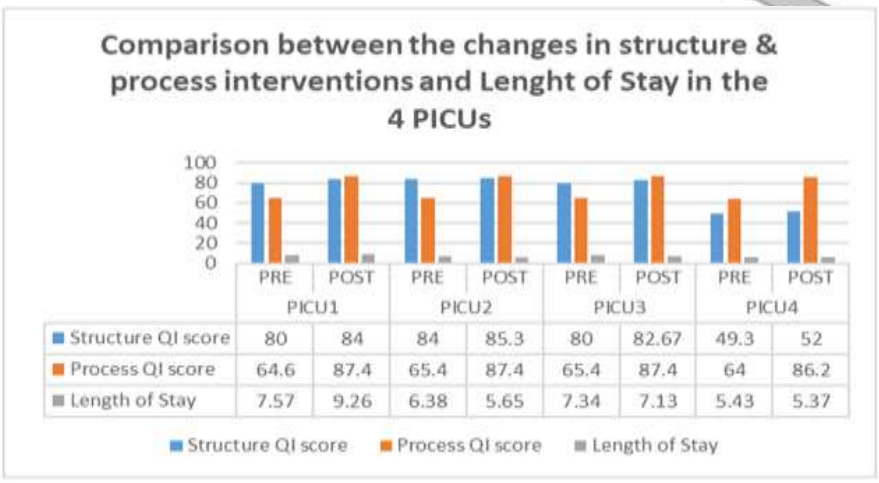
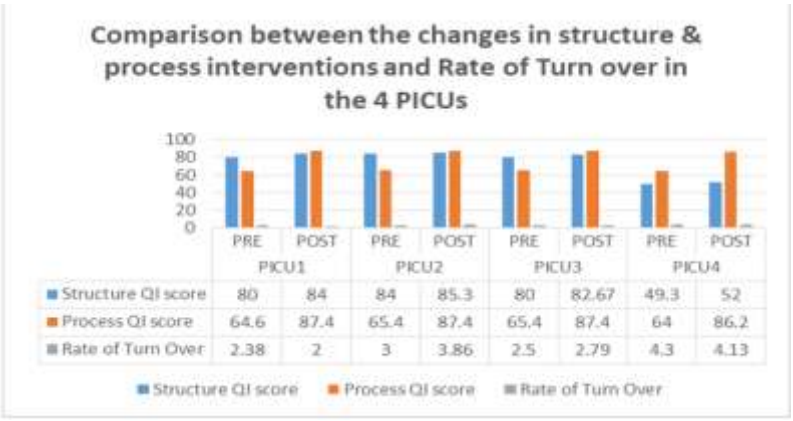


Figure (4): Comparison between the changes in structure & process interventions and Rate of turnover in the 4 PICUs



Discussion

Quality indicators are crucial to measure various aspects of quality and patient safety in pediatric intensive care. It is pivotal that various aspects of structure, process, and outcomes in a system are measurable and reproducible so such a system can give us reproducible results. It is crucial that the data used for measurements are accurate and they are analyzed using appropriate tools, and the quality indicators calculated from the data are appropriately validated. These quality indicators should be compared to the accepted international or national benchmarks on a periodic basis so that the team of doctors, nurses, and administrators are aware of the performance of their units [11].

In Egypt, there are no national benchmarks available to compare the quality indicators of our PICUs, and there is a dearth of such benchmarks for PICUs at international level too. Egypt is one of the low-middle-income countries “LMIC”, where children represent the highest percentage of the population (40% were below 18 years old in 2024) [12].

Providing high-quality care is consistent with evidence base and professional knowledge, where safety, effectiveness, patient-centredness, timeliness, efficiency, and equity are integral outcomes to achieve. However, there are many challenges to establish quality improvement in the PICU, as the PICU environment is characterized by complexity of care, therapeutic choices, time sensitivity for interventions, constantly changing workflow, complicated interaction between the provider, patient and the healthcare environment, large amounts of visual real-time data that need to be interpreted in the context of changing patient status and the interface with devices, create opportunities for unpredictable errors and harm, also healthcare-associated infections, medication errors, device-related safety issues, and failure to provide timely therapies are some of the events seen in such an environment. In addition, lack of engagement from the frontline providers, disruption of autonomy and competing priorities in the units result in a perception of quality improvement efforts as a burden, also lack of leadership buy-in can be a major factor in the failure to sustain quality improvement efforts in the PICU [13].

