Pediatric anesthesia in developing countries
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Purpose of review
To highlight the problems faced in developing countries where healthcare resources are limited, with particular emphasis on pediatric anesthesia.

Recent findings
The fact that very few publications address pediatric anesthesia in the developing world is not surprising given that most anesthetics are provided by nonphysicians, nurses or unqualified personnel. In compiling this article information is drawn from pediatric surgical, anesthetic and related texts. In a recent survey more than 80% of anesthetists in a poor country acknowledged that with the limited resources available, they could not provide basic anesthesia for children less than 6 years. Although many publications could be regarded as anecdotal, the similarities to this survey suggest that the lack of facilities is more generalized than we would like to believe.

Summary
The real risk of anesthesia in comparison to other major health risks such as human immunodeficiency virus, malaria, tuberculosis and trauma remains undetermined. The critical shortage of manpower remains a barrier to progress. Despite erratic electrical supplies, inconsistent oxygen delivery, paucity of drugs or equipment and on occasion even lack of running water, many provide life-saving anesthesia. Perioperative morbidity and mortality is, however, understandably high by developed world standards.

Keywords
anesthesia, developing countries, human immunodeficiency virus, pediatric

Introduction
Defining the developing world in terms of anesthesia practice is difficult. Economists classify countries according to national income, expressed as per capita gross national product. In general, the lower the gross national product, the poorer the health of the nation.

Countries can also be defined according to the Human Development Index, which ranks the average human development in each country on the basis of life expectancy, literacy and gross domestic product, i.e. measures of health and quality of life [1]. The developing world thus defined falls into the medium and low categories of human development.

Though in terms of anesthesia, particularly pediatric anesthesia, one could argue that the divide is not as clear-cut. The reason being that even in some remote rural areas in some high Human Development Index affluent countries the provision of anesthesia for children may fall below the level expected in some institutions of the developing world.

The purpose of this paper is to highlight some of the problems faced in areas where anesthesia resources are limited. Generalizations are made from information gleaned from recent publications that in many cases are remarkably similar to previous publications from decades past. The indication is that little has changed or improved except where the changes for large part are driven by individuals at specific institutions.

The reality
Many developing countries have a colonial history and were exploited for their raw material. The infrastructure was developed for the benefit of the colonial power and not the country or region [1,2**]. As a result many of these countries are today characterized by poverty, poor housing and educational standards, and limited health resources and social services [1,2**,3*]. Of the world's poorest countries, 70% are in sub-Saharan Africa, an area ravaged by human immunodeficiency virus (HIV), malaria and tuberculosis. Although we as anesthesiologists would prefer otherwise, anesthesia services, let alone pediatric anesthesia, are not considered a major healthcare issue.

Nevertheless, children constitute more than half the population in many countries of the developing world [2**]. Many become victims of circumstance – orphaned
by HIV [4*], natural disasters, war, social unrest, economic crises and famine. Furthermore, it is estimated that 85% of children will require surgery of some sort before their 15th birthday [5]. Congenital anomalies, trauma (road traffic accidents, assaults, falls, burns, bites, fractures) and infections (abscess, osteomyelitis) make up the bulk of the surgical workload [6**,7**,8]. Burns, particularly in young children, impact on the resources in many developing countries [9*], but especially in sub-Saharan Africa [10**].

For many, medical care, or timely access thereto, is a remote or even nonexistent possibility [9*,10**]. Fear, lack of understanding and poor education often result in delayed presentation [6**,11]. Frequently, well-meaning traditional healers or bonesetters are the first to be consulted, exposing the child to additional risk [7*,9*,10**,12*]. Further delays are engendered when patients have to undertake long journeys to hospital. As a result dehydration, infection and sepsis, and complications compound the surgical problem and the anesthetic risk.

