

REVIEW ARTICLE

International advocacy for education and safety

Kelly A. McQueen¹, Shobha Malviya², Zipporah N. Gathuya³ & Donald C. Tyler⁴

1 Vanderbilt University Nashville, TN, USA

2 Division of Pediatric Anesthesiology, Department of Anesthesiology, University of Michigan Health Systems Ann Arbor, MI, USA

3 Department of Anaesthesia, Gertrude's Children Hospital Nairobi, Kenya

4 Department of Anesthesiology, The Children's Hospital of Philadelphia Philadelphia, PA, USA

Keywords

outcomes; quality improvement; education; patient safety; developing world; public health

Correspondence

Shobha Malviya, Professor of Anesthesiology, 4-911 Mott Hospital, SPC 4245, 1540 E. Hospital Drive, Ann Arbor, MI 48109-4245, USA
Email: smalviya@umich.edu

Section Editor: Andrew Davidson

Accepted 26 July 2012

doi:10.1111/pan.12008

Summary

Surgical safety has emerged as a significant global public health concern with reported mortality rates varying tremendously between developing and industrialized countries. This manuscript reviews some of the challenges encountered in providing safe anesthesia care in the humanitarian space; identifies the difficulties with providing high-quality education in developing countries; and describes how audits and quality improvement databases enhance our understanding of the nature and causes of harm to patients to inform the development of strategies for improvement.

Introduction

The World Health Organization (WHO) has identified surgical safety as a global public health concern estimating that seven million surgical patients experience a significant adverse event globally each year, and of these, one million patients die in the perioperative period. (1) http://whqlibdoc.who.int/publications/2009/9789241598552_eng.pdf Given the variability in resources, certain areas report an avoidable mortality rate as high as 1 : 150 that can be attributed to anesthesia in otherwise healthy patients (2) compared with reported rates of 1 : 71 000 in industrialized countries.(3) Such disparities have been largely attributed to scarce resources including the lack of availability of pulse oximetry and oxygen during anesthesia, a weak healthcare infrastructure, poor health status and poor health literacy of patients, inadequate record keeping and poor quality of patient information. Recognition of such risks and healthcare disparities has led to several large-scale global initiatives such as the global oximetry (GO) project, the Lifebox initiative by organizations such as the WHO, World Federation of Societies of Anaesthesia (WFSA), and International Alliance of Patients' Organizations (IAPO) that have involved

multiple stakeholders including individual patients, patient organizations, medical specialty and subspecialty societies, healthcare leaders, and policymakers.

The need for surgery and safe anesthesia has never been greater on a global scale. In 2010, a sentinel article revealed that two billion people worldwide have no access to emergency or essential surgery and that it is estimated that more than 175 million anesthetics are provided in unsafe conditions annually. (4) These powerful numbers reveal the urgency of this global discussion and the need for all actors in the surgical space to engage.

Humanitarian delivery of safe anesthesia and surgery

Safe delivery of anesthesia and surgery in the humanitarian space has grown in importance and complexity as unmet surgical needs have been identified (5) and the role of surgery has expanded in global public health. (6) A recent study assessing surgical access and safety (4) revealed that two billion people worldwide lack access to emergency and essential surgery and that approximately 175 million anesthetics are delivered

without a pulse oximeter. Historically, anesthesia and surgery have often been provided by international volunteers responding to disasters and humanitarian crises in low-income settings. As well, many subspecialty surgical needs – clubfeet, cleft lips, and palates – have been met by international surgical teams and organizations, when no local surgical alternative existed. This important work has not been without consequence, and the ‘good’ planned for and desired has often not been measured nor achieved. Well-meaning surgical and anesthesia volunteers have compromised standards of care when faced with the real limitations in a low-income setting with the desire to provide as much care as possible while in the country for a short time. Providing international surgical services for emergency surgery frequently requires compromising first world standards for the settings encountered and doing the best for the most. However, providing essential surgery in low-income settings ethically requires a volunteer to provide the same level of care abroad as at home. The stories and lessons learned from practicing differently abroad are abundant and some of them needlessly tragic.

