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The Relationship Between Anesthesiologists' Knowledge Level and the Incidence Rate of General Anesthesia Complications Among Pediatric Patients in Government Hospitals

Graduation research as part of the requirements for obtaining an anesthesia diploma

BY

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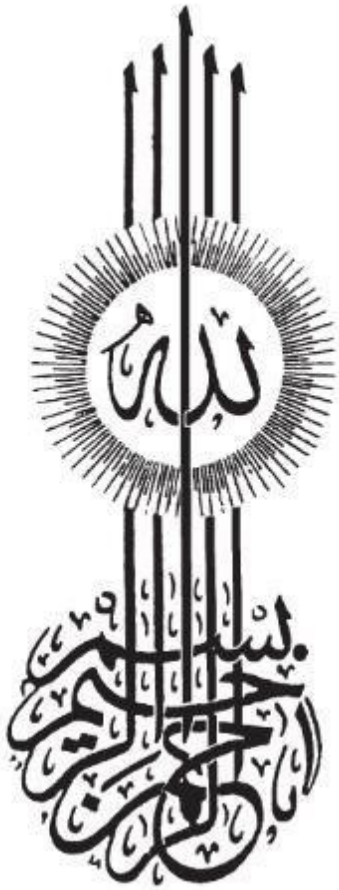
بسم الله الرحمن الرحيم

قال تعالى:

﴿ اقْرَأْ بِاسْمِ رَبِّكَ الذِي خَلَقَ (1) خَلَقَ الْإِنسانَ مِنْ عَلَق (2)

اقْرَأْ وَرَبُّكَ الْأَكْرَمُ (3) الذي عَلَمَ بِالْقَلمِ (4)

عَلَمَ الْإِنْسانَ مَا لَمْ يَعْلَمْ (5) ﴾

سورة: العلق الآية(1)

قال رسول الله صلى عليه وسلم:

(إنما العلم بالتعلم، والحلم بالتحمل، ومن يتحر الخير يعطه،

ومن يتق الشر يوقه) صدق رسول الله

Dedication

We dedicate this humble work…To those who sacrificed for us without expecting anything in return, to our dear parents, who were our constant prayers and our support in every step; our success is the result of their patience before our effort.

To our beloved families, who shared with us the journey of study with all its hardship and hope. To our respected teachers, who taught us that knowledge is a trust and that the profession is humanitarian before being a job. To every sick child who taught us accuracy, compassion, and responsibility inside the operating room, we dedicate this modest effort hoping that Allah makes it beneficial knowledge and a righteous deed.

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for their continuous support, valuable scientific guidance, and patience in follow-up and revision. Their directions had a significant impact on presenting this research in its current form. We also express our great appreciation to 21 September University for Medical and Applied Sciences, the college administration, and the faculty members of the Department of Anesthesia, for the knowledge, guidance, and instruction they provided throughout our years of study, which played a major role in building our scientific and professional foundation. We would also like to thank the hospital administrations and their staff for their cooperation in completing the practical part of this study. Finally, we extend our gratitude to everyone who offered us help and support, even with a word of encouragement.

الملخص

الأهداف :هدفت هذه الدراسة إلى تقييم مستوى المعرفة الإدراكية لدى أطباء وممارسي التخدير وعلاقته بمعدل حدوث مضاعفات التخدير العام لدى المرضى الأطفال في المستشفيات الحكومية بالعاصمة صنعاء، بالإضافة إلى رصد وتحديد مستوى الالتزام بممارسات سلامة المرضى والحد من المخاطر السريرية في غرف العمليات .

المنهجية :اعتمدت الدراسة على المنهج الوصفي المستعرض(Descriptive Cross-Sectional) ، وطُبقت على عينة ملاءمة (Convenience Sample) بلغت 61 ممارساً للتخدير في ثلاثة مستشفيات حكومية تعليمية رئيسة بصنعاء (المستشفى العسكري، مستشفى الجمهوري، ومستشفى الشرطة) .وجُمعت البيانات عبر استبيان مُحكّم وموثوق (معامل ألفا كرونباخ = 0.75) يشتمل على 30 فقرة موزعة على خمسة أبعاد رئيسة تقاس بمقياس ليكرت الخماسي .وجرى تحليل البيانات إحصائياً بواسطة برنامج (SPSS) باستخدام اختبارات "مان-ويتني"، و"كروسكال-واليس"، ومعامل ارتباط "سبيرمان" للرتب .

النتائج :أظهرت النتائج الديموغرافية أن غالبية أفراد العينة من الذكور بنسبة 86.9%، وممن هم دون سن الثلاثين بنسبة 60.7%، ويحملون درجة البكالوريوس في التخدير بنسبة 68.9 .%وفيما يتعلق بأبعاد الدراسة، سجل بُعد "المعرفة الفيزيولوجية والدوائية" أعلى مستوى (متوسط = 4.56)، يليه بُعد "ممارسات السلامة وتقليل المخاطر" (متوسط = 4.45)، ثم بُعد "المعرفة قبل العملية" (متوسط = 4.39)، وبُعد "إدارة مجرى الهواء" (متوسط = 4.14)، بينما جاء معدل حدوث المضاعفات والاستجابة لها بمستوى متوسط (متوسط = 3.84) .وكشفت الدراسة عن وجود ارتباط إيجابي طردي دال إحصائياً بين المعرفة الإدراكية للممارسين وبين جودة التعرف على المضاعفات وتطبيق ممارسات السلامة .(rho approx 0.53 - 0.57, p=0.001) كما تبين أن المشاركة في الدورات المتخصصة أسهمت معنوياً في تحسين المعرفة قبل العملية(p=0.035) ، وأن سنوات الخبرة الطويلة 10<) سنوات) عززت ممارسات السلامة بشكل دال(p=0.040) ، في حين اختلف مستوى المعرفة الدوائية باختلاف مقر العمل لصالح مستشفى الجمهوري .(p=0.035)

الاستنتاجات :خلصت الدراسة إلى أن الكوادر الطبية والفنية القائمة على التخدير في المستشفيات الحكومية تمتلك خلفية معرفية متينة وممارسات آمنة في تخدير الأطفال .ومع ذلك، تم رصد فجوة سريرية حرجة تمثلت في تدني الاستخدام المنتظم لجهاز قياس ثاني أكسيد الكربون (Capnography) (متوسط = 3.16)، إلى جانب الحاجة لتفعيل الآليات المنهجية لمراجعة الأخطاء الطبية بصورة غير عقابية .

الكلمات المفتاحية :أطباء التخدير؛ المعرفة الإدراكية؛ مضاعفات التخدير؛ الأطفال؛ سلامة المرضى؛ المستشفيات الحكومية؛ صنعاء .

Abstract

- **Objectives:** This study aimed to assess the cognitive knowledge level of anesthesiologists and its relationship with the incidence rate of general anesthesia complications among pediatric patients in government hospitals in Sana'a. Additionally, it evaluated the level of adherence to patient safety standards and clinical risk reduction practices within operating theaters.

- **Methodology:** A descriptive cross-sectional design was utilized, targeting a convenience sample of 61 anesthesia practitioners across three major public teaching hospitals in Sana'a: Military Hospital, Republican Hospital, and Police Hospital. Data collection was executed using a validated questionnaire (Cronbach's alpha = 0.75) containing 30 items distributed across five core dimensions evaluated on a 5-point Likert scale. Statistical analysis was conducted via SPSS (Version 27) utilizing the Mann-Whitney U test, Kruskal-Wallis test, and Spearman's rank correlation coefficient.

- **Results:** Demographic analysis indicated that the vast majority of the sample were males (86.9%), under 30 years of age (60.7%), and held a Bachelor's Degree in Anesthesia (68.9%). Regarding study dimensions, "Physiological & Pharmacological Knowledge" yielded the highest competence level (Mean = 4.56), followed by "Patient Safety and Risk Reduction" (Mean = 4.45), "Preoperative Knowledge" (Mean = 4.39), and "Airway Management Knowledge" (Mean = 4.14). Conversely, the indicators of complication incidence and response patterns fell within a moderate range (Mean = 3.84). A statistically significant, moderate-to-strong positive correlation was identified between the practitioners' cognitive level and both complication recognition and patient safety practices (rho range: 0.53 – 0.57, $p = 0.001$). Specialized course participation significantly enhanced preoperative knowledge ($p = 0.035$), while extended clinical experience (>10 years) significantly bolstered safety protocol adherence ($p = 0.040$). Furthermore, pharmacological knowledge significantly varied by work location in favor of the Republican Hospital ($p = 0.035$).

- **Conclusions:** Anesthesia practitioners in Sana'a's government hospitals possess a robust theoretical foundation and maintain safe pediatric practices. Nonetheless, a critical clinical gap was identified regarding the suboptimal, irregular utilization of capnography (Mean = 3.16), alongside a prominent institutional need to establish non-punitive, systematic error review protocols to reinforce the safety culture.

Keywords

Anesthesiologists; Cognitive Knowledge; Anesthesia Complications; Pediatric Patients; Patient Safety; Government Hospitals; Sana'a.

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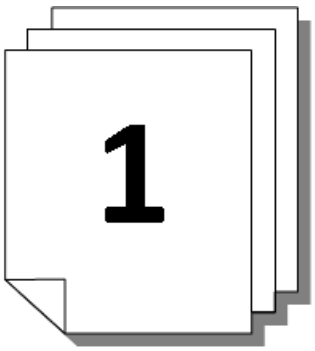


Introduction

1.1 INTRODUCTION:

General anesthesia serves as a foundational pillar of modern surgical interventions, enabling painless procedures through the controlled loss of consciousness, muscle relaxation, and systemic stabilization of vital signs (Miller, 2020). In the context of pediatric care, the delivery of anesthesia transitions into an exceptionally sensitive and complex domain. This heightened complexity is driven by distinct anatomical and physiological disparities between children and adults, including smaller airway calibers, higher basal metabolic rates, and cardiovascular vulnerability, all of which elevate the baseline risk for acute perioperative complications. Within the local landscape, this specialized clinical practice is profoundly shaped by broader systemic challenges; the Yemeni health sector faces deep structural and administrative hurdles, highlighting the vital role that specialized academic institutions must play in spearheading structural reforms and national healthcare reconstruction (Al-Wesabi, 2020). Moreover, in conflict-affected or resource-constrained settings, the rigorous integration of clinical governance frameworks and healthcare quality metrics serves as a critical mechanism to prevent structural decline and optimize hospital performance (Shamlan & Al-Wesabi, 2026).

The systematic optimization of clinical outcomes relies heavily on the implementation of comprehensive institutional quality systems. Empirical evidence demonstrates that adopting Total Quality Management (TQM) principles directly improves healthcare delivery, enhances operational performance, and elevates service quality within Yemeni hospital settings (Al-Saleet et al., 2025; Al-wesabi, 2012). The primary drivers for successfully sustaining these quality standards and mitigating institutional deterioration—especially in environments enduring socioeconomic stress—depend on strict administrative accountability and managerial efficiency rather than merely external environmental constraints (Alsalit et al., 2026). Crucially, the effective translation of total quality systems and international accreditation standards into practice is directly reliant on health human resources development; structured professional training and educational upgrading of public and private healthcare staff act as the primary catalyst for operational efficacy (Al-wesabi, 2017). This human resource development must encompass all allied health branches; strategic career development pathways for nursing and technical staff have been shown to directly enhance localized clinical performance across hospitals in the Sana'a Governorate (Qabban & Al-Wesabi, 2025).

Furthermore, the cultivation of an institutional patient safety culture requires a committed adherence to international benchmarks. Research underscores that aligning hospital operations with the Joint Commission International (JCI) patient-centered standards yields a substantial, positive effect on self-reported nursing and technical performance indicators (Qabban et al., 2026). At the operational level, the strict application of infection prevention and control standards serves as a vital safeguard, directly reducing the intraoperative spread of communicable diseases and epidemics within public facilities (Al-Wesabi & Shamlan, 2022). From a pharmacological safety standpoint, maintaining rigorous cognitive vigilance regarding clinically significant drug-drug interactions is critical to avoiding adverse events in vulnerable or high-risk patient groups (Alyahawi et al., 2024). This overarching need for cognitive precision is mirrored in the anesthesia domain, where practitioners must possess flawless physiological understanding to execute precise weight-based drug calculations, manage fluid balance, and secure pediatric airways without inducing catastrophic respiratory or cardiac depression. Consequently, the present study is designed to empirically evaluate the direct relationship between the cognitive knowledge level of anesthesiologists and the actual incidence of general anesthesia complications among pediatric patients within governmental hospitals in Sana'a.