Access to safe anesthesia and pain relief during surgery could be considered a basic human right in the 21st century [13**,14*]. International standards for the safe practice of anesthesia [15], adopted by the World Federation of Societies of Anesthesia in 1992, are seldom met. Application of international cardiopulmonary resuscitation guidelines is poor because of the lack of organized training [16]. In a recent survey only 13% of Ugandan anesthetists acknowledged that they had the necessary prerequisites to provide anesthesia for children less than 5 years [13**]. In this survey the minimal requirements for anesthesia were an oxygen supply, suction apparatus, a pulse oximeter, a tilting table, a pediatric breathing circuit, a laryngoscope, facemasks, endotracheal tubes, oropharyngeal airways and intravenous cannulae suitable for use in children [13**]. Implausible as these findings may seem to those who have not experienced the austere conditions in some parts of the developing world, many anecdotal reports, both recent and in the past, bear witness to this stark reality.

The challenge

Much of our understanding of anesthesia in the developing world is based on these anecdotal reports or personal experience. Those reports provided by local healthcare workers or visitors on medical missions over the past few decades are remarkably similar. Nonetheless the challenges faced by anesthetists in Nigeria [7*,17,18*,19*,20] Tanzania [6**] and Uganda [13**] are vastly different to those in Iraq [21], Afghanistan [21], Congo [22], Mongolia [22], Ghana [23,24], West Indies [25,26], Guatemala [27], Sudan [11] or Malawi [28]. Some generalizations have been made bearing in mind that conditions may vary even in parts of the same country.

Anesthesia does not enjoy a high profile in developing countries and lacks the voice to demand access to resources. The critical shortage of manpower is a further barrier to progress [9*]. Emigration of scarce trained personnel to developed countries in search of better salaries and an improved lifestyle exacerbates these human resource difficulties [2*,9*,20]. In many African and Asian countries the doctor/patient ratio is so low [1,2**] that the ideal of employing a physician specifically to provide routine anesthesia is invariably out of the question. Most anesthetics are provided by nonphysicians, nurses under the direction of a surgeon or unqualified personnel, with little medical background and 'trained on the job' [11,13**,21]. Access to textbooks, journals or other medical literature is limited [13**]. Internet access, considered the norm in the developed world, is limited given that functional computers are scarce, and electrical supplies and telecommunication networks are unreliable.

Despite erratic electrical supplies, inconsistent oxygen delivery, paucity of up-to-date drugs and equipment, and on occasion even lack of running water [13**], many provide life-saving anesthesia. Few have received formal training in pediatric or neonatal anesthesia. Inadequately trained anesthetists tend to shy away from children, particularly neonates and infants, because of fear and the perceived difficulty. This is understandable in view of the lack of supervision, the severity of the patient's condition and equipment that is more suited for adults. The pediatric anesthesiologist per se is a luxury.

Dealing with the issues

Perioperative morbidity and mortality is understandably high by developed world standards [17,29*]. Facilities considered mandatory for the surgical care of children, such as the provision of adequate analgesia, a recovery area for immediate postoperative observation, ventilatory support or high care following surgery [6**], are inadequate or nonexistent in many parts of the developing world. In some countries pediatric surgery is even considered too expensive to justify these additional needs [6**].

Syringe pumps and other control devices are impractical in environments that have an erratic electricity supply. Endotracheal tubes in the full pediatric range are rarely found and are invariably recycled as there is no other option. Small intravenous cannulae are a precious commodity and butterfly needles are still used (and in some cases re-used!) [10**]. The choice of intravenous fluid is often limited and in short supply [9*,10**]. General facilities for infection control, such as running water, disinfectants or gloves, are not always available even though the re-use of disposable equipment such as endotracheal tubes is normal practice in many institutions [13**].
All these factors have a negative impact on outcome. There is precious little information on the anesthesia morbidity or mortality in developing countries [29]. Fisher et al. [30] reported on the incidence of anesthesia-related problems seen by volunteer services working over 18 months, which reflects the quality assurance data of trained anesthesia providers working in the developing countries. It is likely to be vastly different to the reality. We do not, however, have any idea of the incidence of problems associated with anesthesia provided by nonphysicians, nurses or unqualified personnel 'trained on the job'. In some areas, however, even today, neonatal surgery may be performed without anesthesia [25] or simply under local infiltration only [17,31] in an attempt to improve outcome. Understandably, late presentation, respiratory failure, infection or anesthetic complications [18] are still the major contributors to a poor outcome.

