

## Paediatric anaesthesia safety in low and middle income countries

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### INTRODUCTION

Low- and middle-income countries (LMICs) make up 63% of the world's 218 countries.<sup>1</sup> Many of these LMICs are in Africa, Asia, and Latin America. Children constitute almost half of the population in many LMICs;<sup>2</sup> and therefore, present a large proportion of surgical and anaesthesia workload in LMICs.

A prevalence rate of 35% for surgically correctable conditions in children has been extrapolated to suggest that 2.9 million children in LMICs will require surgery and anaesthesia in their lifetime.<sup>3</sup> That prevalence number may be low, however, as there are 1.7 billion children worldwide who do not have access to surgical care. Nearly two-thirds of these children live in LMICs.<sup>4</sup> Many children present late for surgical care due to inadequate perinatal diagnosis; cultural, societal and religious beliefs; long travel distances; impoverishment; and lack of proper health insurance.<sup>5</sup> These disadvantages put them at risk of having poorer health outcomes in general.

Safety in anaesthesia means more than the absence of mortality. It also includes both avoidable and unavoidable morbidity. Outcome measures that determine safety of anaesthesia in children have not been prioritized in many LMIC countries.<sup>6</sup> Safety in children undergoing anaesthesia and surgery in LMICs hinges on timeliness of presentation, adequacy of trained personnel, and availability of appropriate equipment to deliver safe anaesthesia. Besides surgical interventions, sedation services for children are increasingly being provided outside the operating room, especially in specialized teaching hospitals. The safety of these services in children needs to be addressed.

Very few studies focus on outcome of paediatric anaesthesia in LMICs. This may be due to poor data collection, collation and auditing and the lack of safety cultures and fear of reprisals if mistakes are reported. It has been shown that Sub-Saharan Africa has a significantly higher mortality than high

income countries (HICs) for many paediatric surgical conditions.<sup>7</sup> Newton et al<sup>5</sup> demonstrated a 7-day mortality 100 times higher in LMICs compared to HICs. This mortality was associated with high ASA classification (>III), not using a surgical safety checklist, and out-of-normal hours surgery. In 2022 the African Surgical Outcomes Study – Paeds (ASOS-Paeds) collected paediatric anaesthesia and surgical data from many countries across Africa. We await the results of this important study at this time.

This review focuses on educational opportunities; the people resources, skills and density of anaesthesia providers; and how these impact perioperative safety in children. It also discusses equipment and medication needs as well as fasting protocols.

### Education & Training

Many different groups of health professionals provide anaesthesia care to children in unique hospital settings. The paucity of paediatric anaesthesia subspecialty training in LMICs makes it imperative that anaesthesia providers undergo standardised training in clinical services, emergencies and recognition of when to refer. In most residency training programmes, trainees rotate through various aspects of paediatric anaesthesia. These rotations provide them with exposure to the anaesthetic care of children but not in-depth experience in the speciality.<sup>8,9</sup>

Paediatric anaesthesia fellowship programmes exist in various LMICs (Table I). These numbers are insufficient to provide the skilled personnel required for the LMIC populations. Fellowship training differs across countries and continents and is not regulated by any one body.

The Paediatric Anaesthesia Training in Africa (PATA), a new post-fellowship training alliance runs programmes simultaneously in 3 countries in Africa. These programmes have 2 local faculty and receive support from international sources. The PATA alliance is expected to produce leaders and future trainers in paediatric anaesthesia.

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**Table I** – Recognized Paediatric Anaesthesia Post-Residency Training Programmes in LMICs

Body	Country
WFSA*	Asia - 2 Africa -2 Latin America -2 Serbia -1
University of Nairobi	Kenya
PATA**	Nigeria Uganda Zambia
	India (24)8

\*World Federation of Societies of Anaesthesiologists; \*\* Paediatric Anaesthesia Training in Africa

While physicians trained in the full spectrum of anaesthesia are covered by PATA and WFSA, it is imperative that other physicians and non-physician anaesthetists are also trained in paediatric anaesthesia. For example, Smile Train supports a 6-month training program in basic paediatric anaesthesia and cleft care. It does this in conjunction with the West African College of Surgeons. The program is aimed primarily at physicians who have completed a short, 1-year diploma in anaesthesia training but others may also be included.