A culture of professionalism, responsible ethical choices, and guidelines have emerged where there was previously little guidance (7). The interest in global provision of care and giving back to more than 85 countries in dire need of surgical care has grown exponentially. A structure of surgical priority for low-income settings is important to a process of evaluation for providing services overseas, as well as locally. Both the WHO (Global Initiative for Emergency and Essential Surgical Care) and other organizations including the Bellagio Surgical Group <http://essentialsurgery.org/bellagio/> and the Alliance for Surgery and Anesthesia Presence www.asaptoday.org have attempted such prioritization. While the discussion continues, Mock *et al.* (8) published a rational approach to providing surgical services for these settings. Of course subspecialty surgery for plastic surgery and correction of vaginal fistulas will always be required and for the foreseeable future will need support from international donors, organizations and surgical teams. With so much surgical need and so many interested volunteers, a culture of safety in all clinical settings is essential and timely.

Vigilance and safety are the tenets of anesthesia practice and have impacted surgical outcomes and patient care for nearly a half-century. Even where resources are very constrained, anesthesia safety is essential and possible. It is possible to provide excellent anesthesia, analgesia, and amnesia without a First World Operating Room (O.R.) and without the newest anesthetic drugs, even without oxygen. However, for those trained with

modern monitors and extensive pharmacologic options, providing care in low-income settings is not intuitive.

Providing safe care with limited resources

Understanding local resources and challenges is of utmost importance to an anesthesiologist volunteering in a resource-constrained environment. Electricity, blood availability, resuscitation medicines, and equipment cannot be assumed available. The best plan may not be to take all of the standard equipment and medicines abroad, but rather to adopt a lower resource approach to safety without compromising standards of care. Most patients can be safely anesthetized without advanced and highly technological monitoring devices – a continuously monitored precordial stethoscope, a finger on the pulse and a pulse oximeter can provide all the necessary data on breathing, circulation, and depth of anesthesia to guide appropriate and timely interventions based on the data provided. Ketamine and regional anesthesia are often mainstays in low-income settings and can provide excellent, safe anesthesia in educated hands. Working without muscle relaxants can also be important where ventilators are not common and is entirely possible once considered and practiced.

Appreciating under and untreated medical conditions in low-income settings is also the purview of the international anesthesia volunteer. The burden of disease (9) is regionally specific and chronic disease is exploding into the global health scene throughout Africa and Southeast Asia. Hypertension has long been untreated in most low- and middle-income countries and has contributed to the epidemic of cardiovascular disease now revealed. Smoking is rampant, and chronic respiratory problems ubiquitous. Infectious disease no longer present or generally treated in developed countries, still plagues many patients and is a contributor to premature death and disability. Acknowledging regional and local comorbidities is as critical overseas, as it is in preoperative clinics and hold areas throughout the United States (US), Canada and United Kingdom (UK). Stringent patient selection criteria must be considered even on the shortest surgical team trips. This requirement is often more difficult to accept for the volunteer anesthesia provider than for the same individual in their home institution. The feeling that the patients we are serving overseas have a limited window to the provision of care we are offering is common. But providing excellent, safe anesthesia for every surgical intervention should be our only goal.

Providing safe anesthesia is essential in every setting, but methods to achieve a safe surgical setting are not universal. While this sounds obvious, it remains a challenge for those trained in developed nations such as the

United States, UK, Europe, and Canada. It is an even greater challenge to provide safe anesthesia care to children in international resource poor settings. Pediatric equipment, supplies and other essentials, including warming and cooling devices, are routinely unavailable. The options for medications are just as limited, Dantrolene too expensive to be kept on hand, and anesthetics are often given without oxygen and without adequately trained personnel. For the average pediatric trained anesthesiologist working under such conditions may be insurmountable. Nevertheless, pediatric surgery continues where possible, and even among volunteers providing anesthesia services in these settings, few of them have the experience to deal with a malnourished child with chronic URIs in need of a hernia repair or tumor removal.

The description of this reality is not a criticism. All those working in this realm – local providers and international volunteers – want to provide the best care possible and genuinely hope to fill a gap and improve the quality of life for a child, teenager or adult who otherwise would have no access to surgical intervention. Even in this discussion, there is hope that international delivery of surgery and safe anesthesia will grow and that appropriate, even minimal guidelines improve the experience for the volunteer and most importantly the surgical and anesthesia outcomes for the patient.