Regional anesthesia may provide the solution to some of these problems and may be the only choice in some situations. Apart from providing analgesia without respiratory depression, the need for postoperative ventilatory support for conditions such as esophageal atresia [32], congenital diaphragmatic hernia [33] and abdominal wall defects [34] is reduced. Unfortunately, lack of expertise, lack of equipment (insulated needles, epidural kits, local anesthetic drugs) and resistance from some surgeons [17] limits the advantages offered by regional anesthesia.

Young anesthetists trained in the developed world are at a disadvantage when faced with the challenges of anesthesia in the developing world [30,35,36]. They may be unfamiliar with equipment or outdated drugs that are still used in a particular location [17]. They may never have seen draw-over vaporizers such as the Epstein Macintosh Oxford or Oxford Miniature Vaporizer [27,30] nor trained in the use of ether or halothane anesthesia. Ether and halothane remain the mainstay of inhalational anesthesia in many countries. Unfortunately, ether, and more recently halothane, have virtually disappeared from the operating rooms in the developed world. As a result the demand for these cheaper agents has fallen and lack of profitability claimed by some manufacturers has threatened the withdrawal of halothane [13**]. While this may make commercial business sense, these agents sustain the anesthesia services for millions of patients in the developing world and their loss would have a huge impact [13**].

Similarly, in those institutions where a fiber-optic bronchoscope is available, its use has been over-emphasized for the management of the difficult airway. As a result the art of airway management in the absence of fiber optics may be lost. Blind nasal intubation, with or without a gum elastic bougie [36], remains a valuable technique to overcome the many airway challenges encountered in the developing world.

In many remote rural areas anesthesia for children remains largely ketamine based [15**,17,18*] even when halothane or ether is available. This is dictated by its ease of use, lack of airway equipment such as tracheal tubes, facemasks or breathing circuits and the perception that intravenous access is not necessary or that intravenous cannulae are simply not available [12*,13**].

Other drugs considered basic to anesthesia are seldom available in the developing world. These include induction agents (propofol), neuromuscular blocking agents, analgesics (morphine, pethidine), reversal agents (neostigmine, naloxone) and long-acting local anesthetics (bupivacaine, ropivacaine). The ability to deal with complications, such as malignant hyperthermia, is virtually impossible.

**Human immunodeficiency virus/acquired immunodeficiency syndrome**

Each year 750,000 children acquire HIV infection mainly by mother-to-child transmission [37*]. By the end of 2003 an estimated 40 million people were living with HIV, mostly in the developing world (90%), with sub-Saharan Africa (26 million) and South East Asia (7.5 million) making up more than 75% of the global total. Six percent are children less than 15 years of age [37*]. More than 25 million have died of acquired immunodeficiency syndrome since 1981; as a consequence, there are an estimated 12 million orphans in Africa alone [4*]. This places a huge health and economic burden on countries that can least afford it.

In countries where antiretroviral prophylaxis, elective Caesarean section and refraining from breastfeeding can be applied, vertical transmission of below 2% is being reported [37*]. This success in slowing down the transmission of HIV has been achieved in developed countries [37*,38,39]. In the developing world there are numerous barriers to the treatment of HIV-infected children. Treatment of children has lagged behind that of adults, partly because of the expense, partly the lack of pediatric antiretroviral drug formulations, but mainly due to the paucity of human resources and infrastructure for administration of treatment [40].

Children can be infected by vertical transmission from the mother (more than 90%) or when sexually abused (around 2%) by an infected adult [41]. Transmission via blood products remains a risk, but with the global trend towards volunteer donors and more sophisticated testing of blood, this risk is expected to diminish.

Mortality among children born to HIV-infected mothers in sub-Saharan Africa is substantially higher than those born to noninfected mothers [37*]. Approximately 35% of infected infants die within 1 year and 53% by 2 years,
compared to 5–7.5% of uninfected children [37*]. Even if the mother survives and infection in the child is prevented there would still be a greater risk of dying for these children of HIV-infected mothers [37*].