Hence, in order to achieve a high-quality patient centered care in PICUs, this study was conducted from 2023 to 2024 to assess the current status of patient centered quality standards in the practice of pediatric critical care in Cairo university children's hospitals, to determine possible opportunities and obstacles, and to identify strategies for quality improvement. The current study had included four general PICUs of Cairo University Specialized pediatric hospital with a capacity of 52 beds, where the patient services had been conducted during the study period with a total number of 545 patient medical records in a pre-assessment and 580 in the post-assessment periods had been included in the study.

Providing pediatric critical care in resource-limited settings; like Egypt, is still a challenging concern, in our study we've found a shortage in nursing manpower, where the Nurse: patient ratio≥ 1:2 daily wasn't met neither during pre- or post-intervention. Likewise, Zhang et al. 2017 had investigated structure, process and outcome indicators in seven PICUs in China, where the structure indicators showed that one nurse gave care for an average of 2.8 patients in a PICU, and 44% of nurses had a bachelor's degree [14].

Structure quality indicators reflect pediatric emergency and critical care resources and infrastructure availability, which shows significant deficiency in resource-limited settings in LMIC when compared to high-income countries, where Muttalib et al. 2021 made a multi-country survey that showed statistically significant differences in the proportion of hospitals reporting consistent resource availability between country income groups ($p < 0.05$). Resources with limited availability in LMICs included advanced ventilator support, invasive and noninvasive monitoring, central venous access, renal replacement therapy, advanced imaging, microbiology, biochemistry, blood products, antibiotics, parenteral nutrition, and analgesic/sedative drugs. Seventy-seven ICUs (52.7%) were staffed 24/7 by a pediatric intensivist or anesthetist. The nurse-to-patient ratio was less than 1:2 in 71 ICUs (49.7%) [15].

Outcome quality indicators included many important rates; mortality rate/month was basically reported as 9.37, 11.5, 8 and 16.25, and have been improved to 6.84, 7.83, 11.74 and 8 among PICU1, 2, 3, 4 respectively. However, PICU3 showed increased MR post-intervention; that could be due to use of MR instead of Standardized MR 'SMR'. Besides, Volakli et al. 2023 reported that mortality rates were 24%, 11.8%, 17.5%, 16%, and Standardized Mortality Ratio (SMR) were 1.42, 0.92, 1.56 and 1.33 in 2017, 2018, 2019 and 2020 correspondingly [16].

Olivier et al. 2023 reported the overall mortality rate as 21.49%, with sex ratio at 1.14 and the mean age was 3.17 ± 2.21 years, and deaths were more frequent in January, April and December [17]. Teshager et al. 2020 had conducted a single-centre prospective observational cohort study where 32.6% of children died during the follow-up time, and the incidence of mortality was 6.9 deaths per 100 person-day observation. Weekend admission, critical illness diagnoses, and need for MV were the predictors of mortality [18].

Standardized insertion, care, and maintenance of CVLs are key components aimed at reducing CLABSI, yet maintaining these skills can be challenging. In our study, rate of CLABSI was basically 2.77, 14.12, 6.67, 0 that have been improved to 2.13, 8.33, 2.76, 0, with Percent change from baseline -23.1%, -41%, -58.6%, 0% among PICU1, 2, 3, 4 respectively.