Short courses such as SAFE Paeds, Managing Emergencies in Paediatric Anaesthesia (MEPA), and Paediatric Advanced Life Support (PALS) should be provided for all anaesthesia providers. These courses teach safe conduct of paediatric anaesthesia; management of common paediatric emergencies; and recognition and immediate provision of care for sick children. Ultimately, these all have the goal of improving safety during paediatric anaesthesia. However, they require sponsorship to ensure they are within the financial capacity of all who provide anaesthesia to children in LMICs. For example, SAFE Paeds is well established in East Africa and has recently commenced in West Africa but needs additional resources to expand further.

Conference workshops and training sessions provide opportunities for discussion and training. E-learning may be the most effective way to reach many providers who are spread far apart geographically. As an example, SAFE Paeds has a modified 2-day virtual learning platform. Telemedicine may also provide communication between local and advanced level health providers for various stages of patient care.<sup>10</sup> Unfortunately, online resources may be problematic in LMICs because of poor internet connectivity.

## PEOPLE RESOURCES

Anaesthesia manpower is progressively dwindling in LMICs. This reduction in workforce has obvious implications for the safe delivery of paediatric anaesthesia.<sup>11</sup>

The physician anaesthesia provider (for adults as well as children) ratio per 100,000 population in most LMICs is extremely low. Few, if any, attain the 20 per 100,000 suggested by The Lancet Commission

on Global Surgery or the interim value of 4 per 100,000 suggested by the WFSA.<sup>12-14</sup> In Nigeria the ratio is estimated to be 0.58 per 100,000 population while 1.51 per 100,000 has been calculated for the southwest Pacific Islands.<sup>15</sup> Many reasons beyond the scope of this article are responsible for this. Hence, in many LMICs, anaesthesia is also provided by non-anaesthesiologists. These personnel vary dramatically in their levels of training and have variable skills and knowledge. This issue particularly impacts the anaesthesia care of children. In some communities in LMICs, there are no anaesthesia trained personnel who are comfortable and skilled at caring for children. In extreme instances, some children are subjected to surgery with local anaesthetics only.

The shortage in paediatric anaesthesia workforce increases the burden of children's diseases and also reduces the number of surgeries that can be done in LMICs. In one review, developing countries accounted for only 6% of the total volume of all surgeries done globally in a year.<sup>12</sup> That same low value applies to paediatric surgery, also.

One of the primary determinants of surgical safety is the presence or absence of skilled anaesthesia personnel. Morbidity and mortality is generally high in countries where the anaesthesia workforce is inadequate. The number of trained paediatric anaesthesiologists in Nigeria is as low as 0.028 per 100,000 paediatric density.<sup>9</sup> This value is 0.023 in Uganda, 0.038 in Zambia, and 0.11 in Kenya (personal correspondence). The skills and competencies of anaesthesia personnel vary depending on their training and experience. The dearth of paediatric anaesthesia providers leaves the provision of paediatric anaesthesia mostly in the hands of non-qualified anaesthesia personnel. The absence of well-trained physicians in paediatric anaesthesia results in difficulties with handling complex surgical conditions. Children who require optimization or resuscitation prior to surgery may have little chance of survival.

The lack of standardised paediatric anaesthesia training programmes in LMICs significantly affects the numbers trained. Some countries do not have training programmes in anaesthesia; presently, Liberia is training its anaesthesia residents in Nigeria while Gambia has just started a residency training program. Paediatric anaesthetists across LMICs should actively mentor medical students and junior trainees to help increase interest in paediatric anaesthesia.

In many LMICs, there is progressive workforce migration from rural areas to urban districts as poor work and living conditions in rural areas are bringing more specialists towards regional and tertiary hospitals. This is compounded by local workforce emigrating to developed countries (the "brain drain" phenomenon).

Improvement in paediatric anaesthesia safety requires investment in training and training capacity with assessment of needs in terms of numbers and skill required for the health system. Access to continuing professional development, acceptable working conditions, career progression and adequate remuneration are all essential if paediatric anaesthesia workforce development is to be attained and sustained. It is important to establish appropriate metrics to assess paediatric anaesthesia service at a population level. This should be based on prevalence, backlogs to treatment, and disability incurred by treatment delays.