Differentiating those infants who are infected by vertical transmission from those who are not infected presents a difficult dilemma because one cannot easily differentiate between actively or passively acquired antibodies. All children born to HIV-positive mothers will have acquired HIV antibody for the first 6–18 months. The presence of HIV antibody is therefore not a reliable indicator of infection. More sophisticated expensive tests have been developed, but are not yet widely available. All children born to HIV-positive mothers therefore should be considered potentially infected; if antibody persists beyond 15 months, infection should be assumed.

The prevalence of HIV seropositivity varies from one country to another. In Africa, particularly in sub-Saharan Africa, it may be as high as 40%. In this environment it is prudent for both anesthetist and surgeon to assume a positive status in every patient until proven otherwise [21].

**Children and war**

The magnitude of violence to which we are exposed in our daily lives could also be considered a factor in distinguishing between developed and developing countries. Inevitably anesthetists are involved in the management of the victims and perpetrators of the violence. Children, unfortunately, may be victims of all aspects of violence; they face an intense struggle for survival as a consequence of displacement, separation from or loss of parents, poverty, hunger and disease. They are vulnerable to the abuse of abandonment, abduction, rape and forced soldiering. An estimated 300,000 children are currently being used as child soldiers in over 30 countries [42,43]. Many sustain physical injuries and permanent disabilities, whilst a large number acquire sexually transmitted diseases including HIV/acquired immunodeficiency syndrome. These HIV-positive soldiers become vectors in communities where they are deployed [42].

For many of these children acts of violence become a form of normality, the former victims becoming the perpetrators [43]. Survivors are subjected to the total collapse of economic, health, social and educational infrastructures. Lost and abandoned children sleep on the streets, and are forced to beg for food while trying to find their families. Many become child laborers or turn to crime or prostitution for survival [42,43].

Children in war-torn areas sustain bullet, machete or shrapnel wounds, while others are burned – mutilating injuries that are not commonly seen in civilians [42–44]. Landmines are responsible for killing or maiming an estimated 12,000 civilians per annum. In Angola, a country with the highest rate of amputees in the world, there were an estimated 5,5 landmines for every child. Continuing landmine explosions remain a chronic legacy of that conflict [43]. These blast injuries leave children without feet or lower limbs, with genital injuries, blindness and deafness – a pattern of injury that has become a post-civil war syndrome encountered by surgeons worldwide [43]. Although the war is essentially over, the cost of landmine removal is beyond the means of local governments. Ironically artificial limb manufacture has become a developing industry [43].

The terrible psychological effects of war also persist even though the armed conflict may be over. Mental and psychiatric disorders with all the ramifications of post-traumatic stress disorder are common amongst child survivors.

**Blood safety**

The availability of safe blood is another factor dividing the developed world from the developing world. Blood transfusion services, if they exist, aim to provide a life-saving service by ensuring an adequate supply of safe blood. An estimated 70% of all blood transfusions in Africa are given to children with severe anemia caused by malaria [12*]. Patients, particularly children, in developing countries face the greatest risks from unsafe blood and blood products [12*,45,46].

Fewer than 30% of developing countries have a nationally coordinated blood transfusion service. Many of these do not even perform the most rudimentary tests for diseases such as HIV or hepatitis B and C because of financial constraints [12*]. Even limited testing doubles the basic cost of a unit of blood. In a recent review on hepatitis C, Prati [12*] argues that in resource-rich countries where blood is now so safe that the cost of testing for hepatitis C virus for marginal benefit may not be justified. The risk of acquiring hepatitis C has decreased significantly because of improved infection control standards, effective virus inactivation techniques for blood products and routine testing of blood donors. The picture in developing countries is vastly different. Blood transfusion remains the major cause of spread of hepatitis C, but the tests for the most part are not affordable. It is estimated that globally some six million tests, that should be performed annually to check for major blood borne infections, are not done.