1.2 Problem Research:

Despite advances in anesthesia techniques and monitoring, pediatric anesthesia complications still occur in governmental hospitals. Their prevention depends primarily on the anesthesiologist's knowledge and clinical decision-making (Miller, 2020). Variability in experience and knowledge among anesthesiologists makes it unclear how this affects complication rates, necessitating a study of the relationship between knowledge level and pediatric anesthesia complications (Cote, 2019).

1.3 Research question:

1.3.1 general question:

- What is the relationship between anesthesiologists' knowledge level and the incidence of general anesthesia complications in children?

1.3.2 Specific questions:

1. What is the knowledge level of anesthesiologists regarding pediatric anesthesia?

2. What is the incidence rate of complications?
3. Is there a statistical relationship between knowledge and complications?
4. Do results differ by experience or qualification?

1.4 Research objective:

1.4.1. General objective:

- Determine the relationship between anesthesiologists' knowledge and complication rates.

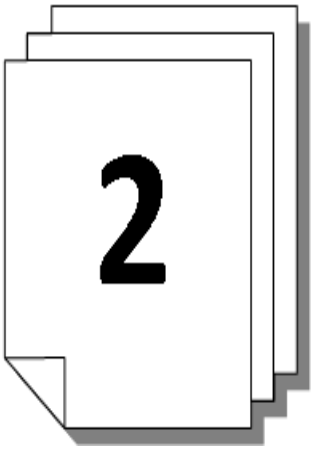
1.4.2. Specific objective:

1. Evaluate theoretical and practical knowledge in pediatric anesthesia.
2. Identify the most common complications.
3. Analyze the effect of experience and qualification.
4. Link knowledge level to patient safety outcomes.

1.5 The importance of research:

- The significance of this study lies in the following aspects:

1. Improve pediatric anesthesia safety.
2. Identify knowledge gaps among anesthesiologists.
3. Support continuous medical education.
4. Help hospitals develop safer protocols.



Literature review

2.1 Theoretical Background

2.1.1 Pediatric General Anesthesia

General anesthesia is defined as a reversible pharmacological state in which complete loss of consciousness occurs, along with absence of pain sensation, muscle relaxation, and loss of protective reflexes, allowing surgical procedures to be performed safely (Miller, 2020).

Anesthesia in children differs significantly from adults, as a child is not merely a small adult, but possesses physiological and anatomical characteristics that directly affect the response to anesthetic drugs and the stability of vital functions during surgery (Cote & Lerman, **2019**).

Pediatric anesthesia aims to achieve four main elements: loss of consciousness, pain relief, muscle relaxation, and maintenance of vital function stability. Achieving these goals in children requires higher precision due to the faster onset of complications compared to adults (Smith, **2017**).

General anesthesia progresses through four main stages:
1. Induction
2. Excitement
3. Surgical Anesthesia
4. Overdose

The excitement stage is particularly risky in children due to the possibility of laryngospasm and airway obstruction (Morgan & Mikhail, 2018).

2.1.1.1 The physiological characteristics of children affecting anesthesia

Physiological differences are the main reason why anesthesia in children is riskier, as they directly affect drug absorption, distribution, elimination, and the stability of vital signs (Cote & Lerman, 2019).

1. **Respiratory System**
    - Children have a narrow airway that can easily collapse due to a relatively large tongue, small lower jaw, and high larynx, increasing the risk of airway obstruction during anesthesia (Hines & Marschall, 2018).
    - Additionally, children have a higher oxygen consumption rate compared to adults and a lower Functional Residual Capacity, which results in a rapid drop in oxygen levels if ventilation is interrupted for a short period (Miller, 2020).
    - For this reason, hypoxemia is among the most common anesthesia complications in children, often associated with poor airway management (Weiss & Engelhardt, 2016).

2. **Cardiovascular System**

- Cardiac output in children primarily depends on heart rate rather than contractile strength, so bradycardia rapidly leads to severe hypotension and poor perfusion (Morgan & Mikhail, 2018).
- Children are also more sensitive to hypoxia and acidosis, and sudden cardiac arrest can occur due to hypoxemia before clear warning signs appear (Cote & Lerman, 2019).

3. **Central Nervous System**

- The pediatric nervous system is characterized by increased blood-brain barrier permeability and incomplete maturation of respiratory centers, making the brain more sensitive to anesthetic drugs and increasing the risk of postoperative respiratory arrest (Smith, 2017).
- Moreover, the rapid delivery of drugs to the brain leads to quick changes in anesthesia depth, requiring careful monitoring to avoid overdose (Miller, 2020).

4. **Liver and Kidneys (Drug Metabolism)**

- Incomplete maturation of liver enzymes and renal functions in children slows the metabolism and elimination of some anesthetic drugs, increasing their duration of action and the likelihood of accumulation (Hines & Marschall, 2018).
- This raises the risk of respiratory depression and delayed recovery if doses are not appropriately adjusted (Cote & Lerman, 2019).

2.1.1.2 Preoperative Assessment

- Preoperative assessment is the most important step in preventing anesthesia complications, as studies indicate that a significant proportion of complications can be avoided through proper evaluation (ASA, 2020).

Assessment includes:

1. **Medical History**: Respiratory diseases, drug allergies, prematurity, genetic disorders.
2. **Airway Evaluation**: Airway examination is a key predictor of difficult intubation, including jaw and tongue size, mouth opening, and neck mobility (Weiss & Engelhardt, 2016).
3. **Preoperative Fasting**: Non-adherence to fasting guidelines increases the risk of pulmonary aspiration, one of the most dangerous anesthesia complications in children (ASA, 2020).
4. **Health Status Classification (ASA Classification):** ASA classification helps estimate anesthesia risk and determine the level of monitoring required during surgery (Morgan & Mikhail, 2018).

2.1.2 Pediatric Anesthesia Management

- Pediatric anesthesia management requires precise scientific and practical skills, as any minor error in dosage or airway management can lead to severe complications within seconds. Therefore, clinical experience and knowledge are crucial for safe pediatric anesthesia (Cote & Lerman, 2019).

2.1.2.1 Induction of Anesthesia

- Induction of anesthesia is the most critical stage in pediatric anesthesia, where most complications occur due to loss of protective reflexes and instability of respiration and circulation (Miller, 2020).

Induction is divided into two main types:

- ***Inhalation Induction***: Often used in uncooperative children, with sevoflurane being the most common due to its rapid effect and minimal airway irritation (Smith, 2017). However, improper concentration or insufficient ventilation can lead to laryngospasm or airway obstruction (Weiss & Engelhardt, 2016).
- ***Intravenous Induction***: Used when a vein is available, allowing rapid transition to surgical anesthesia, but may cause hypotension or apnea if the dose is not precisely calculated (Morgan & Mikhail, 2018).

Importance: Choosing the wrong induction method or incorrect dosage is one of the most common causes of early complications in children.

2.1.2.2 Airway Management

- Airway management is the most critical component of pediatric anesthesia.
- Most studies indicate that the majority of pediatric anesthesia incidents are related to airway management rather than the drugs themselves (ASA, 2020).

- **Mask Ventilation**: The first step after loss of consciousness; ensure proper head position, mask seal, and chest movement observation. Failure leads to hypoxemia in less than a minute in infants (Hines & Marschall, 2018).

- **Laryngeal Mask Airway (LMA):** Used for minor procedures, reduces airway stimulation, but incorrect sizing may cause air leakage or obstruction (Weiss & Engelhardt, 2016).

- **Endotracheal Intubation**: The safest method for major surgeries, requiring accurate tube size, insertion depth, and fixation. Improper sizing may result in:

- Too small → air leak, inadequate ventilation
- Too large → laryngeal edema and postoperative obstruction (Miller, 2020)

❖ **Research point**: Over half of pediatric anesthesia complications are related to poor airway management or inappropriate tube selection.

2.1.2.2 Maintenance of Anesthesia

- After securing the airway, the maintenance phase aims to balance anesthesia depth with vital sign stability (Morgan & Mikhail, 2018).

1. **Anesthetic Gases:** Concentration must be precise to avoid:

   Excess → hypotension, cardiac and respiratory depression

   Deficiency → patient awakening or movement during surgery

2. **Monitoring**: Includes oxygen saturation, ECG, blood pressure, and end-tidal CO_2, which is the most important early indicator of airway problems (ASA, 2020).
3. **Intravenous Fluids**: Children are prone to dehydration and hypoglycemia; fluids should be calculated precisely according to weight (Smith, 2017).
4. **Pain Management**: Pain disrupts vital signs and increases oxygen consumption; analgesics must be carefully dosed to prevent respiratory depression (Cote & Lerman, 2019).

2.1.2.4 Recovery Phase

- The recovery phase is critical as the child gradually regains reflexes, and sudden airway obstruction may occur (Weiss & Engelhardt, 2016).

Major complications include:

1. Respiratory arrest
2. post-anesthesia agitation
3. Vomiting and pulmonary aspiration
4. Laryngospasm after extubation

Guidelines indicate that most postoperative complications occur due to premature tube removal or inadequate monitoring (ASA, 2020).

2.1.3 Complications of Pediatric General Anesthesia

3 Studies indicate that children are more prone to anesthesia-related complications than adults due to their physiological and psychological characteristics, difficulty managing the airway, and sensitivity to anesthetic drugs (Miller, 2020).

2.1.3.1 Respiratory Complications

4 Respiratory complications constitute the majority of pediatric anesthesia complications:

- **Laryngospasm**: Sudden closure of the larynx causing airway obstruction, often during induction or emergence (Weiss & Engelhardt, 2016).
- **Bronchospasm**: Common in children with asthma or upper respiratory infections, may lead to severe hypoxia (Hines & Marschall, 2018).
- **Hypoxia**: Rapid onset in infants due to low functional residual capacity and high oxygen consumption (Miller, 2020).
- **Apnea**: Particularly in preterm infants or those with neurological or muscular disorders (Cote & Lerman, 2019).
- **Airway Obstruction**: Caused by improper head position or tongue blockage, requiring prompt intervention (Morgan & Mikhail, 2018).

2.1.3.2 Cardiovascular Complications

5 Children are more sensitive to blood pressure and heart rate changes:

- **Bradycardia**: Due to hypoxia or severe laryngeal stimulation.
- **Hypotension**: Especially with overdosing of anesthetic gases or analgesics (Smith, 2017).
- **Cardiac Arrest**: Rare, usually associated with uncorrected respiratory complications (Morgan & Mikhail, 2018).

2.1.3.3 Drug-related Complications

6 **Overdose**: Due to improper dose adjustment according to the child's weight or lack of accurate dosage knowledge.

7 **Allergic Reactions**: To certain anesthetics or analgesics (Cote & Lerman, 2019).

8 **Malignant Hyperthermia**: Rare but life-threatening if not promptly diagnosed and treated (Miller, 2020).

2.1.3.4 Postoperative Complications

2.1.4 Knowledge Level of Anesthesia Physicians and Technicians

- The knowledge level of physicians and technicians is a crucial factor affecting pediatric anesthesia safety. Research shows that lack of knowledge is directly linked to increased errors and complications (Cote & Lerman, 2019).

2.1.4.1 Clinical Knowledge

Clinical knowledge consists of three main elements:

- **Theoretical Knowledge**: Understanding the scientific principles of drugs, anesthesia, and managing pediatric complications (Miller, 2020).
- **Practical Knowledge**: Applying theory in the operating room, such as induction choice, dose adjustment, and airway management (Smith, 2017).
- **Clinical Decision-making**: Quickly evaluating cases and selecting the best solution for sudden complications (Morgan & Mikhail, 2018).

2.1.4.2 Knowledge sources for anesthesia physicians and technicians include:

- **Academic education**: foundation of theoretical principles.
- **Clinical training**: hands-on experience under supervision.
- **Workshops:** updating knowledge on protocols and techniques.
- **Guidelines**: such as ASA and WHO recommendations (ASA, 2020).
- **Experience**: learning from previous cases and real-life complications.

2.1.4.3 Measuring Knowledge Level

- Methods to assess knowledge level:
- **Theoretical Tests**: Evaluate scientific understanding of drugs and techniques.
- **Questionnaires:** Assess compliance with protocols and emergency management.
- **Direct Observation**: Observe actual performance in the OR.
- **Performance Assessment**: Evaluate decision-making during emergencies and complications.

2.1.4.4 Effect of Knowledge Deficit on Performance

Knowledge deficits lead to:

- **Errors**: Mistakes in dosage or airway selection.
- **Delayed Response**: Increases risk of respiratory and cardiovascular complications.
- **Medication Miscalculation**: Particularly in preterm infants or complex cases (Miller, 2020).

❖ Non-compliance with Guidelines: Directly causes preventable complications.

