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Original Article

The Safer Anaesthesia from Education (SAFE)® paediatric anaesthesia course: educational impact in five countries in East and Central Africa*

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Summary

There is an urgent need to improve access to safe surgical and anaesthetic care for children living in many low- and middle-income countries. Providing quality training for healthcare workers is a key component of achieving this. The 3-day Safer Anaesthesia from Education (SAFE)® paediatric anaesthesia course was developed to address the specific skills and knowledge required in this field. We undertook a project to expand this course across five East and Central African countries (Ethiopia, Kenya, Malawi, Uganda and Zambia) and train local faculty. This study reports the outcomes from course evaluation data, exploring the impact on knowledge, skills and behaviour change in participants. Eleven courses were conducted in a 15-month period, with 381 participants attending. Fifty-nine new faculty members were trained. Knowledge scores (0–50 scale) increased significantly from mean (SD) 37.5 (4.7) pre-course to 43.2 (3.5) post-course ($p < 0.0001$). Skills scores (0–10 scale) increased significantly from 5.7 (2.0) pre-course to 8.0 (1.5) post-course ($p < 0.0001$). One hundred and twenty-six participants in Malawi, Uganda and Zambia were visited in their workplace 3–6 months later. Knowledge and skills were maintained at follow-up, with scores of 41.5 (5.0) and 8.3 (1.4), respectively ($p < 0.0001$ compared with pre-course scores). Content analysis from interviews with these participants highlighted positive behaviour changes in the areas of preparation, peri-operative care, resuscitation, management of the sick child, communication and teaching. This study indicates that the SAFE paediatric anaesthesia course is an effective way to deliver training, and could be used to help strengthen emergency and essential surgical care for children as a component of universal health coverage.

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Introduction

Surgery and anaesthesia have historically been neglected in low- and middle-income countries (LMIC), even though the burden of surgical disease exceeds that of malaria, tuberculosis and HIV combined [1, 2]. In 2015, the World Health Assembly responded by passing a resolution to strengthen emergency and essential surgical care as a component of universal health coverage, including providing training for healthcare workers at the first-referral hospital level [3]. The greatest unmet need for surgery is in sub-Saharan Africa, where an estimated one billion people (14% of the world's population) live [1].

Children comprise approximately half the population in sub-Saharan Africa, and it has been estimated that 85% are likely to require surgery before their fifteenth birthday [4]. Infants and children differ from adults in their anatomy, physiology, metabolism and clearance of drugs, and their emotional development. They have limited cardiovascular reserves and can deteriorate quickly when unwell. Their small size may present a technical challenge to the anaesthetist, and the surgical conditions of childhood are different to those seen in adult life. There are very few physician anaesthetists in sub-Saharan Africa, and even fewer with training in specialist paediatric anaesthesia [5, 6]. The delivery of anaesthesia for children is, by necessity, the responsibility of a non-specialist non-physician anaesthetist, who typically receives 12–18 months training with little continuing education or opportunity for professional development. Many do not even own their own textbook [5]. There is, therefore, an urgent need to address the training needs of anaesthetists caring for children in sub-Saharan Africa and other low-resource settings.

Training specialist paediatric physician anaesthetists, a recognised sub-speciality in many high-income countries, will require significant investment and will take decades to achieve. Short courses are one method of providing training for existing healthcare providers and have been used in low-resource settings, for instance the Primary Trauma Care and Essential Pain Management courses, both of which have shown encouraging outcomes [7, 8]. To address this training need, a 3-day course in paediatric anaesthesia was developed in partnership between the Association of Anaesthetists, the World Federation of Societies of Anaesthesiologists (WFSA) and the Association of Anesthesiologists of Uganda (AAU), forming part of the Safer Anaesthesia from Education (SAFE)® project (see: https://www.wfsahq.org/wfsa-safer-anaesthesia-from-education-safe). The SAFE paediatric anaesthesia course is accompanied by a Train-the-Trainer course in order to assist in the scale, pace and sustainability of course delivery. The course employs a standardised monitoring and evaluation programme, which evaluates acceptability, learning and behaviour change [9]. The course was first piloted in Uganda in 2014, before this larger expanded project across East and Central Africa.