Many countries still rely on paid donors or a family member to donate blood prior to surgery [45]. In Argentina, for instance, up 92% of the blood supply is from family members. Pakistan, on the other hand, has increased its voluntary unpaid blood donation to 20%
in the last 5 years; family donors made up 70% and paid donors 10% in 2004. Over the past decade, through concerted efforts by the World Health Organization to improve blood safety worldwide, the number of voluntary unpaid donors has increased considerably. In China, following the introduction of a law prohibiting paid donation in 1998, voluntary blood donation went from 45% of donations in 2000 to 90% in 2004. In Bolivia, the rate of voluntary, unpaid donations increased from 10% in 2002 to 50% in 2005.

There are risks in any system. Family and paid donors may compromise the health and lifestyle that could make the blood unsafe for different reasons. Family members may feel pressured to donate, whereas paid donors are driven by need and avoid important details about their health status.

Voluntary unpaid donors are hard to come by in developing countries not only because of the lack of resources, but also because of traditional or religious beliefs [10**]. In traditional Chinese culture, for example, blood loss is detrimental to health and donation shows disloyalty to one's ancestors. In Africa blood donation may lead to impotency [12*].

Therefore, it is not surprising that the list of pathogens transmitted by transfusion continues to increase. These include viral (HIV; hepatitis A, B, C, D, E, G; cytomegalovirus; human T cell leukemia virus-I and II; Epstein–Barr virus; human herpes virus; parvovirus B19; West Nile virus), bacterial (syphilis), prion and parasitic (malaria, toxoplasmosis) infections [46].

Storage of blood is difficult considering the unreliable and unpredictable electricity supply in many of the poorer countries. To obviate the risk of transmission of malaria, HIV and other infectious diseases, blood should be transfused only when absolutely necessary. In sophisticated units the use of predominated autologous blood is an option [47]. In poorer countries this is not practical because malnutrition and chronic anaemia are common. Lack of appropriate equipment and cost is also prohibitive. Similarly, intraoperative blood salvage, let alone cell savers appropriate for use in children, is simply not available. Recombinant Factor VII, which is being used more and more to reduce blood usage by those who can afford it [47], is beyond the scope of practice in many countries.

Pain management

Pain management is another factor that divides the developed world from the developing world. Provision of pain relief in the face of limited resources, a limited spectrum of analgesics, if available, and inadequately trained staff is a challenge. Attempting to apply similar standards to those used in sophisticated units is fraught with difficulty. Illiteracy, malnutrition, poor cognitive development, differing copying strategies, and pharmacogenetic, cultural and language differences all add to the complexity of the problem [14*].

Children of the developing world learn to cope with vastly different problems. Their attitude towards pain, and tolerance thereof, is different. Children from an impoverished background seem more stoical and indifferent to even severe pain [14*]. Following cardiac surgery, for example, these children appear to need very little pain relief and are easily soothed by lollipops or play therapy (A. Davis, personal communication). Many will walk from the intensive care unit to the general ward on the first postoperative day (R. Ing, personal communication). This may be an indication that pain assessment in children from an impoverished background is difficult and inaccurate.

Many children in acute pain do not show facial expression. Is this stoicism or simply a reflection of malnutrition, lack of social stimulation, severity of illness or even cultural attitude? Language difficulties, cultural barriers and outdated attitudes of the caregiver may endorse this quaudary. Although there are many pain assessment instruments available, few have been validated in children from the developing world [14*]. There is an urgent need not only to make analgesia universally available, but also for developing strategies that can be safely applied to the children of the developing world. Simple pain management strategies may produce the most benefit with the least risk.

More complex techniques that offer the most benefit require a minimum standard of monitoring and regular reassessment to allow individualized titration of analgesia; however, these are seldom available to children of the developing world. The final choice of analgesia, unfortunately, is dictated by economic pressures or by the facilities available rather than what would be considered best for the child. Nonetheless it is morally, ethically and physiologically beneficial to provide children with effective analgesia despite the immense inequalities that exist in our world [14*].

Conclusion

What can be done to improve the lot of children who undergo anesthesia in the developing world? Send money is one suggestion [48]! Unfortunately with all the goodwill in the world there is no guarantee that money will ever reach the right people and be put to the best use. Purchasing equipment without subsequent maintenance is wasteful. Disposables are short-lived even if they are recycled. Human resources are needed!