❖ Conclusion: Clinical knowledge is not just theoretical learning; it forms the foundation for correct decision-making, reducing complications and enhancing pediatric safety

2.2 Previous Studies

- The topic of the current research has received the attention of several researchers at the international level. The following is a presentation of (3) previous studies, followed by a comment on them.

- Lee et al. (2021). Impact of adherence to pediatric anesthesia protocols on complication rates
  Aim:
  This study aimed to evaluate the effect of adherence to pediatric anesthesia safety guidelines on reducing anesthesia-related complications in children.
  Methods:
  A multicenter observational study was conducted in pediatric surgical units. Anesthesia providers were divided into two groups based on their adherence to international pediatric anesthesia protocols. Patient monitoring records and postoperative complication reports were reviewed. Statistical analysis was performed using SPSS.
  Results:
  The study showed that adherence to protocols reduced anesthesia complications by approximately 40%. Respiratory complications such as laryngospasm and oxygen desaturation were significantly lower among trained providers.

- Smith (2017). Medication dosing knowledge among anesthesia residents in pediatric anesthesia
  Aim:
  To assess the level of pharmacological knowledge among anesthesia residents regarding drug dosing in pediatric anesthesia.
- **Methods**:
  A questionnaire-based assessment and clinical scenario test were conducted among anesthesia residents in a teaching hospital. The answers were compared with standard pediatric dosing guidelines.

- **Results**:
  The study found frequent dosing errors among less experienced residents, which were associated with increased postoperative respiratory complications. Knowledge level was strongly correlated with patient safety outcomes.
- Walker (2018). Perioperative complications in pediatric anesthesia in general hospitals **Aim**:
  To determine the factors associated with increased anesthesia complications among children in public hospitals.

Methods:
A retrospective analysis of pediatric surgical records was performed. Complication rates during anesthesia and recovery were analyzed in relation to provider experience and training level
.
Results:
Higher complication rates were observed in hospitals with limited training and less experienced anesthesia providers, especially in children under five years of age.

Comment on Previous Studies

Previous studies indicate that pediatric anesthesia complications remain a significant clinical concern. They demonstrate that inadequate knowledge, lack of adherence to protocols, and limited clinical experience increase the risk of complications. However, most studies examined these factors separately, such as training, experience, or guidelines adherence. Few studies investigated the direct relationship between the knowledge level of anesthesia providers and the actual occurrence of complications in governmental hospitals

Therefore, the current study aims to bridge this gap by assessing anesthesia providers' knowledge and correlating it with pediatric general anesthesia complications.

Materials & Methods

CHPTER THREE

METHOD

Overview

This part describes the methodology of the present **s**tudy in terms of design, setting and duration, population including sampling, tools, data collection, ethical considerations and data analysis.

Study Design:

The type of study was cross-sectional descriptive**.**

Study setting and Duration:

This study was conducted from Military Hospital. Republican Hospital. Police Hospital in Sana'a . from April to June 2025 AD

Sample:

The sample size was 61, The convenience sampling method was used.

Data collection Tool

Questionnaire design:

The study instrument was designed to measure the relationship between anesthesiologists' cognitive abilities and the incidence of general anesthesia complications in children. The questionnaire consisted of three main axes encompassing five distinct dimensions, with a total of 30 items. All items were measured using a five-point Likert scale ranging from "Never" (1) to "Always" (5), allowing participants to self-report the frequency of their knowledge application and clinical practices.

The first axis addressed the independent variable, focusing on cognitive level and knowledge application in pediatric anesthesia. This axis comprised three dimensions: Preoperative Knowledge (6 items) examining practices related to risk assessment using ASA classification, application of fasting guidelines, airway examination for difficult intubation signs, medical history review, equipment checklist preparation, and family communication regarding anesthesia plans. The second dimension within this axis was Physiological and Pharmacological Knowledge (6 items), which explored weight-based drug dosage calculation, consideration of physiological differences in neonates, emergency drug dilution practices, syringe labeling adherence, fluid management according to the 4-2-1 rule, and avoidance of

high-risk medications. The third dimension was Airway Management Knowledge (6 items), investigating endotracheal tube selection based on scientific formulas, cuff pressure monitoring, clinical distinction between laryngospasm and bronchospasm, extubation timing, availability of alternative airway devices as backup plans, and capnography utilization for verifying ventilation efficiency.

The second axis represented the dependent variable, measuring indicators of complication occurrence and management. This axis included the fourth dimension: Complications Incidence and Response (6 items), which assessed the frequency of observed desaturation events, encountered laryngospasm cases, management of sudden bradycardia episodes, documentation of emergence agitation, application of PALS algorithms during deterioration, and requests for immediate assistance during unexpected difficult airway situations.

The third axis continued the dependent variable measurement through the fifth dimension: Patient Safety and Risk Reduction (6 items), examining practices related to temperature maintenance using warming devices, PACU monitoring until vital sign stability, accurate documentation of adverse events, systematic error review for learning purposes, personal verification of oxygen source and suction apparatus readiness, and adherence to instrument sterilization and single-use item protocols to prevent infection transmission.

This comprehensive instrument structure allowed for thorough assessment of the relationship between anesthesiologists' cognitive knowledge and their clinical practices in pediatric anesthesia, providing valuable insights into both strengths and areas requiring improvement in governmental teaching hospitals in Sana'a Capital Municipality.

Tools validity and reliability:

The validity of the questionnaire was verified in two ways: **Trustees validity** : Tools of data collection were reviewed by three panel expertise according to their comments, modifications were done. Total KAP Cronbach's alpha was equal (0.75). which showed acceptable internal consistency

Ethical Considerations

Approval to conduct the study was obtained from the Scientific Research Ethical Committee, Faculty of. An official permission from the selected study setting was obtained for the fulfillment of the study.. Allowing freedom to the participation to withdraw from the study at any time.

Data Analysis

If the scale used is a five-point Likert scale, write the actual limits for each category according to the mean, given that: Never = 1, Rarely = 2m Sometimes = 3, Often = 4, Always = 5 Then data was statistically analyzed using Statistical Package for the Social“SPSS (IBM SPSS, Version 27. The Spearman’s Rank correlation Mann-Whitney U Test and , and (Kruskal-Wallis Test) . p-value of <0.05 was considered statistically significant.

The Calculation Process:

1. **Find the overall range:** Highest value (5) - Lowest value (1) = 4
2. **Divide by the number of categories:** 4/5 =0.8 (This is the length of each category interval).
3. **Build the limits:** Start from "Never" (1) and add 0.8 to get the upper limit for each category.

The Actual Limits for Each Category (in English):

- **Never:** From **1.00** to **1.80**
- **Rarely:** From **1.81** to **2.60**
- **Sometimes:** From **2.61** to **3.40**
- **Often:** From **3.41** to **4.20**
- **Always:** From **4.21** to **5.00**

Results & Discussion

RESULT & DISCUSSION

Overview

This chapter includes the results and discussion as follows:.

4. 1. Result

4.1.1. Demographic and functional data

The study included a total of 61 participants. Regarding gender distribution, the vast majority of the sample were males, consisting of 53 participants (86.9%), while females represented 13.1% (n=8).

Concerning the age groups, more than half of the participants were under 30 years old, accounting for 60.7% (n=37). Those aged between 30 and 40 years constituted 37.7% (n=23). The smallest age group was participants between 41 and 50 years, representing only 1.6% (n=1) of the total sample.

In terms of educational qualifications, most participants held a Bachelor's Degree in Anesthesia, with a frequency of 42 (68.9%). This was followed by those holding a Diploma in Anesthesia/Technician at 23.0% (n=14). A smaller proportion held a Master's Degree (6.6%, n=4), and only one participant (1.6%) was Board Certified or held a PhD.

Regarding years of experience, the majority of the sample had less than 5 years of professional experience (63.9%, n=39). Those with 5 to 10 years of experience accounted for 31.1% (n=19), while only 4.9% (n=3) had over 10 years of experience.

The distribution of work locations was relatively even. Both Military and Republican Hospitals each represented 34.4% (n=21) of the participants. The remaining 31.1% (n=19) worked in other locations (coded as 4.00).

Finally, regarding professional development, an overwhelming majority of participants (83.6%, n=51) reported that they had participated in a specialized course, while only 16.4% (n=10) had not.

Table 4.1: Demographic and functional data of Participants (N=61)

Variable	Category	Frequency (n)	Percent (%)
Gender	Male	53	86.9
	Female	8	13.1
Age	Less than 30 years	37	60.7
	30 to 40 years	23	37.7
	41 to 50 years	1	1.6
Qualifications	Diploma in Anesthesia/Technician	14	23.0
	Bachelor's Degree in Anesthesia	42	68.9
	Master's Degree in Anesthesia	4	6.6
	Board Certified/PhD (Specialist/Consultant)	1	1.6
Years of Experience	< 5 years	39	63.9
	5-10 years	19	31.1
	>10 years	3	4.9
Work Location	Military Hospital	21	34.4
	Republican Hospital	21	34.4
	Other	19	31.1
Training course(2024-2025)	Yes	51	83.6
	No	10	16.4

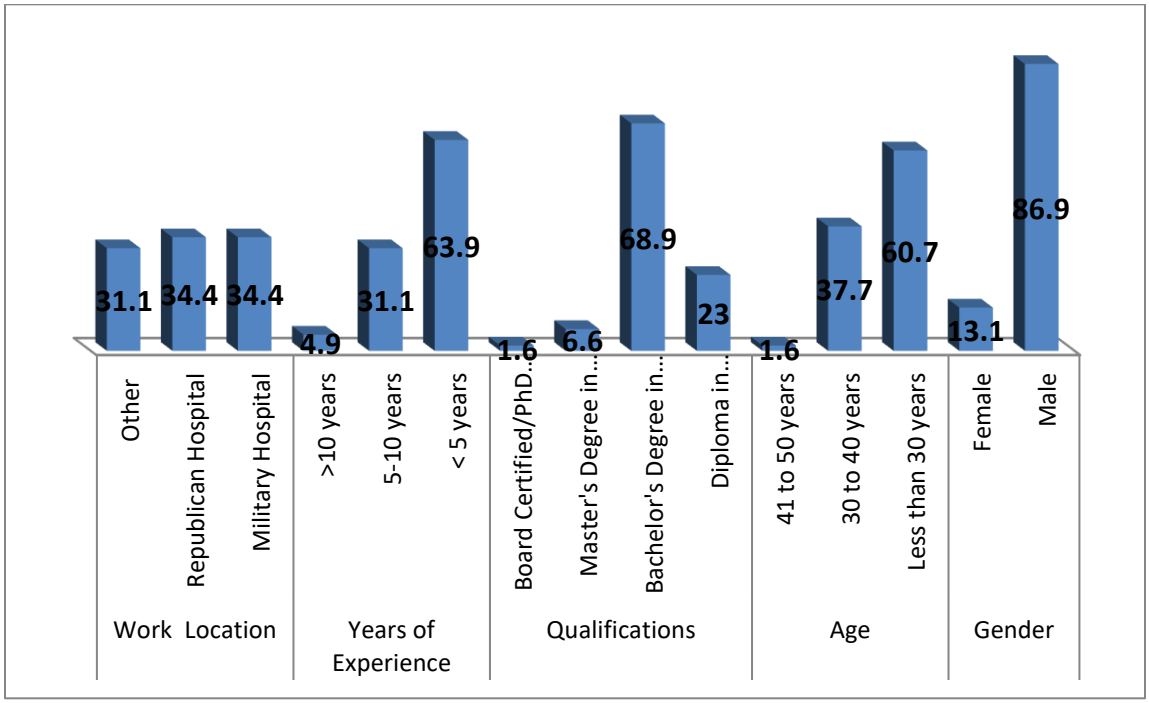


Table 4.2: Demographic and functional data of Participants (N=61)

4.1.2. Preoperative Knowledge

The results presented in Table 3 reveal the level of preoperative knowledge among anesthesiologists participating in the study. The overall mean score for this dimension was 4.39 (SD = .522) , indicating a high level of self-reported knowledge regarding preoperative assessment and preparation for pediatric anesthesia.

Analyzing the individual items, the highest mean score was for item 2, "I apply modern fasting guidelines (2-4-6) for clear fluids and solid foods to avoid dehydration or pulmonary aspiration" (Mean = 4.74, SD = .656) , demonstrating strong adherence to evidence-based fasting protocols. This was closely followed by item 6, "I explain the anesthesia plan and potential complications to the parents to obtain informed consent and reduce the child's anxiety" (Mean = 4.51, SD = .924) , and item 4, "I review the child's medical history to ask parents about any previous allergic reactions or family history of anesthesia complications" (Mean = 4.44, SD = .646) . These findings suggest that anesthesiologists place a high priority on communication with families and thorough history-taking.