Development of safety guidelines

The Harvard Humanitarian Initiative (10) has supported the exploration of improving surgical delivery in the humanitarian space for the last few years. The Harvard Humanitarian Action Summit, 2009 and 2011, reviewed recent surgical response in disaster and humanitarian settings. This effort resulted in the first guidelines for surgery and anesthesia, as well as for pain management (11). This important first step is only the beginning. Other international entities, including the WFSA (12), the WHO (13) and the Sphere Project (14) have provided some guidance for anesthesia in low-income settings, but these recommendations require important updates and in the case of Sphere, expansion of their recommendations for the provision of safe anesthesia and surgery. Much work remains, both from a distance in resource-rich countries providing aid and within low-income countries to raise the bar for surgical care.

Personnel issues

Humanitarian organizations, charity foundations, and nongovernmental organizations (NGOs) have and will continue to have an important role in the provision of

surgery, especially specialty surgery, and anesthesia in low-income countries (15). The global burden of surgical disease is large and growing, and the global public health community has only begun to address the critical unmet need for emergency and essential surgery (8). The safe provision of anesthesia by international organizations (16) and personnel in low-income countries is hugely underappreciated and underserved. A crisis has been looming and expanding in the provision of anesthesia, and it is amplified as the global burden of surgical disease is revealed. The leading causes of death worldwide include cardiovascular disease, trauma, and cancer. Surgical intervention for these disease classes is necessary and often unavailable. But the paucity of anesthesia providers is the rate-limiting gap. Not only are there few providers (including nurses and technicians) but of greater concern is the lack of interest among medical students in anesthesia as a specialty, and the dwindling numbers of anesthesiologists in many countries (17). The future of anesthesiology is tenuous in many countries across Africa and Southeast Asia.

The fragile state of global anesthesia must be recognized. The full spectrum of aid and support must be considered, service delivery will remain important, but the role of education and training, adequate equipment, consistent availability of oxygen, and expanding the essential medicine list must be part of the process. Guiding organizations, volunteers, and national medical systems must too be expanded and thoughtfully considered. The bar has been raised and the process of professionalizing the global delivery and safe anesthesia is underway (18). The time is now for all interested to engage, acknowledge the many unmet surgical and anesthesia needs, and appropriately respond.

Education as the foundation of safety: training programs in the developing world

Training is the backbone of acquisition and improvement of skills. Improved skills, especially in the field of anesthesia in general and pediatric anesthesia specifically greatly enhance safety. To achieve this objective, training must be tailored to meet various goals that are dependent on the trainees, trainers, and the resources available. Training should lead to improved quality of care for patients regardless of their geographical, economical or other differences.

The premise of see one, assist one and do the rest that is common in the developing world is outdated in more developed nations (19). This premise does not enhance safety in the delivery of service and may in some cases compromise the ability to provide safe care particularly in children. Furthermore, variability in the learning

capabilities of the trainees and teaching skills of the instructors make it difficult to discern the effectiveness of this approach. Training programs in the developing world are mainly driven by dedicated individuals. Many training programs do not have a specific outlined curriculum for training though this is changing. Given the lack of a specific curriculum, there remains a tendency for teachers to impart lessons that they are most comfortable with, thus leaving gaps in the knowledge and skill set of the trainees. Therefore, in ideal circumstances, all the training should be standardized. In addition to limited availability of teachers, most of the teachers are primarily clinicians who have had no formal education in how to teach. Simulators are now being increasingly used for training in countries with adequate resources. Simulated scenarios may provide a practical approach to training groups of individuals in the management of both common and rare events. This improves quality and safety in the same setting (20) Hands-on training in real patients may be ideal to enhance provider comfort and remains essential. The availability of human resource is the major limiting factor to education on safety.

The WFSA currently has five training programs for pediatric anesthesia in the developing world, which are 6–12 months in duration. Some have performed better than others. Suitable applicants should be fully trained in anesthesia in their home country and must be supported in their application by their own National Society of Anesthesia. They must be supported in their application by the chief of their home department of anesthesia and must plan to return to their home country to a recognized post. They must be under 40 years of age and preferably be working in a teaching hospital. The courses are intended mainly for young anesthesiologists from the geographical region near where the course is based. A new program is also underway in Nairobi for the East and Central Africa regions. The challenge of introducing such a program in a university setting has been expressed very well in this particular program.