## PREOPERATIVE FASTING

The most commonly used guidelines for preoperative fast recommends intervals of 6, 4, and 2 hours (6–4–2) of fasting for solids, breast milk, and clear fluids. Despite these guidelines, children are often subjected to prolonged fasting before surgery. This predisposes them to avoidable hypoglycaemia and dehydration. As a result, there is often haemodynamic instability, irritability, poor control of pain, postoperative vomiting, and prolonged recovery.<sup>16–18</sup>

A more liberal approach to preoperative fasting in children may enhance favourable postoperative outcomes. That depends, of course, on strong implementation of preoperative fasting guidelines. Sadly, many facilities do not have a good implementation of fasting guidelines for children and prolonged fasts and even dehydration pre-operatively are the norm. More liberal use of clear fluids or carbonated drinks has been recently advocated, right up until the call to surgery. Many factors may lead to a prolonged period of preoperative fast among children in our daily practice (Table II).

There are no well outlined guidelines on what oral intake and quantity should be allowed before surgery in many of the facilities in LMICs.<sup>19</sup> Exactly what constitutes clear fluid may be vague to an uneducated and often anxious mother who will eventually do what she thinks is best for her child.

It is the responsibility of every member of the surgical team to have updated evidence regarding perioperative fasting. Developing local guidelines from contributions from every member will enhance standard practice. Compliance to a standard protocol will not be achieved overnight but with proper education, collaboration, and more local research, achieving an optimum period of preoperative fasting and better outcome in children's surgery is feasible.

## EQUIPMENT & MONITORING

The delivery of safe and effective surgical care to children requires appropriate anaesthesia and monitoring equipment. For anaesthesia providers caring for children in LMICs, the lack of appropriate equipment, and deficiencies in postoperative care are especially difficult.<sup>20</sup>

A study in Niger reported a perioperative critical incidence of 11.7%. Over four-fifths of these occurred during induction of anaesthesia and at the postoperative period. A good number were believed to be avoidable with appropriate monitoring.<sup>21</sup>

Perioperative monitoring is an essential component of anaesthetic care regardless of technique being employed. The continuous presence of a trained anaesthesia provider together with regular clinical assessments with the use of monitoring devices is the recommended standard of monitoring.<sup>22</sup> Oxygenation, ventilation, circulation and temperature are essential parameters being monitored by pulse oximetry, capnography, electrocardiography, arterial blood pressure and appropriate thermometers. Sadly, some of these core components of monitoring are absent during paediatric anaesthesia in many LMICs.

Hospital assessments carried out in Ghana demonstrated marked deficiencies in several essential items including basic airway supplies and blood pressure cuffs.<sup>23</sup> This experience may be similar in other LMICs. The wide range of equipment sizes needed to provide safe, high-quality anaesthesia to children is often absent or lacking in the LMICs.<sup>24</sup> Temperature conservation and blood glucose control are also challenging because of lack of active warming and monitoring devices.<sup>25</sup> Many interventions such as the WHO pulse oximetry project have alleviated to some extent the problem of lack of pulse oximeters in many facilities. Furthermore, the KidsOR and the SmileTrain/KidsOR collaborations have equipped many hospitals in LMICs with functional and equipped theatres for surgery and anaesthesia. This has gone a very long way to reduce healthcare worker frustration, improve surgery turnover, reduce wait times and improve safety of paediatric anaesthesia in these hospitals.<sup>24,27</sup>

To improve this situation, better training of staff in paediatric anaesthesia is essential. Ability to understand the peculiarities of the work environment, and skill to maximize the available equipment and devices will enhance safety. The place of government intervention and commitment of various health institutions to the provision of appropriate sizes of equipment and devices for the paediatric age group cannot be overemphasized. Skilled and efficient biomedical engineering staff will also prevent long periods of equipment breakdown and maximize the effectiveness of available equipment.