Items related to clinical assessment also scored highly, with item 1, "I accurately assess the child's potential risks based on the ASA classification" (Mean = 4.31, SD = .958) , and item 3, "I examine the child's airway for signs of 'difficult intubation' associated with congenital syndromes" (Mean = 4.36, SD = .857) , both reflecting strong clinical evaluation practices.

Notably, the lowest mean score within this dimension was for item 5, "I prepare a checklist of anesthesia equipment and supplies appropriate for the child's age and weight before they enter the operating room" (Mean = 3.98, SD = .940) . While still indicating a relatively high level of practice (approaching "Often"), this comparatively lower score suggests a potential area for improvement in systematic equipment preparation and checklist utilization prior to pediatric cases.

Overall, the findings demonstrate that anesthesiologists in governmental teaching hospitals in Sana'a possess a robust foundation in preoperative knowledge, with particular strengths in fasting guidelines, family communication, and risk assessment. However, enhancing the consistent use of preoperative checklists for equipment preparation could further strengthen safety practices.

Table 3: Descriptive Statistics for Preoperative Knowledge (N=61)

No.	Item	Mean	Std. Deviation
1.	I accurately assess the child's potential risks based on the American Society of Anesthesiologists (ASA) classification before the procedure.	4.31	.958
2.	I apply modern fasting guidelines (2-4-6) for clear fluids and solid foods to avoid dehydration or pulmonary aspiration.	4.74	.656
3.	I examine the child's airway for signs of "difficult intubation" associated with congenital syndromes.	4.36	.857
4.	I review the child's medical history to ask parents about any previous allergic reactions or family history of anesthesia complications.	4.44	.646
5.	I prepare a checklist of anesthesia equipment and supplies appropriate for the child's age and weight before they enter the operating room.	3.98	.940
6.	I explain the anesthesia plan and potential complications to the parents to obtain informed consent and reduce the child's anxiety.	4.51	.924
	Overall Dimension (Mean)	**4.39**	**.522**

4.1.3. Physiological & Pharmacological Knowledge

The findings presented in Table 4 illustrate the level of physiological and pharmacological knowledge among anesthesiologists in pediatric practice. The overall mean score for this dimension was **4.56 (SD = .392)** , representing the highest mean among all knowledge dimensions and indicating an excellent level of self-reported competence in drug dosing and physiological considerations for children.

Examining the individual items, the highest mean score was for item 1, "I precisely calculate drug dosages (hypnotics, muscle relaxants, analgesics) based on the child's weight in kilograms" **(Mean = 4.80, SD = .477)** . This exceptionally high score, approaching "Always" in practice, reflects the critical importance anesthesiologists place on accurate weight-based dosing as a fundamental safety principle in pediatric anesthesia. The low standard deviation (.477) indicates strong consensus among participants regarding this practice.

Item 5, "I manage fluid replacement (Maintenance & Deficit) according to approved calculation rules (e.g., 4-2-1 rule)" also demonstrated a very high mean score **(Mean = 4.64, SD = .606)** , showing

consistent application of standard fluid management protocols in children. Similarly, item 4, "I adhere to placing colored identification labels on all syringes immediately after drawing up the medication to avoid injection errors" **(Mean = 4.56, SD = .671)** , indicates strong commitment to medication safety practices through proper syringe labeling.

Items related to special physiological considerations scored somewhat lower but remained high. Item 2, "I consider physiological differences (immaturity of the liver and kidneys) in neonates when determining dosing intervals" **(Mean = 4.48, SD = .622)** , and item 6, "I avoid using medications that may cause severe cardiac or respiratory depression in high-risk children" **(Mean = 4.48, SD = .924)** , both reflect awareness of age-specific pharmacological principles and risk avoidance in vulnerable populations.

The lowest mean score within this dimension was for item 3, "I pre-dilute emergency and cardiac drugs (e.g., epinephrine) to have them ready in safe, pediatric-appropriate concentrations" **(Mean = 4.39, SD = .954)** . While still indicating a high level of practice, this relatively lower score, combined with the largest standard deviation in this dimension, suggests some variability in the preparation of emergency drugs at pediatric-appropriate concentrations. This finding may point to an opportunity for standardization in emergency drug preparation protocols.

Overall, these results demonstrate that anesthesiologists in governmental teaching hospitals in Sana'a exhibit exemplary physiological and pharmacological knowledge, with particular strengths in weight-based dosing, fluid management, and medication safety labeling. The high overall mean (4.56) reflects a strong foundation in the scientific principles essential for safe pediatric anesthesia practice.

Table 4: Descriptive Statistics for Physiological & Pharmacological Knowledge (N=61)

No.	Item	Mean	Std. Deviation
1.	I precisely calculate drug dosages (hypnotics, muscle relaxants, analgesics) based on the child's weight in kilograms.	4.80	.477
2.	I consider physiological differences (immaturity of the liver and kidneys) in neonates when determining dosing intervals.	4.48	.622
3.	I pre-dilute emergency and cardiac drugs (e.g., epinephrine) to have them ready in safe, pediatric-appropriate concentrations.	4.39	.954
4.	I adhere to placing colored identification labels on all syringes immediately after drawing up the medication to avoid injection errors.	4.56	.671
5.	I manage fluid replacement (Maintenance & Deficit) according to approved calculation rules (e.g., 4-2-1 rule).	4.64	.606
6.	I avoid using medications that may cause severe cardiac or respiratory depression in high-risk children.	4.48	.924
	Overall Dimension (Mean)	**4.56**	**.392**

4.1.4. Airway Management Knowledge

The results presented in Table 5 reveal the level of airway management knowledge among anesthesiologists in pediatric practice. The overall mean score for this dimension was 4.14 (SD = .422) , indicating a high level of self-reported knowledge and practice in pediatric airway management, though slightly lower than the previous dimensions of Preoperative Knowledge (4.39) and Physiological & Pharmacological Knowledge (4.56).

Analyzing the individual items, the highest mean score was for item 1, "I select the size and type (cuffed/uncuffed) of the endotracheal tube (ETT) based on scientific formulas for the child's age" (Mean = 4.52, SD = .829) . This high score demonstrates that anesthesiologists consistently rely on evidence-based formulas for appropriate ETT selection, which is fundamental to safe airway management in children whose airway anatomy differs significantly from adults.

Items related to intraoperative airway monitoring and complication recognition also scored highly. Item 2, "I monitor the cuff pressure to ensure it does not exceed safe limits to prevent laryngeal edema" (Mean = 4.40, SD = .616) , and item 3, "I accurately distinguish clinically between laryngospasm and bronchospasm" (Mean = 4.39, SD = .759) , reflect strong awareness of both preventive measures and diagnostic skills essential for managing common pediatric airway complications. The low standard

deviation for item 2 (.616) indicates consistent practice among participants regarding cuff pressure monitoring.

Items related to extubation timing and backup planning showed somewhat lower scores. Item 4, "I determine the optimal timing for extubation (either fully awake or deeply anesthetized) to avoid spasms" (Mean = 4.16, SD = .879) , and item 5, "I ensure the availability of different sizes of laryngeal mask airways (LMA) as a backup plan (Plan B) for difficult intubation" (Mean = 4.18, SD = .646) , both indicate good practice but suggest some variability in approach to these critical aspects of airway management.

Notably, the lowest mean score by a substantial margin was for item 6, "I use capnography as a primary standard to verify ventilation efficiency and tube placement" (Mean = 3.16, SD = 1.214). This score falls within the "Sometimes" to "Often" range and represents the single lowest-scoring item across all knowledge dimensions. Furthermore, the large standard deviation (1.214) indicates considerable variability in capnography utilization among participants. This finding is particularly significant given that capnography is considered an essential standard of care for verifying endotracheal tube placement and monitoring ventilation adequacy, especially in pediatric patients who are at higher risk for unrecognized esophageal intubation or ventilator disconnection.

The relatively lower score for capnography use may reflect limitations in equipment availability, varying practice standards across different hospital settings, or potential areas for continuing education. This finding identifies a critical gap in adherence to international safety standards that warrants attention, as consistent capnography monitoring is strongly associated with reduced incidence of adverse respiratory events during anesthesia.

Overall, while anesthesiologists demonstrate strong knowledge in most aspects of pediatric airway management—particularly in ETT selection, cuff pressure monitoring, and complication recognition—the suboptimal utilization of capnography represents a significant patient safety concern that should be addressed through equipment provision and protocol reinforcement

Table 5: Descriptive Statistics for Airway Management Knowledge (N=61)

No.	Item	Mean	Std. Deviation
1.	I select the size and type (cuffed/uncuffed) of the endotracheal tube (ETT) based on scientific formulas for the child's age.	4.52	.829
2.	I monitor the cuff pressure to ensure it does not exceed safe limits to prevent laryngeal edema. (N=60)	4.40	.616
3.	I accurately distinguish clinically between laryngospasm and bronchospasm.	4.39	.759
4.	I determine the optimal timing for extubation (either fully awake or deeply anesthetized) to avoid spasms.	4.16	.879
5.	I ensure the availability of different sizes of laryngeal mask airways (LMA) as a backup plan (Plan B) for difficult intubation.	4.18	.646
6.	I use capnography as a primary standard to verify ventilation efficiency and tube placement.	3.16	1.214
	Overall Dimension (Mean)	**4.14**	**.422**

4.1.5. Dependent Variable (Indicators of Complication Occurrence and Management)

The findings presented in Table 6 illustrate the frequency of observed complications and the reported response practices among anesthesiologists during pediatric anesthesia. The overall mean score for this dimension was 3.84 (SD = .496) , which falls between "Often" and "Sometimes" on the response scale. This score is notably lower than the knowledge dimensions (which ranged from 4.14 to 4.56), reflecting that while anesthesiologists possess strong knowledge, the occurrence of complications and specific response patterns show greater variability.

Regarding item 1, "I observe occurrences of desaturation during anesthesia requiring rapid intervention" (Mean = 4.10, SD = 1.012) , the relatively high mean indicates that desaturation events are commonly encountered in pediatric practice. However, the large standard deviation (1.012) suggests considerable variation in how frequently different practitioners observe these events, which may reflect differences in patient populations, case complexity, or vigilance levels.

Items related to specific complication types showed notably lower frequencies. Item 2, "I encounter cases of laryngospasm after extubation in children" (Mean = 3.07, SD = .854) , and item 4, "I record cases of delayed emergence or severe emergence agitation in children after inhalational anesthesia" (Mean = 3.13, SD = 1.204) , both fell near the "Sometimes" range. The particularly large standard deviation for item 4 (1.204) indicates substantial variability in the reporting or occurrence of emergence agitation, which may be influenced by differences in documentation practices, anesthetic techniques, or patient populations across hospitals.

Item 3, "I manage sudden bradycardia episodes as a serious sign of hypoxia in children" (Mean = 3.72, SD = .933) , scored in the upper "Sometimes" to "Often" range, reflecting moderate frequency of encountering this critical event. Given that bradycardia in children is often a harbinger of hypoxemia until proven otherwise, this finding underscores the importance of maintaining high vigilance for this serious sign.

Notably, the highest scores in this dimension related to crisis response behaviors. Item 6, "I request immediate assistance from colleagues (Call for Help) when facing an unexpected difficult airway" (Mean = 4.72, SD = .662) , demonstrated an exceptionally high level of practice, approaching "Always." This finding reflects a strong safety culture and appropriate recognition of the importance of teamwork during airway emergencies. The low standard deviation indicates consistent agreement on this practice across participants.

Table 6 Descriptive Statistics for Complications Incidence & Response Dimension (N=61)

No.	Item	Mean	Std. Deviation
1.	I observe occurrences of desaturation during anesthesia requiring rapid intervention.	4.10	1.012
2.	I encounter cases of laryngospasm after extubation in children.	3.07	.854
3.	I manage sudden bradycardia episodes as a serious sign of hypoxia in children.	3.72	.933
4.	I record cases of delayed emergence or severe emergence agitation in children after inhalational anesthesia.	3.13	1.204
5.	I apply Pediatric Advanced Life Support (PALS) algorithms in the correct sequence when sudden deterioration in vital signs occurs.	4.28	.799
6.	I request immediate assistance from colleagues (Call for Help) when facing an unexpected difficult airway.	4.72	.662
	Overall Dimension (Mean)	**3.84**	**.496**

The results presented in Table 7 demonstrate the level of patient safety practices and risk reduction behaviors among anesthesiologists in pediatric anesthesia. The overall mean score for this dimension was 4.45 (SD = .402) , indicating a high level of self-reported adherence to safety protocols and risk prevention strategies. This score is comparable to the knowledge dimensions (ranging from 4.14 to 4.56)

and substantially higher than the Complications Incidence dimension (3.84), suggesting that anesthesiologists place strong emphasis on preventive safety measures.