Although high-quality training exists, there are very few doctors and by extrapolation anesthesia providers per population. (see Table 1). (21) Consequently, these individuals have to work under very tough conditions to provide safe anesthesia. Task shifting (22) is a common phenomenon in the developing world, with most anesthesia care being neither delivered nor supervised by physicians. Physician anesthesia providers are found only in the large hospitals which are mainly in the urban areas. The training programs available in most of the developing world include Masters of Medicine (MMed) in anesthesia, nurse anesthesia training, and clinical anesthesia training. Most have been developed with

Table 1 A comparison of figures in the developing and developed world. (21, 46)

Country	Year	Doctors/1000	Nurses/1000	Total/1000
Kenya	2007	0.18	1.28	1.69
Uganda	2004	0.08	0.73	0.82
Malawi	2004	0.02	0.26	0.29
South Africa	2004	0.74	3.93	4.68
United States	2000	2.4*	9.01	11.47
United Kingdom	1997	2.7*	11.7	15.52

*2009 Data from Thomson *et al.* (21).

support and partnership from the developed world. The trained personnel have to almost always work without much assistance or supervision once their training is complete because of limited ancillary and support personnel. Thus, education and acquisition of adequate skill sets during the limited training period is of paramount importance to ensure the safety of patients because the individuals are left to work by themselves.

The American Society of Anesthesiologists (ASA) founded the Overseas Teaching Program (OTP) www.asahq.org/gho in 1991. Since then, the ASA often in collaboration with the WFSA and the Canadian Society of Anesthesiologists has been implementing the 'teach the teacher' vision original to Nicholas M Greene, a pioneer in anesthesia education in low-income settings. A sole OTP program now exists in Rwanda. But the ASA remains committed to global anesthesia education and safety through the ASA Global Humanitarian committee and volunteer website.

Audits, incidents and QI databases: lessons and opportunities for international cooperation

Anesthesiology has been a leader among medical specialties in reducing errors and improving the safety of care, with a dramatic reduction in deaths from anesthesia over the last 30 years. Although improvements in monitoring are a large part of the cause of that improvement, analysis of errors and learning from the problems that do occur have also been important. Cooper (23, 24) reported on analysis of events, and over time analysis of events has become a standard practice in most anesthesiology departments. Other initiatives also used analysis of events to improve care, among these the Closed Claims Project (25–38) and the Perioperative Cardiac Arrest Registry (POCA) (39–42).

As international programs develop and humanitarian organizations expand further into surgery, quality improvement must be included. Outcomes must be measured and key events tracked and followed. The evolution of this process for low-income countries is

possible, perhaps similarly to the evolution of QI in the United States. In 2008, the Society for Pediatric Anesthesia (SPA) and 10 pediatric institutions in the United States (with a grant from the Anesthesia Patient Safety Foundation) launched an initiative entitled Wake up Safe <http://www.wakeupsafe.org/>. Wake up Safe is a registry of serious events that occur during pediatric anesthetics, along with an analysis of why the event happened. In addition, participants report basic demographic data on all anesthetics, which allow determination of incidence of events. The initial finding was five reports of wrong side procedures, including two wrong side regional anesthesia blocks. In most of these cases, policies and procedures were in place to prevent wrong side events but they were not followed. Wake up Safe alerted members of the society that these events can and do occur in leading pediatric institutions and made recommendations to prevent wrong side procedures.

The most common type of report received by Wake up Safe has been medication error. Many are ten time dose errors, and there are a significant number of wrong drug errors. Fortunately, there have not been any significant patient injuries resulting from these errors, but the possibility for injury is certainly there. Medication errors are problems unique to anesthesiology as anesthesiologists are the only physicians who regularly prepare and administer medications, and the rapid pace of practice in the Operating Room does not permit techniques such as double checks used in other parts of the hospital by other practitioners. Consequently, we believe that anesthesiologists must lead the way in dealing with this problem.