Gauntt et al. 2022 had implemented the following interventions: the use of sequential cleaning between line accesses, Kamishibai card audits, central line utilization and entry audits, and proctored simulation of line access in order to reduce CLABSI rates, which reduced from 1.52 per 1,000 central line days in 2018 to 0.37 per 1,000 central line days in 2020 and 0.32 in 2021. Additionally, central line days per 100 patient days decreased from 77 to 70 days over the study period. The cardiothoracic intensive care unit went 389 days without a CLABSI from October 2020 to November 2021 [19]. According to Volakli et al. 2023 CLABSI rates were 1.37:1000, 1.37:1000, 1.26:1000 and 1.39:1000 catheter days in 2017, 2018, 2019 and 2020 respectively [16].

A longitudinal study of PICUs in NHS hospitals regarding PICU CLABSI prevention practices, including self-reported compliance with elements of central line bundles was performed according to Edwards et al. 2015, where CLABSI rates decreased during the study period, from 5.8 per 1,000-line days in 2006 to 1.4 in 2011-2012, $P < .001$. Although 73% of PICUs had policies for all central line prevention practices, only 35% of those with policies reported ≥95% compliance. PICUs with ≥95% compliance with central line infection prevention policies had lower reported CLABSI rates [20].

Implementing the prevention bundles reduced CLABSI significantly in Kingdom of Bahrain, according to Al-Khawaja et al. 2021, the infection's time trend displayed significant reductions over time concomitantly with the CLABSI prevention bundle's reinforcement from 4.7/1000 central line days at the beginning of 2016 to 1.4/1000 central line days by 2018 [21].

In our study, rate of CAUTI was basically 0, 6.47, 0, and 0 and changed to 5.39, 0, 0, and 0 among PICU1, 2, 3, 4 respectively, where PICU1 showed post-intervention increased rate that requires thorough investigation and application of IPC standards. Moreover, Elegant & Sorce 2017 had showed that the mean monthly CAUTIs rate was reduced by 50%, yet catheter utilization remained stable. They clearly elucidated the importance of the application of a quality process to reduce HAIs [22]. However, Rasslan et al. 2012 had reported that CAUTI rate per 1000 UC-days was 0.0 in the PICUs [23].

An intervention executed by Gupta et al. 2020 through empowering front-line nurses for automatic stop orders and ensuring compliance to the catheter insertion and maintenance bundles revealed a drop of the rate of CAUTIs from 7.6 per 1000 catheter days in January 2017 to 0 from October 2021 to August 2022, also the unit had achieved 280 calendar days free of CAUTI until August 2022 [24].

PICU length of stay 'LOS' is an important measure of resource use and economic performance. In our study, PICU1 had the highest "Average length of PICU stay/month: 7.57 days", while PICU4 had the least; 5.43 days. Marcin et al. 2001 defined long-stay patients (LSPs) as patients having a length of stay greater than the 95th percentile (>12 days). They concluded that LSPs have less favorable outcomes and use more resources than non-LSPs. The clinical profile of LSPs includes those who are younger and those that require chronic care devices [25]. Meanwhile, Pollack et al. 2018 had selected patients from 8 PICUs where the mean LOS for was 5.0 days (SD 11.1), with a median of 2.0 days, they concluded that PICU bed utilization was dominated by a minority of patients and the 5% of patients staying the longest utilized almost 40% of the bed days [26].

Critical children with prolonged stay in the PICU show important morbidity and mortality, and an important consumption of healthcare resources, according to González-Cortés et al. 2011, mortality was higher in patients with a long stay (22.9%) than in the rest of the patients (2%) (p< 0.001). In 52.6% of these patients, death occurred after withdrawal of treatment or after not starting resuscitation measures. Patients with prolonged stay showed a high incidence of nosocomial infection (96.3%) and an important consumption of healthcare resources (97.6% required conventional mechanical ventilation, 90.2% required transfusion of blood products, 86.7% required intravenous vasoactive drugs and 22.9% required extracorporeal membrane oxygenation [ECMO]). The adoption of specific measures permitting early identification of patients at risk of prolonged stay is needed in order to adapt therapeutic measures and available resources, and to improve treatment efficiency [27].