The highest mean score in this dimension—and indeed one of the highest across all study items—was for item 5, "I personally verify the readiness of the oxygen source and suction apparatus before starting each case" (Mean = 4.82, SD = .428) . This exceptionally high score, approaching "Always," reflects an ingrained safety culture and recognition that equipment failure can have catastrophic consequences, particularly in pediatric patients who have minimal physiological reserve. The remarkably low standard deviation (.428) indicates near-universal consensus on this practice, suggesting that pre-induction equipment checks are a standardized and non-negotiable component of anesthesia practice in these hospitals.

Item 3, "I accurately document any adverse events or complications that occurred during anesthesia in the patient's file" (Mean = 4.54, SD = .697) , scored very high, demonstrating strong commitment to accurate medical record-keeping. Proper documentation is essential for continuity of care, medicolegal purposes, and quality improvement initiatives. The relatively low standard deviation suggests consistent documentation practices across the sample.

Item 2, "I monitor the child in the Post-Anesthesia Care Unit (PACU) until vital signs are completely stable before allowing discharge" (Mean = 4.46, SD = .743) , reflects appropriate attention to the critical recovery phase. Pediatric patients are particularly vulnerable to airway obstruction, respiratory depression, and hemodynamic instability in the immediate postoperative period, making thorough PACU monitoring essential for patient safety.

Item 1, "I maintain the child's normal temperature using warming devices to prevent metabolic complications and delayed recovery" (Mean = 4.38, SD = .969) , and item 6, "I adhere to sterilizing instruments and using single-use items (e.g., breathing circuits) to prevent infection transmission to the child" (Mean = 4.38, SD = .840) , both scored highly, though with larger standard deviations indicating some variability in practice. Perioperative hypothermia in children is associated with increased metabolic demands, coagulopathy, and delayed emergence, while infection prevention is fundamental to patient safety. The slightly lower scores and greater variability for these items may reflect differences in resource availability across hospital settings or varying levels of adherence to protocols.

Learning from Errors

The lowest mean score within this dimension was for item 4, "I review errors that occurred with me or my colleagues with the aim of learning and preventing their recurrence (not for blame)" (Mean = 4.13, SD = .785) . While still indicating a relatively high level of practice (above "Often"), this comparatively lower score suggests that systematic error review and learning from adverse events may be less consistently implemented than other safety practices. This finding is particularly significant given that a "just culture" approach—where errors are investigated for system improvements rather than individual blame—is recognized as essential for organizational learning and safety enhancement. The lower score may reflect workplace cultural factors, time constraints, or the absence of formal morbidity and mortality conference structures in some settings.

The overall dimension mean of 4.45 demonstrates that anesthesiologists in governmental teaching hospitals in Sana'a maintain strong patient safety practices, with particular excellence in pre-induction equipment verification, complication documentation, and PACU monitoring. These behaviors align with international safety standards and reflect a professional commitment to preventing adverse events.

However, the somewhat lower score for systematic error review (item 4) represents an opportunity for improvement. Establishing regular morbidity and mortality conferences, promoting a non-punitive approach to error reporting, and creating structured processes for learning from adverse events could further enhance the safety culture and potentially reduce complication rates.

The high overall safety practices score (4.45) compared to the complication incidence score (3.84) suggests that while anesthesiologists implement robust preventive measures, complications still occur with moderate frequency—a finding consistent with the inherent risks of pediatric anesthesia even in the presence of excellent safety practices. This underscores the importance of continued vigilance, protocol adherence, and organizational learning to further minimize avoidable harm to pediatric patients

Table 7: Descriptive Statistics for Patient Safety and Risk Reduction (N=61)

No.	Item	Mean	Std. Deviation
1.	I maintain the child's normal temperature using warming devices to prevent metabolic complications and delayed recovery.	4.38	.969
2.	I monitor the child in the Post-Anesthesia Care Unit (PACU) until vital signs are completely stable before allowing discharge.	4.46	.743
3.	I accurately document any adverse events or complications that occurred during anesthesia in the patient's file.	4.54	.697
4.	I review errors that occurred with me or my colleagues with the aim of learning and preventing their recurrence (not for blame).	4.13	.785
5.	I personally verify the readiness of the oxygen source and suction apparatus before starting each case.	4.82	.428
6.	I adhere to sterilizing instruments and using single-use items (e.g., breathing circuits) to prevent infection transmission to the child.	4.38	.840
	Overall Dimension (Meann)	4.45	.402

4.1.7. Correlation between Cognitive Level (Knowledge Application) and

The findings reveal a **moderate to strong positive correlation** between anesthesiologists' cognitive level and the Complications Incidence and Response dimension **($\rho = .568$, $p = .001$)** . This correlation is statistically significant at the 0.01 level, indicating that higher cognitive knowledge and its application are associated with increased recognition, reporting, and management of complications.

This relationship can be interpreted in several ways. Anesthesiologists with stronger cognitive foundations may be more vigilant in identifying complications when they occur, more accurate in recognizing subtle signs of physiological deterioration, and more thorough in documenting adverse events. Rather than indicating that higher knowledge leads to more complications, this finding likely reflects that knowledgeable practitioners are better equipped to detect, acknowledge, and respond to complications—an essential attribute for safe practice. The significant positive correlation suggests that cognitive competence enhances situational awareness and complication recognition, which are prerequisites for timely and effective intervention.

Correlation with Patient Safety and Risk Reduction

Similarly, a **moderate positive correlation** was found between anesthesiologists' cognitive level and Patient Safety and Risk Reduction practices **($\rho = .531$, $p = .001$)** . This statistically significant relationship indicates that higher cognitive knowledge is associated with greater adherence to safety

protocols, more consistent equipment verification, better documentation practices, and stronger commitment to infection control and thermoregulation.

This finding aligns with theoretical expectations that knowledge serves as the foundation for safe practice behaviors. Anesthesiologists who possess deeper understanding of physiological principles, pharmacological mechanisms, and risk factors are better positioned to implement preventive measures effectively. The correlation suggests that cognitive competence translates into tangible safety behaviors that reduce the risk of complications before they occur.

Interpretation of Findings

The significant positive correlations between cognitive level and both complication-related dimensions have important implications for clinical practice and patient safety in pediatric anesthesia. The findings suggest that:

1. **Cognitive competence enhances complication recognition:** Higher knowledge levels enable practitioners to identify complications more readily, which is essential for timely intervention. This vigilance may explain why more knowledgeable practitioners report higher complication observation rates—they are simply more attuned to detecting them.
2. **Knowledge translates into preventive action:** The correlation with patient safety practices demonstrates that theoretical knowledge is effectively translated into clinical behaviors that reduce risk and prevent harm.
3. **Both correlations are moderate in strength (ρ ≈ .53-.57):** While statistically significant, these correlations indicate that factors beyond cognitive knowledge also influence complication rates and safety practices. These may include institutional resources, team dynamics, workload, equipment availability, and individual experience levels.
4. **The consistency of findings across both dependent variables:** The similar correlation coefficients for both complication dimensions (.568 and .531) suggest that cognitive level has a balanced relationship with both complication recognition/response and preventive safety practices.

These findings support the central hypothesis of this study: that anesthesiologists' cognitive abilities and knowledge application are significantly associated with both the recognition of complications and the implementation of safety measures in pediatric anesthesia. The results underscore the importance of

continuous education, knowledge reinforcement, and competency assessment as strategies for enhancing patient safety and reducing anesthesia-related complications in children.

The moderate strength of the correlations also highlights the multifactorial nature of patient safety outcomes, suggesting that optimizing cognitive competence should be complemented by improvements in systems, resources, and team processes to achieve the highest levels of safety in pediatric anesthesia practice.

Table 8: Spearman's Correlation between Cognitive Level and Complication-Related Dimensions (N=61)

	Spearman's rho	Cognitive level and application of knowledge)
Complications Incidence and Response	Correlation Coefficient	.568**
	Sig. (2-tailed)	0.001
Patient Safety and Risk Reduction	Correlation Coefficient	.531**
	Sig. (2-tailed)	0.001

4.3. Comparative Analysis of Study Dimensions by Demographic Variables

4.3.1 Differences Based on Gender

Preoperative Knowledge

For the Preoperative Knowledge dimension, male participants demonstrated a slightly higher mean rank (31.27) compared to female participants (29.19). However, this difference was not statistically significant (p = .754), indicating that gender does not influence the level of preoperative knowledge and assessment practices among anesthesiologists in this sample.

Physiological & Pharmacological Knowledge

In contrast, female participants showed a marginally higher mean rank (33.19) than their male counterparts (30.67) in the Physiological & Pharmacological Knowledge dimension. Despite this numerical difference, the p-value (p = .704) far exceeds the conventional significance threshold of .05, confirming that the observed difference is not statistically meaningful and likely attributable to random variation.

Airway Management Knowledge

The mean ranks for Airway Management Knowledge were remarkably similar between genders, with males scoring 30.91 and females scoring 31.63. The extremely high p-value (p = .914) provides strong evidence that there are no gender-based differences in airway management knowledge and practices among the study participants.

Complications Incidence & Response

The largest numerical difference between genders was observed in the Complications Incidence and Response dimension, where female participants achieved a substantially higher mean rank (38.25) compared to males (29.91). Despite this apparent difference, the statistical test yielded a p-value of .210, which does not reach statistical significance. This finding may be influenced by the small number of female participants (n=8), which limits the statistical power to detect true differences even when they exist in the population.

Patient Safety & Risk Reduction

Similarly, female participants demonstrated a higher mean rank (34.88) than males (30.42) in the Patient Safety and Risk Reduction dimension, but this difference was not statistically significant (p = .502). The lack of significance suggests that both male and female anesthesiologists report comparable levels of adherence to safety protocols and risk reduction practices.

Overall Interpretation

The findings consistently demonstrate that **gender is not a determining factor** in anesthesiologists' cognitive knowledge, complication recognition, or safety practices in pediatric anesthesia. All p-values exceeded the .05 threshold, indicating that male and female practitioners report similar levels of competence across all dimensions measured in this study.

Several factors may explain these findings:

1. **Homogeneous training standards:** Both male and female anesthesiologists in governmental teaching hospitals likely undergo similar training programs and adhere to the same professional standards, resulting in comparable knowledge levels.

2. **Professional selection criteria:** Entry into anesthesia training programs and professional practice is based on qualifications and competencies rather than gender, minimizing gender-based differences in clinical knowledge.
3. **Limited sample size of females:** The small number of female participants (n=8, representing only 13.1% of the sample) reduces statistical power to detect potential differences. Future studies with larger, more balanced samples might reveal subtle gender-based differences that could not be detected in the current analysis.
4. **Self-report methodology:** The use of self-reported measures may obscure actual differences in practice, as social desirability bias could influence responses similarly across genders.

Despite these considerations, the current evidence strongly suggests that both male and female anesthesiologists in Sana'a's governmental teaching hospitals possess comparable cognitive abilities and demonstrate similar practices regarding pediatric anesthesia safety and complication management. These findings support the conclusion that patient safety outcomes are likely influenced more by individual competence, training, and experience than by gender per se.

Table9: Mann-Whitney U Test Results for Study Dimensions by Gender (N=61)

Dimension	Gender	N	Mean Rank	P.value
Preoperative Knowledge	Male	53	31.27	.754
	Female	8	29.19	
Physiological & Pharmacological Knowledge	Male	53	30.67	.704
	Female	8	33.19	
Airway Management Knowledge	Male	53	30.91	.914
	Female	8	31.63	
Complications Incidence & Response	Male	53	29.91	.210
	Female	8	38.25	
Patient Safety & Risk Reduction	Male	53	30.42	.502
	Female	8	34.88	

Note: No statistically significant differences were found between males and females across all dimensions ($p > .05$).

The results presented in Table 10 compare the mean ranks of anesthesiologists who participated in specialized courses (Yes, n=51) versus those who did not (No, n=10) across all five study dimensions. The Mann-Whitney U test was employed to determine whether course participation is associated with differences in knowledge, complication recognition, and safety practices.

Preoperative Knowledge

A statistically significant difference was observed in the **Preoperative Knowledge** dimension between anesthesiologists who had participated in specialized courses and those who had not **(p = .035)** . Participants who attended courses demonstrated a substantially higher mean rank (33.10) compared to non-participants (20.30). This finding indicates that course participation is positively associated with enhanced knowledge and practices related to preoperative assessment, including accurate ASA classification, application of fasting guidelines, airway examination for difficult intubation signs, medical history review, checklist preparation, and family communication.