Other reports are of cases of cardiac arrest or near arrest related to hyperkalemia from transfusion of old blood in small infants. This complication was previously reported by POCA (40), and the fact that the problem continues to occur points out a major issue with registries, namely reporting events does not necessarily lead to a reduction in the occurrence of those events. Another instance of the failure of reporting to cause changes in practice is seen in the state of Pennsylvania's experience with wrong side procedures. Pennsylvania has a mandatory event reporting system and provides updates periodically on the incidence of wrong side procedures. In spite of repeated publications and alerts, the incidence of wrong side procedures has not really decreased. (43) These observations from POCA and the Pennsylvania state experience emphasize that publications alone do not necessarily lead to improvements in care and demonstrate to the leaders of Wake up Safe the need to use the data reported in new ways to produce changes in practice.

As a first step to using the data collected to change practice, Wake up Safe has developed a quality improvement initiative designed to reduce medication errors. We developed a list of the key drivers for safe medication administration, and based on the key driver diagram, we selected syringe labeling as the initial improvement effort. In their own institutions, members monitored correct syringe labeling (defined as a label with the legible name of the drug and concentration) and reported the results. The institutions that achieved greater than 90% correct labeling usually had either pharmacy prepared syringes or processes in place that provided anesthesiologists with labels with the necessary information already preprinted. As a next step, institutions that had less than 90% accuracy in correct labeling are now making interventions and measuring the effects of their interventions.

Wake up Safe has also recognized how isolated we are from each other in clinical practice in the United States. We work in different medical cultures, and we do things differently, often for no proven reason. Wake up Safe believes that we can learn much from each other and that by observing each other's practice, we can find best practices that can lead to practice improvement. We are developing techniques to learn from each other, to define best practices and to identify funding and channels for implementing best practices.

Other examples of safety initiatives include the Safe Surgery Saves Lives, WHO initiative (44) which advocates for the use of the surgery checklist and a pulse oximeter in all surgical settings. This seems intuitive to anesthesiologists in the United States and UK, but the reality is that pulse oximeters are scarce in low-income countries. The Lifebox Initiative, www.lifebox.org, was founded in follow-up to the global oximetry project (45) which first revealed the critical shortage of pulse oximeters during the World Congress of Anaesthesiology in Paris, 2004. Since then, the 501c3 has committed itself to supply pulse oximetry, the checklist and the education necessary for routine use, for more than 77 000 operative sites worldwide. With cooperation from the WFSA, the ASA, the Australian Society of Anesthesiologists, the Canadian Society of Anesthesiologists and the Anesthesia Association of Great Britain and Ireland the project will be fulfilled in the coming years.

Humanitarian Organizations and the initiatives committed to professionalizing the humanitarian space have a unique opportunity to impact the global anesthesia crisis and anesthesia safety in low-income settings. (18) The organizations and initiatives mentioned above are all important actors for improving global anesthesia. But there is no panacea; the greatest challenge for achieving safe anesthesia in all setting may be cooperation.

Nonprofit organizations, international humanitarian organizations and educational organizations must unite for the promotion of the global anesthesia crisis and the solutions which will lead to universal anesthesia safety. The professionalization of international volunteers is one step in the right direction, but this education will not succeed in a vacuum. Education of volunteers, local providers must occur in tandem and coordinated with the addition of appropriate, cost-effective safety technology whenever possible. Advocating for the universal availability of oxygen and an improved essential medicines list must prevail. The role of the anesthesiologist and those trained in pediatric anesthesia cannot be overstated. We must reach out to the global community and ensure safe anesthesia for the world.

Ethical approval

This manuscript does not involve the use of human or animal subjects. It reflects the honest opinion and

experience of the coauthors. As such, no ethical approval could be obtained.

Sources of funding

This research was carried out without funding.

Conflicts of interest

No conflicts of interest relevant to this manuscript were declared. Dr. Shobha Malviya has received research funding for a clinical drug trial conducted with Cadence Pharmaceuticals; however, this funding is not relevant to the content of this manuscript.