## MEDICATIONS- AVAILABILITY AND ERRORS

Availability of medications vary within LMICs and even within countries there are disparities in the anaesthesia medications available. Hospital leaders often look for ways to reduce costs. This extends to anaesthesia practice. Sevoflurane, a useful inhalational agent in the

**Table II** – Perceived Factors and Proposed Solutions to Prolonged Preoperative Fasting

Reason	Proposed solutions
Lack of clear fasting protocol	Establish protocols and train all staff involved.
Lack of clarity of Instruction due to language barrier or poor understanding	Print leaflets or posters in different languages, get interpreters to explain.
Unpredictable time of commencement of surgery; Undefined or unachievable	Establishment of institution protocols and sorting of logistics, insurance cover for children, investment in paediatric surgery by government and institutions.
Unduly delayed surgical start time due to Personnel, equipment or patient factors	Establishment of institution protocols and sorting of logistics, insurance cover for children, investment in paediatric surgery by government and institutions.
Negative influence of nursing staff to tailored fasting guidelines	Education of nursing staff, get them to become champions of proper pre-operative fast.

paediatric population is not widely available due to the perceived notion that it is expensive. Halothane is still the most widely used inhalational agent in some LMICs. Its safety in inexperienced hands is questionable.<sup>28</sup>

Various regulations and prioritization of funds makes the supply of opioids erratic. Common opioids employed are morphine, fentanyl, pethidine and the less potent pentazocine and tramadol, as the newer opioids are usually unavailable. However, remifentanyl is available in countries like Uganda and India. Even when opioids are available, some anaesthetists are wary of administering opioids into the recovery period and thereafter to children, due to fears of respiratory depression especially in a setting of poor monitoring, lack of oxygen and non-availability of naloxone. Sometimes, only paracetamol and an NSAID are administered, which are inadequate for many surgeries.<sup>29</sup>

Suxamethonium is still the muscle relaxant of choice for rapid sequence induction and difficult airway despite its numerous well-known disadvantages. Safer drugs like rocuronium and cis-atracurium, are hardly found in many theatres, while availability of sugammadex is rare.

Medication errors may result in morbidity and even mortality. They are typically underreported in paediatric anaesthesia practice.<sup>30</sup> Reasons include no formal channel for reporting, non-encouragement to report, no action or improvement of systems from those reported, lack of awareness of the importance to report, and fear of punitive action. Medication errors in paediatric anaesthesia vary from 0.04% to 2.6% in LMICs.<sup>31</sup> A survey done in Nigeria revealed that most medication errors were due to incorrect dosing (55%) or incorrect medications given (28%) and 14.8% of anaesthetists reported medication error of at least once a week in children. Medication errors occurred most commonly during a critical event (51.4%) and during an emergency procedure (50%). Top reasons for medication errors were failure to weigh the child (77.9%), haste or insufficient preparation (69%), fatigue (62%), anaesthetist's inexperience (54.2%) and poor team communication (47.9%).<sup>32</sup> Table III suggests opportunities to reduce perioperative medication errors in children.

Reporting of errors or sentinel events needs to be encouraged; unfortunately, reporting is not common in many LMICs. There are no registries and no established protocols for reporting medication errors and therefore, audits of these errors are few. Audits of medication errors will help to determine causes and ways to prevent them, which can lead to better safety in paediatric anaesthesia practice in LMICs.

## REGIONAL BLOCKS

Paediatric regional anaesthesia has many advantages; improved post-operative pain management, early ambulation, reduced length of stay in post-anaesthesia care units, reduced opioid administration and their side effects. Despite these advantages, the use of regional anaesthesia for children in the LMICs is still low in many countries.

Safe paediatric regional anaesthesia requires knowledge, expertise and the provision of appropriate equipment and monitoring compliant with the international standards for a safe practice of anaesthesia. Competency varies across regions with many practitioners adept at caudals and spinals while few are competent in epidurals and nerve blocks. All paediatric regional anaesthetists should be adequately trained to monitor and diagnose complications associated with regional blocks and an appropriate level of postoperative monitoring must be ensured to allow for early detection of any complication.

The deployment of inappropriate devices in paediatric regional anaesthesia frequently occurs with anaesthesia providers resorting to the use of hypodermic needles for central neuraxial block and spinal needles when instituting ultrasound guided peripheral nerve blocks. This can lead to local anaesthetic systemic toxicity (LAST). Unfortunately, the earliest sign of LAST may be difficult to recognize because of paucity of ECG monitoring. The lack of availability of intra-lipid in most centres makes the management of LAST difficult. It is therefore imperative that the maximum allowable LA dose is not exceeded, a test dose is given and incremental administration of the LA employed.