The significant difference in this dimension is particularly noteworthy because preoperative assessment forms the foundation of safe pediatric anesthesia practice. The findings suggest that structured educational interventions effectively enhance anesthesiologists' competencies in this critical area, potentially leading to better risk identification and preparation before anesthetic delivery.

Physiological & Pharmacological Knowledge

For the Physiological & Pharmacological Knowledge dimension, course participants again demonstrated a higher mean rank (32.74) compared to non-participants (22.15). However, this difference did not reach statistical significance **(p = .079)** , though it approached the conventional threshold. The p-value of .079 suggests a trend toward significance that might become statistically meaningful with a larger sample of non-participants. This near-significant finding indicates that course participation may positively influence knowledge of drug dosing, physiological considerations in neonates, emergency drug preparation, syringe labeling, fluid management, and avoidance of high-risk medications.

Airway Management Knowledge

Interestingly, no meaningful difference was found between course participants and non-participants in Airway Management Knowledge, with mean ranks of 31.07 and 30.65 respectively **(p = .945)** . This finding suggests that airway management knowledge—including ETT selection, cuff pressure monitoring, differentiation of laryngospasm and bronchospasm, extubation timing, LMA availability, and capnography use—may be acquired primarily through clinical experience and residency training rather than through specialized courses. Alternatively, it may reflect that airway management is such a fundamental component of anesthesia training that all practitioners, regardless of additional course participation, achieve comparable competency levels.

Complications Incidence & Response

In the Complications Incidence and Response dimension, non-participants actually demonstrated a slightly higher mean rank (32.40) compared to course participants (30.73), though this difference was not statistically significant **(p = .782)** . This finding suggests that course participation is not associated with differences in the frequency of observed complications or in the reported management of events such as desaturation, laryngospasm, bradycardia, emergence agitation, or the application of PALS algorithms. The lack of difference may reflect that complication recognition and response are skills developed through direct clinical experience rather than through didactic instruction.

Patient Safety & Risk Reduction

For the Patient Safety and Risk Reduction dimension, course participants showed a higher mean rank (32.03) compared to non-participants (25.75), but this difference was not statistically significant **(p = .300)** . While the numerical difference suggests a trend toward enhanced safety practices among those who attended courses—including temperature maintenance, PACU monitoring, complication documentation, error review, equipment verification, and infection control—the small sample of non-participants limited the statistical power to detect a significant effect.

Overall Interpretation

The findings from this analysis provide partial support for the value of specialized course participation in enhancing anesthesiologists' cognitive abilities and practices. Specifically:

1. **Significant benefit for preoperative knowledge:** Course participation was associated with significantly higher preoperative knowledge scores, suggesting that structured educational programs effectively enhance competencies in preoperative assessment and preparation.
2. **Trend toward benefit for pharmacological knowledge:** The near-significant finding for physiological and pharmacological knowledge (p = .079) suggests that courses may also contribute to enhanced medication safety practices, though this requires confirmation with larger samples.
3. **No detectable benefit for airway management and complication dimensions:** The lack of significant differences in airway management, complication response, and safety practices may reflect that these competencies are primarily developed through clinical experience rather than courses, or that the small number of non-participants limited statistical power.

4. **Implications for continuing education:** The significant finding for preoperative knowledge supports the continued investment in specialized courses as a means of enhancing specific aspects of anesthesia practice. However, the lack of differences in other dimensions suggests that comprehensive competency development requires a combination of didactic instruction, simulation-based training, and supervised clinical experience.
5. **Sample size considerations:** The small number of non-participants (n=10, representing only 16.4% of the sample) limits the statistical power to detect differences. Future studies with larger, more balanced groups of course participants and non-participants would provide more definitive evidence regarding the impact of continuing education on anesthesia practice.

Overall, these findings suggest that specialized course participation is particularly valuable for enhancing preoperative knowledge among anesthesiologists in Sana'a's governmental teaching hospitals. Given the critical importance of thorough preoperative assessment for pediatric patient safety, these results support the expansion of continuing education opportunities focused on this domain.

Table 10: Mann-Whitney U Test Results for Study Dimensions by Course Participation (N=61)

Dimension	Course Participation	N	Mean Rank	P.value
Preoperative Knowledge	Yes	51	33.10	**.035***
	No	10	20.30	
Physiological & Pharmacological Knowledge	Yes	51	32.74	.079
	No	10	22.15	
Airway Management Knowledge	Yes	51	31.07	.945
	No	10	30.65	
Complications Incidence & Response	Yes	51	30.73	.782
	No	10	32.40	
Patient Safety & Risk Reduction	Yes	51	32.03	.300
	No	10	25.75	

The results presented in Table 11 compare the mean ranks of anesthesiologists across three age groups (Less than 30 years, 30 to 40 years, and 41 to 50 years) for all five study dimensions. The Kruskal-Wallis test, a non-parametric alternative to one-way ANOVA, was employed to determine whether age is associated with differences in knowledge, complication recognition, and safety practices. It is important to note that the 41-50 years age group contained only one participant, which limits the interpretability of findings for this category.

Preoperative Knowledge

For the Preoperative Knowledge dimension, the mean ranks were remarkably similar between the two larger age groups: anesthesiologists under 30 years (31.55) and those aged 30-40 years (30.85). The single participant in the 41-50 years age group demonstrated a substantially lower mean rank (14.00). However, the overall difference across groups was not statistically significant **(p = .613)** , indicating that age does not significantly influence preoperative assessment knowledge and practices among anesthesiologists in this sample.

Physiological & Pharmacological Knowledge

A more notable pattern emerged in the Physiological & Pharmacological Knowledge dimension. Anesthesiologists under 30 years demonstrated the highest mean rank (34.05), followed by those aged 30-40 years (27.26), while the single participant in the 41-50 years group showed a markedly lower mean rank (4.00). This pattern suggests a trend toward decreasing pharmacological knowledge with increasing age, though the difference did not reach statistical significance **(p = .101)** . The p-value approaching the .05 threshold may indicate a potential age-related effect that could become significant with a larger sample of older anesthesiologists.

Airway Management Knowledge

Similar patterns were observed for Airway Management Knowledge, with younger anesthesiologists (under 30 years) showing the highest mean rank (32.89), followed by the 30-40 years group (28.85), and the single older participant (10.50). These differences were not statistically significant **(p = .341)** , suggesting that airway management knowledge remains relatively stable across age groups, though the trend may warrant investigation with larger samples.

Complications Incidence & Response

The Complications Incidence and Response dimension demonstrated a pattern comparable to the pharmacological knowledge dimension. Anesthesiologists under 30 years reported the highest mean rank (34.00), followed by those aged 30-40 years (27.33), with the older participant showing a substantially lower mean rank (4.50). The p-value of .112, while not statistically significant, suggests a trend toward younger anesthesiologists reporting more frequent observation and management of complications. This finding may reflect several possibilities: younger practitioners may encounter more complications due to

less refined preventive skills, they may be more vigilant in recognizing and documenting complications, or they may work in settings with higher-acuity patients.

Patient Safety & Risk Reduction

An interesting pattern emerged in the Patient Safety and Risk Reduction dimension. While anesthesiologists under 30 years demonstrated the highest mean rank among the larger groups (33.04), followed by those aged 30-40 years (26.59), the single participant in the 41-50 years group showed the highest mean rank overall (57.00). This pattern suggests that the oldest anesthesiologist in the sample reported exceptionally strong safety practices. However, with only one participant in this age group, this finding cannot be generalized, and the overall difference across groups was not statistically significant **(p = .125)** .

Overall Interpretation

The findings from this analysis demonstrate that **age is not a statistically significant determinant** of anesthesiologists' cognitive knowledge, complication recognition, or safety practices in pediatric anesthesia within this sample. Several important observations emerge from these results:

1. **Consistent absence of significant differences:** Across all five dimensions, p-values ranged from .101 to .613, all exceeding the conventional .05 significance threshold. This consistency provides strong evidence that age alone does not predict competency levels among anesthesiologists in this setting.
2. **Potential trends warranting further investigation:** Despite the lack of statistical significance, several dimensions (Physiological & Pharmacological Knowledge, Complications Incidence & Response) showed patterns suggesting higher mean ranks among younger practitioners. These trends may reflect:

- **Recency of training:** Younger anesthesiologists may have benefited from more updated educational curricula emphasizing evidence-based pharmacological practices and complication recognition.
- **Practice patterns:** Younger practitioners may work in settings with higher patient volumes or more complex cases, influencing their exposure to complications.
- **Documentation practices:** Age-related differences in documentation thoroughness could influence self-reported complication rates.

3. **Limitations of the age distribution:** The extremely small number of participants in the 41-50 years age group (n=1) severely limits the interpretability of comparisons involving older anesthesiologists. This

participant's exceptionally high score in Patient Safety and Risk Reduction (57.00) and low scores in other dimensions highlight the instability of findings based on single cases.

4. **Clinical implications:** The absence of significant age-related differences suggests that both younger and mid-career anesthesiologists in Sana'a's governmental teaching hospitals maintain comparable knowledge and practice standards. This finding supports the effectiveness of ongoing professional development and the maintenance of competencies throughout anesthesiologists' careers.
5. **Recommendations for future research:** Studies with larger, more balanced samples across all age groups—particularly including more anesthesiologists over 40 years—would provide more definitive evidence regarding age-related patterns in knowledge and practice. Additionally, objective assessments of clinical performance (rather than self-report) might reveal age-related differences not captured in the current study.

Overall, these findings suggest that anesthesiologists' cognitive abilities and safety practices are maintained consistently across age groups in this sample, with no evidence that age significantly impacts the quality of pediatric anesthesia care in Sana'a's governmental teaching hospitals.

Table 11: Kruskal-Wallis Test Results for Study Dimensions by Age (N=61)

Dimension	Age Group	N	Mean Rank	Asymp. Sig.
Preoperative Knowledge	Less than 30 years	37	31.55	.613
	30 to 40 years	23	30.85	
	41 to 50 years	1	14.00	
Physiological & Pharmacological Knowledge	Less than 30 years	37	34.05	.101
	30 to 40 years	23	27.26	
	41 to 50 years	1	4.00	
Airway Management Knowledge	Less than 30 years	37	32.89	.341
	30 to 40 years	23	28.85	
	41 to 50 years	1	10.50	
Complications Incidence & Response	Less than 30 years	37	34.00	.112
	30 to 40 years	23	27.33	
	41 to 50 years	1	4.50	
Patient Safety & Risk Reduction	Less than 30 years	37	33.04	.125
	30 to 40 years	23	26.59	
	41 to 50 years	1	57.00	

The results presented in Table 12 compare the mean ranks of anesthesiologists across four qualification levels: Diploma in Anesthesia/Technician (n=14), Bachelor's Degree in Anesthesia (n=42), Master's Degree in Anesthesia (n=4), and Board Certified/PhD (n=1). The Kruskal-Wallis test was employed to determine whether educational qualifications are associated with differences in knowledge, complication recognition, and safety practices. It is important to note that the Master's and Board Certified/PhD groups contained very small sample sizes, which limits the interpretability and statistical power for detecting significant differences.

Preoperative Knowledge

For the Preoperative Knowledge dimension, mean ranks varied across qualification levels. The single Board Certified/PhD participant demonstrated the highest mean rank (58.00), followed by Diploma holders (32.68), Bachelor's degree holders (30.74), and Master's degree holders (21.13). Despite these numerical differences, the overall comparison was not statistically significant **(p = .287)** . The pattern suggests that the highest qualification level may be associated with enhanced preoperative assessment knowledge, but the extremely small sample size in the advanced qualification groups precludes definitive conclusions.

Physiological & Pharmacological Knowledge

In the Physiological & Pharmacological Knowledge dimension, Bachelor's degree holders showed the highest mean rank among the larger groups (32.75), followed by Diploma holders (29.68) and Master's degree holders (16.13). The Board Certified/PhD participant demonstrated a mean rank of 35.50. These differences were not statistically significant **(p = .324)** , indicating that qualification level does not significantly predict pharmacological knowledge and practices in this sample. The notably lower mean rank for Master's degree holders (16.13) is unexpected and may reflect the small sample size (n=4) and individual variation rather than a true effect of qualification level.

Airway Management Knowledge

A similar pattern emerged for Airway Management Knowledge, with the Board Certified/PhD participant showing the highest mean rank (54.00), followed by Diploma holders (30.93), Bachelor's degree holders (30.65), and Master's degree holders (29.13). These differences were not statistically significant **(p = .618)** , suggesting that airway management competencies are distributed relatively evenly across

qualification levels. This finding may reflect that airway management is a fundamental clinical skill developed through practical experience rather than through formal academic qualifications.