Suboptimal hand hygiene remains a significant modifiable cause of HAIs, in our study, percentage of adherence to hand hygiene monthly was lower among doctors (69.3%) than nurses (92.67%), yet, showed post-intervention improvement. A multifaceted hand hygiene educational program was introduced by Nteli et al. 2014, with compliance assessed during successive observational surveys, where he total healthcare professionals' compliance increased from 31.8% in the baseline period to 51.5% immediately after the first educational intervention, and it remained at improved levels (45.9%) six months later, while after the completion of the second educational intervention it increased to 67.7% [28].
Albert et al. 2019 proved that multidisciplinary quality improvement intervention achieved sustained improvement in hand hygiene, where all clinical groups demonstrated hand hygiene compliance >90% during the post-intervention period. The improvements in practice were sustained for a year after the intervention [29].
According to Teymourlouy et al. 2021, Root cause analysis of falling out of bed in one of the Pediatric Hospitals in Tehran showed that lack of effective training of patient companions, old hospital beds, short, and long distance between bed railings, training of nurses, and controlling of the restless children were obtained as root causes [30].
In resource limited areas and LMICs, identifying and assessment of need for pediatric critical care training and resources is of utmost importance, Ibrahim et al. 2022 conducted an analysis from 67 responses revealed that care delivered to critically ill pediatric patients was by anesthesiologists (77%), pediatricians (26%), and adult intensive care specialists (10%). The acquisition of clinical skills was perceived to be an essential need (65%), followed by adequate staffing of critical care units (19%), continuing medical and nursing education (13%), and availability of medical equipment (3%); a model that could improve PICUs situation [31].

In developing countries, there is scarce data on pediatric critical care. This makes modification of practices to improve outcome difficult. Within this scope, a retrospective study in India by Sahoo et al. 2017 with a total of 848 children were admitted to the PICU with diagnoses included infectious diseases (20.7%), respiratory disease (19.1%), central nervous system diseases (14.3%), cardiovascular diseases (10.8%), gastrointestinal diseases (7%), surgical problems (4.7%) hematological (4%), renal (3.3%), poisonings (1.4%), and others (14.3%). Out of 848 admitted children, 4.1% died and (1.4%) left against medical advice, (8.5%) children received mechanical ventilation, among which (62.5%) improved, 34.7% died and 2.8% children left against medical advice. Multi-organ dysfunction syndrome (MODS) and co-morbidity were present in 25% and 22% respectively. The proportion of death among patients admitted to PICU was 4.1% [32].

On the other hand, a retrospective study by Bhavari et al. 2019 revealed that mortality was low in a rural Indian PICU with better treatment protocols, skilled expertise/ Pediatric Intensivist with chances to facilitate the care of critically ill patients giving desirable outcome, with a total of 417 patients were admitted, the most common diagnosis was Lower Respiratory Tract Infection which was observed in 61(14.7%) of cases. The most common system involved was respiratory system which was observed in 101(21.8%) cases. Of total cases studied, 357(85.6%) were discharged, 36(8.6%) had DAMA (discharge against medical advice) and 24(5.8%) died [33].
Tripathi et al. 2015 conducted a survey on the resources and practices in pediatric critical care of resource-rich and resource-limited countries, completed by 73 centers in 34 countries (34 from high-income countries and 39 from LMICs). Compared with high-income countries, the PICUs in LMICs were characterized by a lower number of critical care specialists, more difficult access to hemodialysis, and a lower number of elective postoperative patients, but a similar overall disease burden. Training and resources for research were comparable in the two cohorts [34].