References

- WHO guidelines for safe surgery, 2009. Available at: http://whqlibdoc.who.int/publications/2009/9789241598552_eng.pdf. Accessed 19 July 2012.
- Ouro-Bang'na Maman AF, Tomta K, Ahouangbevi S *et al.* Deaths associated with anaesthesia in Togo, West Africa. *Trop Doct* 2005; **35**: 220–222.
- Jenkins K, Baker AB. Consent and anaesthetic risk. *Anaesthesia* 2003; **58**: 962–984.
- Funk LM, Weiser TG, Berry WR *et al.* Global operating theatre distribution and pulse oximetry supply: an estimation from reported data. *Lancet* 2010; **376**: 1055–1061.
- Bickler S, Ozgediz D, Gosselin R *et al.* Key concepts for estimating the burden of surgical conditions and the unmet need for surgical care. *World J Surg* 2010; **34**: 374–380.
- McQueen KA, Parmar P, Kene M *et al.* Burden of surgical disease: strategies to manage an existing public health emergency. *Prehosp Disaster Med* 2009; **24**(Suppl 2): s228–s231.
- Harvard humanitarian action summit. Available at: www.hhiharvard.edu. Accessed 30 June 2012.
- Mock C, Cherian M, Juillard C *et al.* Developing priorities for addressing surgical conditions globally: furthering the link between surgery and public health policy. *World J Surg* 2010; **34**: 381–385.
- The global burden of disease update, 2004. Available at: http://www.who.int/healthinfo/global_burden_disease/GBD_report_2004update_full.pdf. Accessed 24 July 2012.
- Harvard humanitarian Initiative. Available at: www.hhiharvard.edu. Accessed 30 June 2012.
- Chackungal S, Nickerson JW, Knowlton LM *et al.* Best Practice Guidelines on Surgical Response in Disasters and Humanitarian Emergencies: report of the 2011 Humanitarian Action Summit Working Group on Surgical Issues within the Humanitarian Space. *Prehosp Disaster Med* 2011; **26**: 429–437.
- World Federation of Societies of Anaesthesia. Available at: www.anaesthesiologists.org. Accessed 16 July 2012.
- Cherian MN, Merry AF, Wilson IH. The World Health Organization and anaesthesia. *Anaesthesia* 2007; **62**(Suppl 1): 65–66.
- Sphere project. Available at: www.sphereproject.org. Accessed 8 July 2012.
- McQueen KA, Casey KM. The impact of global anesthesia and surgery: professional partnerships and humanitarian outreach. *Int Anesthesiol Clin* 2010; **48**: 79–90.
- McQueen KA. Anesthesia and the global burden of surgical disease. *Int Anesthesiol Clin* 2010; **48**: 91–107.
- Dubowitz G, Detlefs S, McQueen KA. Global anesthesia workforce crisis: a preliminary survey revealing shortages contributing to undesirable outcomes and unsafe practices. *World J Surg* 2010; **34**: 438–444.
- Walker P, Hein K, Russ C *et al.* A blueprint for professionalizing humanitarian assistance. *Health Aff (Millwood)* 2010; **29**: 2223–2230.
- Bradley P. The history of simulation in medical education and possible future directions. *Med Educ* 2006; **40**: 254–262.
- Eich C, Timmermann A, Russo SG *et al.* Simulator-based training in paediatric anaesthesia and emergency medicine—thrills, skills and attitudes. *Br J Anaesth* 2007; **98**: 417–419.
- Thomson S, Osborn R, Squires D *et al.* Profiles of health care systems, 2011. Available at: <http://www.commonwealthfund.org/Publications/Fund-Reports/2011/Nov/International-Profiles-of-Health-Care-Systems-2011.aspx>. Accessed 24 July 2012.
- WHO working together for health, 2006. Available at: <http://www.who.int/whr/2006/en/>. Accessed 24 July 2012.
- Cooper JB, Long CD, Newbower RS *et al.* Critical incidents associated with intraoperative exchanges of anesthesia personnel. *Anesthesiology* 1982; **56**: 456–461.
- Cooper JB, Newbower RS, Kitz RJ. An analysis of major errors and equipment failures in anesthesia management: considerations for prevention and detection. *Anesthesiology* 1984; **60**: 34–42.
- Caplan RA, Ward RJ, Posner K *et al.* Unexpected cardiac arrest during spinal anesthesia: a closed claims analysis of predisposing factors. *Anesthesiology* 1988; **68**: 5–11.
- Tinker JH, Dull DL, Caplan RA *et al.* Role of monitoring devices in prevention of anesthetic mishaps: a closed claims analysis. *Anesthesiology* 1989; **71**: 541–546.
- Caplan RA, Posner KL, Ward RJ *et al.* Adverse respiratory events in anesthesia: a closed claims analysis. *Anesthesiology* 1990; **72**: 828–833.