Complications Incidence & Response

The most noteworthy finding in this analysis was observed in the Complications Incidence and Response dimension, where the overall comparison approached statistical significance **(p = .055)** . Diploma holders demonstrated the highest mean rank among the larger groups (39.46), followed by Bachelor's degree holders (28.38) and Master's degree holders (22.13). The Board Certified/PhD participant again showed the highest mean rank (58.00). The p-value of .055, falling just above the conventional .05 threshold, suggests a trend toward significant differences that might become statistically meaningful with larger sample sizes, particularly in the advanced qualification categories.

This near-significant finding raises interesting questions about the relationship between qualifications and complication recognition. The higher mean ranks among Diploma holders compared to Bachelor's and Master's degree holders may reflect that Diploma-level practitioners work in different clinical settings, have different documentation practices, or encounter different patient populations. Alternatively, this finding could be influenced by the small sample sizes in some groups and may not represent a true population difference.

Patient Safety & Risk Reduction: For the Patient Safety and Risk Reduction dimension, mean ranks increased progressively with qualification level: Diploma holders (25.86), Bachelor's degree holders (32.04), Master's degree holders (33.50), and Board Certified/PhD (49.50). While this pattern suggests a positive association between higher qualifications and enhanced safety practices, the differences were not statistically significant **(p = .467)** . The lack of significance is likely influenced by the small sample sizes in the advanced qualification groups and the substantial individual variation within groups.

Overall Interpretation: The findings from this analysis demonstrate that **educational qualifications are not statistically significant determinants** of anesthesiologists' cognitive knowledge, complication recognition, or safety practices in pediatric anesthesia within this sample. Several important observations emerge:

1. **Consistent absence of significant differences:** Across all five dimensions, p-values ranged from .055 to .618, with only the Complications dimension approaching significance. This consistency suggests that qualification level alone does not predict competency among anesthesiologists in this setting.

2. **The near-significant finding for Complications Incidence & Response (p = .055):** This result warrants attention despite not reaching conventional significance thresholds. Several interpretations are possible:

- Diploma holders may work in settings with higher patient acuity or more frequent complications.
- Differences in documentation training or practices may influence reporting rates.
- The finding may reflect a true difference that requires larger samples to detect reliably.
- The small sample sizes in advanced qualification groups may have obscured meaningful patterns.

3. **Patterns in advanced qualification holders:** The Board Certified/PhD participant consistently demonstrated the highest mean ranks across all dimensions, suggesting that the highest level of qualification may be associated with enhanced knowledge and practices. However, with only one participant in this category, this observation cannot be generalized and may reflect individual characteristics rather than qualification effects.
4. **Limitations of qualification distribution:** The small numbers of participants with Master's degrees (n=4) and Board Certification/PhD (n=1) severely limit statistical power to detect differences involving these groups. Future studies with larger, more balanced samples across qualification levels would provide more definitive evidence.
5. **Clinical implications:** The absence of significant qualification-related differences suggests that anesthesiologists at various educational levels in Sana'a's governmental teaching hospitals maintain comparable knowledge and practice standards. This finding supports the effectiveness of on-the-job training, clinical experience, and continuing professional development in maintaining competencies regardless of baseline qualifications.
6. **Recommendations for future research:** Studies with larger samples of advanced qualification holders, objective assessments of clinical performance, and longitudinal designs tracking knowledge and practice changes with additional qualifications would provide valuable insights into the relationship between education and clinical competence.

Overall, these findings suggest that while advanced qualifications may confer some advantages in knowledge and practice, anesthesiologists at all qualification levels in this sample demonstrate comparable competencies in pediatric anesthesia. The near-significant finding for complication recognition among Diploma holders merits further investigation to understand the factors underlying this pattern.

Table 12: Kruskal-Wallis Test Results for Study Dimensions by Qualifications (N=61)

Dimension	Qualification Level	N	Mean Rank	P. Value.
Preoperative Knowledge	Diploma in Anesthesia/Technician	14	32.68	.287
	Bachelor's Degree in Anesthesia	42	30.74	
	Master's Degree in Anesthesia	4	21.13	
	Board Certified/PhD	1	58.00	
Physiological & Pharmacological Knowledge	Diploma in Anesthesia/Technician	14	29.68	.324
	Bachelor's Degree in Anesthesia	42	32.75	
	Master's Degree in Anesthesia	4	16.13	
	Board Certified/PhD	1	35.50	
Airway Management Knowledge	Diploma in Anesthesia/Technician	14	30.93	.618
	Bachelor's Degree in Anesthesia	42	30.65	
	Master's Degree in Anesthesia	4	29.13	
	Board Certified/PhD	1	54.00	
Complications Incidence & Response	Diploma in Anesthesia/Technician	14	39.46	.055
	Bachelor's Degree in Anesthesia	42	28.38	
	Master's Degree in Anesthesia	4	22.13	
	Board Certified/PhD	1	58.00	
Patient Safety & Risk Reduction	Diploma in Anesthesia/Technician	14	25.86	.467
	Bachelor's Degree in Anesthesia	42	32.04	
	Master's Degree in Anesthesia	4	33.50	
	Board Certified/PhD	1	49.50	

The results presented in Table 13 compare the mean ranks of anesthesiologists across three experience levels: Under 5 years (n=39), 5-10 years (n=19), and Over 10 years (n=3). The Kruskal-Wallis test was employed to determine whether years of clinical experience are associated with differences in knowledge, complication recognition, and safety practices. The small sample size in the Over 10 years group (n=3) limits the interpretability of findings for this category.

Preoperative Knowledge

For the Preoperative Knowledge dimension, mean ranks were remarkably similar across experience groups: Under 5 years (30.22), 5-10 years (32.58), and Over 10 years (31.17). The differences were not statistically significant **(p = .891)** , indicating that years of experience do not significantly influence preoperative assessment knowledge and practices. This finding suggests that competencies in preoperative evaluation—including ASA classification, fasting guidelines, airway examination, history

review, checklist preparation, and family communication—are established early in training and maintained consistently throughout anesthesiologists' careers.

Physiological & Pharmacological Knowledge

A more notable pattern emerged in the Physiological & Pharmacological Knowledge dimension. Anesthesiologists with Under 5 years of experience demonstrated the highest mean rank (32.06), followed by those with 5-10 years (30.97), while those with Over 10 years showed a substantially lower mean rank (17.33). Despite this apparent decline with increasing experience, the differences were not statistically significant **(p = .371)** . The low mean rank for the most experienced group (17.33) may reflect the small sample size (n=3) and individual variation rather than a true experience-related effect. However, this pattern could also suggest that more experienced practitioners may rely on established practices rather than updated pharmacological knowledge, or that recency of training among younger anesthesiologists confers advantages in this domain.

Airway Management Knowledge

An interesting U-shaped pattern was observed in Airway Management Knowledge. Anesthesiologists with Over 10 years of experience demonstrated the highest mean rank (35.33), followed by those with Under 5 years (32.32), while those with 5-10 years showed the lowest mean rank (27.61). These differences were not statistically significant **(p = .571)** . The high mean rank among the most experienced group suggests that accumulated clinical experience may enhance airway management competencies, particularly in areas such as ETT selection, cuff pressure monitoring, complication differentiation, extubation timing, and backup planning. However, the lack of statistical significance and small sample size in the Over 10 years group caution against overinterpretation.

Complications Incidence & Response

For the Complications Incidence and Response dimension, mean ranks decreased progressively with increasing experience: Under 5 years (32.46), 5-10 years (28.97), and Over 10 years (24.83). This pattern suggests that less experienced anesthesiologists report observing and managing complications more frequently than their more experienced colleagues. However, these differences were not statistically significant **(p = .639)** . Several interpretations are possible:

- Less experienced practitioners may encounter more complications due to less refined preventive skills.

- More experienced practitioners may have developed skills to prevent complications before they occur.
- Experienced practitioners may be less likely to document or recall complications due to familiarity or workload.
- The small sample size in the Over 10 years group limits statistical power to detect true differences.

Patient Safety & Risk Reduction

The only statistically significant finding in this analysis was observed in the Patient Safety and Risk Reduction dimension **(p = .040)** . Anesthesiologists with Over 10 years of experience demonstrated the highest mean rank (51.83), followed by those with Under 5 years (32.18), while those with 5-10 years showed the lowest mean rank (25.29).

This significant finding indicates that years of experience are associated with differences in safety practices, including temperature maintenance, PACU monitoring, complication documentation, error review, equipment verification, and infection control. The exceptionally high mean rank among the most experienced group (51.83) suggests that accumulated clinical experience enhances adherence to safety protocols and risk reduction strategies. Several factors may explain this finding:

1. **Wisdom and judgment developed through experience:** Veteran anesthesiologists may have personally encountered or witnessed adverse events that reinforced the importance of rigorous safety practices.
2. **Pattern recognition and anticipation:** Experienced practitioners may be better able to anticipate potential problems and implement preventive measures proactively.
3. **Role modeling and teaching responsibilities:** Senior anesthesiologists often serve as teachers and supervisors, which may heighten their attention to safety protocols as they model best practices for trainees.
4. **Comfort with uncertainty:** Experience may confer greater comfort with clinical uncertainty, allowing practitioners to focus more attention on safety checks rather than being distracted by anxiety about technical performance.

The lower mean rank among practitioners with 5-10 years of experience (25.29) compared to those with Under 5 years (32.18) is noteworthy. This pattern may reflect a "mid-career dip" in safety vigilance, where practitioners have gained enough confidence to become more efficient but have not yet accumulated the wisdom that comes with extended experience. Alternatively, this group may work in settings with different patient populations or resource availability.

Overall Interpretation

The findings from this analysis demonstrate that **years of experience are significantly associated with Patient Safety and Risk Reduction practices** but not with other knowledge dimensions. Several important observations emerge:

1. **Experience matters for safety practices:** The significant finding for Patient Safety and Risk Reduction ($p = .040$) suggests that accumulated clinical experience enhances anesthesiologists' commitment to and implementation of safety protocols. This has important implications for workforce planning, mentorship programs, and the value of retaining experienced practitioners.
2. **Knowledge dimensions are experience-invariant:** The absence of significant differences in preoperative, pharmacological, and airway management knowledge across experience groups suggests that these fundamental competencies are established early and maintained consistently throughout anesthesiologists' careers. This finding supports the effectiveness of basic training and continuing education in maintaining knowledge standards.
3. **The value of experienced practitioners:** The exceptionally high mean rank for safety practices among the most experienced group (51.83) highlights the unique contributions of veteran anesthesiologists to patient safety culture. Their expertise in risk reduction may be difficult to quantify through traditional knowledge assessments but is clearly valuable for clinical outcomes.
4. **Limitations of the experience distribution:** The small number of participants with Over 10 years of experience ($n=3$, representing only 4.9% of the sample) limits the generalizability of findings for this group. Future studies with larger samples of experienced anesthesiologists would provide more robust evidence.
5. **Clinical implications:** These findings suggest that while basic knowledge competencies are maintained across experience levels, the development of safety practices may require sustained clinical exposure and the accumulation of practical wisdom. Mentorship programs pairing less experienced practitioners with senior colleagues may accelerate the development of safety competencies.
6. **Recommendations for future research:** Longitudinal studies tracking changes in knowledge and practices as anesthesiologists gain experience would provide valuable insights into the development of clinical expertise. Additionally, objective measures of safety practices and complication rates would complement self-report data.

Overall, these findings highlight the unique contribution of clinical experience to patient safety practices in pediatric anesthesia, while confirming that fundamental knowledge competencies are well-maintained across all experience levels in Sana'a's governmental teaching hospitals.

Table 13: Kruskal-Wallis Test Results for Study Dimensions by Years of Experience (N=61)

Dimension	Experience Level	N	Mean Rank	Asymp. Sig.
Preoperative Knowledge	Under 5 years	39	30.22	.891
	5-10 years	19	32.58	
	Over 10 years	3	31.17	
Physiological & Pharmacological Knowledge	Under 5 years	39	32.06	.371
	5-10 years	19	30.97	
	Over 10 years	3	17.33	
Airway Management Knowledge	Under 5 years	39	32.32	.571
	5-10 years	19	27.61	
	Over 10 years	3	35.33	
Complications Incidence & Response	Under 5 years	39	32.46	.639
	5-10 years	19	28.97	
	Over 10 years	3	24.83	
Patient Safety & Risk Reduction	Under 5 years	39	32.18	**.040***
	5-10 years	19	25.29	
	Over 10 years	3	51.83	

The results presented in Table 14 compare the mean ranks of anesthesiologists across three work locations: Military Hospital (n=21), Republican Hospital (n=21), and Other locations (n=19). The Kruskal-Wallis test was employed to determine whether the hospital setting is associated with differences in knowledge, complication recognition, and safety practices. The relatively balanced distribution across locations (approximately one-third each) provides a robust basis for comparison.