In the first PICU in Malawi, mortality was relatively high, of 531 included PICU admissions, 149 children died (28.1%). Mortality was higher in neonates (88/167; 52.7%) than older children (61/364; 16.8%; p ≤ 0.001). On univariate analysis, gastroschisis, trachea-esophageal fistula, and sepsis had higher PICU mortality, while Wilms tumor, other neoplasms, vocal cord papilloma, and foreign body aspiration had higher survival rates compared with other conditions. On multivariable analysis, neonatal age, decreased mental state, post-cardiac arrest, severe hypotension, lactate greater than 5 mmol/L, pH less than 7.2, and platelets less than 150 × 109/L were associated with increased mortality. According to de Visser et al. 2023, surgical neonates and septic patients were identified as highly vulnerable, which stresses the importance of improvement of PICU care bundles for these groups [35].
Neonatal sepsis caused by Klebsiella pneumoniae at one of NICUs in Minia, Egypt yielded twenty-four K. pneumoniae isolates (15.3%) were collected out of the 156 sepsis diagnosed neonates. These samples showed extensive drug resistance (XDR) to most of the tested antimicrobials, except fluoroquinolones, represent an alarming occurrence of XDR among K. pneumonia

isolates recovered from neonatal sepsis in Egypt, according to Hassuna et al. 2020, this necessitate proper antimicrobial stewardship as the choices will be very limited [36].

In addition, Salama et al. 2021 studied sepsis profile in Cairo University NICU, with 153 cases of neonatal sepsis; 63 (41.2%) early onset sepsis (EOS) and 90 (58.8%) late onset sepsis (LOS). The majority of the neonates had very low or moderately low birth weight (90.9%). Mortalities were more common among EOS group ($p < 0.017$). Positive blood cultures were detected in 61 neonates (39.8%) with a total number of 66 cultures. The most commonly encountered organisms were Klebsiella MDR and coagulase negative staphylococci (CoNS) (31.8% each). Klebsiella MDR was the most predominant organism in EOS (28.9%), while CoNS was the most predominant in LOS (39.2%) [37].

ElMashad et al. 2023 conducted a retrospective study on 155 Egyptian neonates aged from 1 day up to 4 weeks to evaluate the risk factors of the mortality rates at Giza Governorate hospitals NICU, with 6.5% of the studied neonates experienced complications such as sepsis, chronic heart disease or hypoxic ischemic encephalopathy, another 20.6% of the studied neonates were on mechanical ventilation. Survival rates were reported in 84.5% of the studied neonates, moreover; the incidence of neonatal mortality among studied sample was 15.5%. The most common cause of death was Sepsis followed by CHD, Sepsis and Prematurity (50%, 20.8%, 8.3%) respectively [38].

Conclusion

This study demonstrates that structured quality improvement interventions, including staff training, role clarification, and systematic monitoring, can significantly enhance patient-centered quality standards in pediatric intensive care units. While both structure and process indicators showed improvement post-intervention, they remained only partially met, highlighting persistent resource constraints in low-middle-income settings. Notable reductions in mortality rates and CLABSI rates, alongside improved hand hygiene compliance, confirm the effectiveness of targeted interventions. However, the variability in outcomes across units underscores the need for unit-specific contextual evaluation and sustained efforts to address structural deficiencies, particularly in nursing shortages and equipment availability. Achieving high-quality, patient-centered care in PICUs requires embedding these interventions into routine practice with continuous monitoring, leadership support, and adaptation to local resource realities.

Limitations

This study has several limitations, including a short follow-up period that may not capture long-term sustainability, the use of crude mortality rates without severity adjustment, reliance on voluntary reporting with potential underreporting, and conduct in a single Egyptian tertiary hospital, limiting generalizability. The absence of national benchmarks hindered performance contextualization, and the Hawthorne effect may have influenced provider behavior during observation.

Recommendations

Based on the study findings, we recommend expanding quality improvement interventions to more PICUs and wards, adopting electronic medical records, and using standardized mortality rates for better outcome assessment. Hiring additional nurses and PICU specialists is essential to address staffing shortages, while implementing a rewarding system can boost staff morale. Any rise in healthcare-associated infections must be promptly investigated. Long-term QI initiatives with multiple follow-up phases are needed to ensure sustainable improvements embedded in daily practice, and PICU leaders should strive to transform their units into high-reliability systems that prioritize safety, continuous learning, and provider well-being.

Conflict of interest

All authors have no conflicts of interest that are directly relevant to the content of this review.

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