In LMICs, landmark-guided regional anaesthesia techniques are usually deployed for regional blocks because of the paucity of ultrasound scans as well as the lack of expertise in its interpretation. This often requires multiple attempts at needle passes, increased dosage of local anaesthetics, and higher incidences of LAST. It is important to expand the use of image guided techniques to reduce these limitations, as well as ensure adequate training. The high cost of imaging machines continues to be a barrier in many LMIC settings.

Anaesthesia personnel must realize that a regional technique should not be seen as an option to deficient airway skills. Anaesthetists caring for children should be adequately trained and prepared in airway management as most children will either require sedation or general anaesthesia, and some may even require resuscitation.

**Table III** – Suggested ways to Prevent Medication Errors in Paediatric Practice

Medication Error	Suggested Preventions
Overdosing	Weigh patient or use estimated weight, calculate medications carefully
Underdosing	Weigh patient or use estimated weight, calculate medications carefully
Wrong drug	Label correctly, do not place similar drugs side by side
Wrong concentration	Label properly, use pre-formed labels, double check dilution with a colleague.

**Table IV** – Suggested Ways to Improve Postoperative Pain Control

A plan for postoperative pain management should be decided before the end of every surgery
Adoption of pain management protocols
Education of healthcare personnel to create awareness
Availability of the right analgesic medications
Anaesthetists who administer paediatric anaesthesia should learn basic regional blocks
Anaesthetists who administer paediatric anaesthesia should be conversant with analgesic medications

## POSTOPERATIVE PAIN

In many LMICs anaesthesia personnel focus on the immediate postoperative pain management while pain management on the postoperative ward is essentially handled by the surgeons. Reasons for lack of involvement of anaesthesia personnel in postoperative pain management are inadequate manpower, long surgical lists, disinterest, the lack of availability of devices/ consumables and equipment such as patient controlled analgesia devices, epidural kits, and syringe pumps.

Lack of medications, equipment and consumables, especially specific to children, is a huge deterrent to effective postoperative pain management. Many times the choice of analgesics is limited. Even when medications like opioids are available, they are often underdosed or not administered at all due to fear of adverse effects like respiratory depression because there are too few ward nurses to do proper observation and to little appropriate monitoring available. In some hospitals, postoperative analgesics are still being administered intramuscularly as many believe the side effects to be less. The incidence of poorly managed postoperative pain in children in LMICs is high.<sup>33</sup>

Poor intraoperative pain management makes postoperative pain management more challenging and can also lead to chronic pain. The detrimental effects in children include brain changes, anxiety, depression, poor academic performance, anti-social behaviour and future risk of opioid dependence.<sup>34</sup> The techniques and medications used to prevent/ control pain intraoperatively are important and can be extended into the postoperative period. Rectal administration of paracetamol and diclofenac should be encouraged instead of the intramuscular route.

Regional anaesthesia has been shown to improve postoperative pain management and reduce postoperative pain scores. Incorporation of regional anaesthesia in paediatric anaesthesia practice is one way to improve postoperative analgesia. Simple techniques like caudal block and some peripheral nerve blocks can be incorporated into the anaesthetic plan and provide long duration of analgesia well beyond the immediate postoperative period.

The importance of good postoperative pain control has to be emphasised to Paediatric anaesthetists and generalists who practice paediatric anaesthesia. Future surgeries may be traumatic for children from bad surgical pain experience, and this should be avoided. Table IV suggests opportunities to improve postoperative pain control in children.

## CONCLUSION

Many factors compromise delivery of safe anaesthesia to children in LMICs. While some of these such as education and training can be more readily accomplished, support and advocacy by institutional, political, and governmental agents are essential for long-term sustained goals.

Anaesthesia standards for children should be developed in the LMICs with appropriate outcome measures as safety indices. Safety in children should not only be reflected in mortality figures but all critical incidents and morbidities should be recorded and used as instruments to identify immediate and remote causes, plan and execute appropriate intervention in order to improve paediatric patient safety in anaesthesia.

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