Preoperative Knowledge

For the Preoperative Knowledge dimension, anesthesiologists at the Republican Hospital demonstrated the highest mean rank (35.33), followed by those at the Military Hospital (30.26), while practitioners at Other locations showed the lowest mean rank (27.03). Despite these numerical differences, the overall comparison was not statistically significant **(p = .318)** . This finding suggests that preoperative

assessment practices—including ASA classification, fasting guidelines, airway examination, history review, checklist preparation, and family communication—are relatively consistent across hospital settings in Sana'a.

Physiological & Pharmacological Knowledge

A statistically significant difference was observed in the **Physiological & Pharmacological Knowledge** dimension across work locations **(p = .035)** . Anesthesiologists at the Republican Hospital demonstrated the highest mean rank (37.26), followed by those at the Military Hospital (31.90), while practitioners at Other locations showed the substantially lower mean rank (23.08).

This significant finding indicates that work location is associated with differences in pharmacological knowledge and practices, including weight-based drug dosing, consideration of physiological differences in neonates, emergency drug preparation, syringe labeling, fluid management, and avoidance of high-risk medications. Several factors may explain this variation:

1. **Resource availability:** Republican and Military Hospitals may have better access to up-to-date pharmacological references, dosing calculators, and pediatric-specific drug formulations.
2. **Continuing education opportunities:** These hospitals may offer more frequent educational activities, grand rounds, or workshops focusing on pediatric pharmacology.
3. **Case volume and diversity:** Differences in patient populations and case mix across locations may influence exposure to various pharmacological scenarios and reinforce knowledge through practice.
4. **Protocol standardization:** Some hospitals may have implemented standardized protocols for drug dosing and preparation that enhance consistent practice.
5. **Supervision and mentorship:** The presence of senior specialists or academic faculty at certain locations may promote knowledge sharing and skill development.

The substantially lower mean rank at Other locations (23.08) compared to the two major hospitals (31.90 and 37.26) suggests that anesthesiologists working outside the main military and republican hospitals may have less access to resources, training, or clinical experiences that support pharmacological knowledge in pediatric anesthesia. This finding has important implications for equitable professional development and patient safety across all healthcare settings in Sana'a.

Airway Management Knowledge

An interesting pattern emerged in Airway Management Knowledge, with anesthesiologists at the Military Hospital demonstrating the highest mean rank (37.02), followed by those at the Republican Hospital (28.10) and Other locations (27.55). While these differences were not statistically significant **(p = .150)** , the substantially higher mean rank at the Military Hospital suggests a trend toward enhanced airway management competencies in this setting. This pattern may reflect:

- Specialized training or protocols at the Military Hospital
- Differences in patient populations or case complexity
- Greater availability of advanced airway equipment
- Emphasis on trauma and emergency airway management

Complications Incidence & Response

For the Complications Incidence and Response dimension, anesthesiologists at the Republican Hospital again demonstrated the highest mean rank (34.79), followed by those at the Military Hospital (31.83), while practitioners at Other locations showed the lowest mean rank (25.89). These differences were not statistically significant **(p = .268)** , suggesting that complication recognition and response practices are relatively consistent across locations. However, the pattern of lower mean ranks at Other locations may warrant attention, as it could indicate differences in:

- Vigilance and complication detection
- Documentation practices
- Access to monitoring equipment (e.g., capnography)
- Support systems for managing complications

Patient Safety & Risk Reduction

In the Patient Safety and Risk Reduction dimension, anesthesiologists at the Military Hospital demonstrated the highest mean rank (34.45), followed by those at the Republican Hospital (29.48) and Other locations (28.87). These differences were not statistically significant **(p = .534)** , indicating that safety practices—including temperature maintenance, PACU monitoring, complication documentation, error review, equipment verification, and infection control—are generally consistent across hospital settings.

Overall Interpretation

The findings from this analysis demonstrate that **work location is significantly associated with Physiological & Pharmacological Knowledge** but not with other knowledge dimensions or practice areas. Several important observations emerge:

1. **Location matters for pharmacological knowledge:** The significant finding for Physiological & Pharmacological Knowledge ($p = .035$) suggests that anesthesiologists at different hospitals have varying levels of pharmacological expertise in pediatric anesthesia. This has important implications for medication safety, as accurate dosing and appropriate drug selection are critical for preventing adverse events in children.
2. **Republican Hospital as a center of excellence:** The consistently highest mean ranks at the Republican Hospital across multiple dimensions (Preoperative Knowledge, Physiological & Pharmacological Knowledge, Complications Incidence & Response) suggest that this institution may serve as a center of excellence for pediatric anesthesia in Sana'a. Factors contributing to this pattern may include:

- Academic affiliation and teaching mission
- Concentration of specialist expertise
- Access to resources and equipment
- Standardized protocols and quality improvement initiatives

3. **Military Hospital strengths in airway management:** The highest mean rank for Airway Management Knowledge at the Military Hospital (37.02) suggests particular strengths in this domain, possibly related to trauma care expertise or specific training programs.
4. **Disparities affecting Other locations:** The consistently lower mean ranks at Other locations across most dimensions—particularly the significantly lower score for Physiological & Pharmacological Knowledge—suggest potential disparities in resources, training opportunities, or professional support for anesthesiologists working outside the main military and republican hospitals. This finding merits attention from healthcare administrators and professional organizations.
5. **Clinical implications:** These findings highlight the importance of:

- Ensuring equitable access to continuing education across all hospital settings
- Developing standardized protocols for pharmacological practices in pediatric anesthesia
- Facilitating knowledge sharing and collaboration between institutions
- Conducting needs assessments for anesthesiologists at smaller or less-resourced facilities

- Considering tele-mentoring or outreach programs to support practitioners at Other locations

6. **Recommendations for future research:** Studies examining specific factors that contribute to location-based differences—such as resource availability, case volume, continuing education access, and supervision structures—would provide valuable insights for targeted interventions. Additionally, objective assessments of clinical outcomes across locations would complement self-report data.

Overall, these findings reveal important variations in physiological and pharmacological knowledge across work locations in Sana'a's governmental teaching hospitals, with anesthesiologists at the Republican Hospital demonstrating the highest levels and those at Other locations showing relative disadvantages. Addressing these disparities through targeted educational initiatives and resource allocation could enhance the consistency and quality of pediatric anesthesia care across all settings.

Table 14: Kruskal-Wallis Test Results for Study Dimensions by Work Location (N=61)

Dimension	Work Location	N	Mean Rank	Asymp. Sig.
Preoperative Knowledge	Military Hospital	21	30.26	.318
	Republican Hospital	21	35.33	
	Other	19	27.03	
Physiological & Pharmacological Knowledge	Military Hospital	21	31.90	**.035***
	Republican Hospital	21	37.26	
	Other	19	23.08	
Airway Management Knowledge	Military Hospital	21	37.02	.150
	Republican Hospital	21	28.10	
	Other	19	27.55	
Complications Incidence & Response	Military Hospital	21	31.83	.268
	Republican Hospital	21	34.79	
	Other	19	25.89	
Patient Safety & Risk Reduction	Military Hospital	21	34.45	.534
	Republican Hospital	21	29.48	
	Other	19	28.87	

CHAPTE FIVE

CONCLSION and RECOMMENDATION

5.1. Conclusion

Conclusion

The findings of this study reveal that anesthesiologists in governmental teaching hospitals in Sana'a demonstrate a high level of cognitive knowledge across all dimensions of pediatric anesthesia practice. Physiological and pharmacological knowledge, patient safety practices, preoperative assessment, and airway management all showed strong mean scores, indicating sound theoretical foundations and adherence to evidence-based guidelines.

Anesthesiologists exhibited particular strengths in weight-based drug dosage calculation, application of modern fasting guidelines, requesting immediate assistance during difficult airway situations, personal verification of essential equipment, and application of resuscitation algorithms during emergencies. These practices reflect a strong commitment to patient safety and professional competence.

However, several areas requiring improvement were identified. Capnography utilization as a primary standard for verifying ventilation efficiency showed the lowest score among all items, with considerable variability in practice. Additionally, preparation of emergency drug checklists before pediatric cases, systematic review of errors for learning purposes, and optimal timing for extubation to avoid spasms emerged as areas needing attention.

Complications such as desaturation, laryngospasm, bradycardia, and emergence agitation were encountered with moderate frequency in pediatric anesthesia practice, highlighting the ongoing challenges in this field despite strong knowledge foundations.

A significant positive correlation was found between anesthesiologists' cognitive level and both complication recognition and patient safety practices, confirming that higher knowledge is associated with better clinical vigilance and adherence to safety protocols. This finding underscores the critical importance of continuous knowledge enhancement for improving patient outcomes.

Demographic factors such as gender and age showed no significant influence on knowledge or practices, suggesting that professional competence is distributed equitably across these characteristics. However, course participation emerged as a significant factor, with anesthesiologists who attended specialized courses demonstrating higher preoperative knowledge scores and showing trends toward better pharmacological knowledge.

Years of experience significantly influenced patient safety practices, with the most experienced anesthesiologists demonstrating the highest levels of safety protocol adherence. This finding highlights the unique value of accumulated clinical wisdom in promoting patient safety.

Notably, work location was significantly associated with physiological and pharmacological knowledge, with anesthesiologists at the Republican Hospital demonstrating the highest levels and those at other locations showing relative disadvantages. This disparity suggests unequal access to resources, training opportunities, or professional support across different healthcare settings.

Finally, a near-significant trend was observed in complication recognition across qualification levels, suggesting potential differences that warrant further investigation with larger samples of anesthesiologists holding advanced degrees.

Recommendations

Based on these findings, several recommendations are proposed to enhance pediatric anesthesia practice and patient safety.

Regarding clinical practice, mandatory capnography utilization should be established as a standard monitoring modality for all pediatric anesthesia cases, accompanied by training sessions on interpretation and equipment availability. Standardized preoperative checklists specifically designed for pediatric anesthesia should be implemented with regular audits to monitor compliance. Error review systems should be strengthened through regular morbidity and mortality conferences and the establishment of non-punitive incident reporting systems that promote learning rather than blame. Standardized protocols for emergency drug dilution and preparation should be developed, including pre-calculated dosing references for rapid access during emergencies.

In terms of continuing education, specialized course offerings should be expanded and made accessible to anesthesiologists at all hospital locations, with particular emphasis on reaching those at smaller facilities. Targeted training should address identified gap areas including capnography utilization, extubation timing, complication recognition, and systematic error review. Simulation-based training for managing pediatric airway emergencies should be incorporated into regular educational activities. Formal mentorship programs should be established pairing less experienced anesthesiologists with senior colleagues to facilitate the development of safety practices and clinical judgment.

For healthcare institutions and policymakers, location-based disparities must be addressed through needs assessments, equitable resource allocation, and tele-mentoring or outreach programs to support practitioners at smaller facilities. Essential equipment including capnography monitors, warming devices, and appropriate-sized airway equipment should be ensured in all operating rooms. Hospital-wide or region-wide standardized protocols for pediatric anesthesia should be developed and regularly updated based on current evidence. Quality improvement programs should be established with clear indicators for monitoring pediatric anesthesia quality and safety, including regular audits and feedback mechanisms.

Regarding future research, larger studies should be conducted including more anesthesiologists with advanced qualifications and extensive experience to better understand patterns related to these factors. Objective outcome measures should complement self-report data through direct observation, patient record reviews, and measurement of actual patient outcomes. Factors underlying location-based differences should be investigated through qualitative studies examining resource availability, case volume, and access to continuing education. Longitudinal studies tracking changes in knowledge and practices over time would provide valuable insights into professional development patterns. Multi-center research should be expanded to include private hospitals and facilities outside Sana'a to identify regional variations requiring targeted interventions.

For patient safety culture, open communication should be promoted, encouraging team members to speak up about safety concerns without fear of retribution. Family-centered care should be strengthened through continued communication with families regarding anesthesia plans and risks, involving parents in preoperative preparation, and providing clear postoperative instructions. Pediatric-specific safety initiatives should be developed, including child-friendly environments in preoperative and recovery areas and ensuring all staff caring for children receive training in pediatric-specific considerations.

In conclusion, implementing these recommendations has the potential to further enhance the safety and quality of pediatric anesthesia care in Yemen, building on existing strengths while addressing identified gaps to achieve even higher standards of safety for children undergoing anesthesia.

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