- 28 Kroll DA, Caplan RA, Posner K *et al.* Nerve injury associated with anesthesia. *Anesthesiology* 1990; **73**: 202–207.
- 29 Cheney FW, Posner KL, Caplan RA. Adverse respiratory events infrequently leading to malpractice suits. A closed claims analysis. *Anesthesiology* 1991; **75**: 932–939.
- 30 Gild WM, Posner KL, Caplan RA *et al.* Eye injuries associated with anesthesia. A closed claims analysis. *Anesthesiology* 1992; **76**: 204–208.
- 31 Caplan RA, Vistica MF, Posner KL *et al.* Adverse anesthetic outcomes arising from gas delivery equipment: a closed claims analysis. *Anesthesiology* 1997; **87**: 741–748.
- 32 Domino KB, Posner KL, Caplan RA *et al.* Awareness during anesthesia: a closed claims analysis. *Anesthesiology* 1999; **90**: 1053–1061.
- 33 Cheney FW. The American Society of Anesthesiologists Closed Claims Project: what have we learned, how has it affected practice, and how will it affect practice in the future? *Anesthesiology* 1999; **91**: 552–556.
- 34 Domino KB, Posner KL, Caplan RA *et al.* Airway injury during anesthesia: a closed claims analysis. *Anesthesiology* 1999; **91**: 1703–1711.
- 35 Domino KB, Bowdle TA, Posner KL *et al.* Injuries and liability related to central vascular catheters: a closed claims analysis. *Anesthesiology* 2004; **100**: 1411–1418.
- 36 Lee LA, Posner KL, Domino KB *et al.* Injuries associated with regional anesthesia in the 1980s and 1990s: a closed claims analysis. *Anesthesiology* 2004; **101**: 143–152.
- 37 Peterson GN, Domino KB, Caplan RA *et al.* Management of the difficult airway: a closed claims analysis. *Anesthesiology* 2005; **103**: 33–39.
- 38 Bhananker SM, Posner KL, Cheney FW *et al.* Injury and liability associated with monitored anesthesia care: a closed claims analysis. *Anesthesiology* 2006; **104**: 228–234.
- 39 Morray JP, Geiduschek JM, Caplan RA *et al.* A comparison of pediatric and adult anesthesia closed malpractice claims. *Anesthesiology* 1993; **78**: 461–467.
- 40 Morray JP, Geiduschek JM, Ramamoorthy C *et al.* Anesthesia-related cardiac arrest in children: initial findings of the Pediatric Perioperative Cardiac Arrest (POCA) Registry. *Anesthesiology* 2000; **93**: 6–14.
- 41 Bhananker SM, Ramamoorthy C, Geiduschek JM *et al.* Anesthesia-related cardiac arrest in children: update from the Pediatric Perioperative Cardiac Arrest Registry. *Anesth Analg* 2007; **105**: 344–350.
- 42 Ramamoorthy C, Haberkern CM, Bhananker SM *et al.* Anesthesia-related cardiac arrest in children with heart disease: data from the Pediatric Perioperative Cardiac Arrest (POCA) registry. *Anesth Analg* 2010; **110**: 1376–1382.
- 43 Available at: <http://patientsafetyauthority.org/EducationalTools/PatientSafetyTools//Pages/home.aspx>. Accessed 17 July 2012.
- 44 WHO safe surgery saves lives, 2012. Available at: <http://www.who.int/patientsafety/safesurgery/en>. Accessed 24 July 2012.
- 45 Walker IA, Merry AF, Wilson IH *et al.* Global oximetry: an international anaesthesia quality improvement project. *Anaesthesia* 2009; **64**: 1051–1060.
- 46 Luoma M, Doherty J, Muchiri S *et al.* Kenya health system assessment, 2010. Available at: <http://www.healthsystems2020.org/content/resource/detail/2760/>. Accessed 24 July 2012.