Training anesthetists in the skills required for pediatric anesthesia is a slow process, which it is hoped will soon
snowball. Through a World Federation of Societies of Anaesthesia-driven sponsorship programme, pediatric anesthetists are being trained in Chile, South Africa and Tunisia. The advantage of this training is that the trainees are exposed to similar problems as they would encounter in their own country. On completion of their training they must return to their country of origin to ‘spread the word’.

Attracting trained anesthetists to work in austere environments is the challenge! Temporary sojourns with volunteer medical groups are for the most part stimulating. Few, if any, of these volunteers are likely to return for longer periods, however, let alone permanently. Is it the environment? Is it the lack of home comforts? Is it the family that finds it difficult? How much influence does political uncertainty have? Unfortunately, until these questions and many others can be answered and addressed, anesthesia in the developing world, particularly for children, is unlikely to advance.

References and recommended reading

- Papers of particular interest, published within the annual period of review, have been highlighted as:
  - of special interest
  - of outstanding interest

Additional references related to this topic can also be found in the Current World Literature section in this issue (p. 296).

3. An astute letter referring to the challenges of pediatric surgery in sub-Saharan Africa and suggesting that more should be trained locally to cope with projected population explosion in Africa. Similar observations are made in [19].
5. Intensive care, despite lack of both human and material resources, has developed even in the smallest countries out of necessity. This paper provides an overview of the issues, the burden of disease, the financial limitations, the lack of supporting disciplines, the poor general health of the patients and the high mortality rate.
7. Outlines the issues and problems faced by orphans exposed to HIV virus who are more vulnerable than orphans not exposed to HIV.
10. This paper gives an insight into the pathology and difficult challenges a pediatric surgeon in sub-Saharan Africa faces when managing a neonate or child and no trained anesthetists nor facilities for the postoperative care are available.
12. Outlines the similar problems faced by orthopedic surgeons when dealing with children with traumatic injuries.
15. Burns are the scourges of many developing countries. Anesthetists should be involved in the resuscitation and pain management of these children. The results of a Medline search presented in this publication gives insight into the causes, initial management and prevention of burns in the developing world.
17. In the same issue as Ref. [9], this paper outlines the available information on the problems of sub-Saharan Africa. The influence of traditional healers is described.
20. compares the transmission of the virus in developed and developing countries. In so doing some of the problems related to the health services, in general, and blood products, in particular, are brought to the readers attention.
22. The shocking reality of the anaesthetic services in the Ugandan health system is conveyed in the results of this survey. Twenty-three percent of anesthesia providers, representatives of hospitals with an average annual surgical caseload of around 7500, could provide safe anesthesia for adults, 18% for children and only 6% for Caesarean section. Lack of facilities, i.e. no electrical supply in 41% hospitals, unreliable oxygen sources in 20% and running water in only 56%, affects the whole healthcare system. Also see the accompanying Editorial [48], whose message is a plea to the goodwill of anaesthetists for a financial contribution to improve anesthesia in poor countries.
24. This brief abstract highlights the differing attitudes to pain, difficulties in pain assessment across cultural barriers and problems with pediatric pain management in developing countries.
29. Delayed presentation, infection, respiratory failure and anesthetic complications contribute to the 1.8% mortality of children who present for correction of congenital anomalies at a hospital in south Nigeria with inadequate facilities and shortage of personnel.
31. The pattern of surgical disease is changing in Africa. Dietary changes and malnutrition may be contributing. Appendicitis, degenerative disease, cancer and road traffic accidents together with HIV and its new breed of communicable disease form part of an emerging problem with profound implications on surgical practice in Africa.

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An anecdotal report from Karachi, Pakistan provides insight to statistics of less-developed countries where the anaesthesia-related mortality was reduced from 0.88 to 0.18 per 10 000 over a decade – considerably better than 56.6 published from Zimbabwe in 1996. Improvements in preoperative assessment, monitoring and supervision were considered the main contributors.