This study aimed to explore whether: knowledge and skills of local providers could be improved in paediatric anaesthesia using this short course model; learning would be maintained over time; and what the impact of the course would be in the clinical work of these anaesthesia providers. Here, we report an analysis of the evaluation outcomes from a programme to expand the SAFE paediatric anaesthesia and Train-the-Trainer courses in five countries in East and Central Africa (Ethiopia, Kenya, Malawi, Uganda and Zambia).

Methods

The 3-day SAFE paediatric anaesthesia course was developed by UK and US specialist paediatric anaesthetists with experience of working in LMICs. The course content was created following a review of activity from hospitals in south-western Uganda, to ensure that the course was relevant to the type of surgery undertaken, anaesthetic techniques and equipment and drug availability [10]. The course materials were peer reviewed by anaesthetists and surgeons in Uganda, Malawi and Kenya. The course was piloted in Masaka, Uganda in July 2014 and January 2015, and refined following feedback from course participants and visiting and local faculty. The final course consisted of six lectures and 10 themed modules delivered as low-fidelity simulation, case-based discussions and skill stations (Appendix S1).

Monitoring and evaluation was conducted using the first three levels of the four-level evaluation method described by Kirkpatrick: level 1 – Reaction; level 2 – Learning; level 3 – Behaviour change [11].

Level 1: Reaction was evaluated using anonymous, structured feedback from participants at the end of the course, with each session and general feedback rated on a 10-point linear scale.

Level 2: Learning was assessed using pre- and post-course knowledge and skills testing of each delegate. Knowledge was evaluated using 50 true/false multiple choice questions (MCQ). These were piloted and refined alongside the course materials to ensure appropriate understanding and a focus on key areas of knowledge. Skills were assessed using an objective structured clinical examination (OSCE) model. Each delegate was randomly allocated to one of four clinical skills (tracheal intubation,

basic life support, neonatal life support and trauma), and asked to carry out that skill while being observed by a member of the faculty. One point was given for correct completion of each essential step using structured marking criteria, and an overall mark given out of 10. Delegates completed the same OSCE station before and after the course. In addition, delegates who were followed up 3–6 months later repeated these tests.

Level 3: Behaviour change was evaluated by four SAFE paediatric fellows who visited course participants in their place of work 3–6 months after training. The fellows explored the behaviour change in the trainees during a structured face-to-face interview (Appendix S2) and a SAFE logbook, in which delegates recorded clinical cases they had managed differently as a result of attending the course. The fellows also reviewed the operating theatre logbooks, in order to estimate paediatric case-load.

Five partner countries were identified in the East and Central African region that had pre-existing links with UK paediatric anaesthetists: Ethiopia; Kenya; Malawi; Uganda; and Zambia. Twenty-four physician anaesthetists from these countries were invited to attend an inaugural SAFE paediatric anaesthesia course in Masaka, Uganda in January 2016, delivered by experienced faculty from the UK, USA and Uganda (Fig. 1). Immediately following this, participants attended a one-day SAFE Train-the-Trainer course, and then taught a SAFE paediatric anaesthesia course for Ugandan non-physician anaesthetists, mentored by the visiting faculty.

The regional faculty were funded to organise and teach a second round of SAFE paediatric anaesthesia and Train-the-Trainer courses in their home countries, prioritising anaesthesia providers (including trainees) in hospitals with a substantial paediatric workload. All courses included experienced SAFE faculty from the UK as well as neighbouring African countries, to encourage ongoing collaboration in the region. All courses were fully funded as part of this project including travel, board and lodging for all course attendees and funding for equipment required. Course participants were not paid a per-diem to attend training.

We intended to run two courses in each country with at least 25 anaesthetists attending per course, giving at least 250 expected participants in this evaluation. All anaesthetists who attended a SAFE course as part of the second round five-country expansion project were eligible for inclusion in the evaluation. Multiple choice questions and OSCE scores for the physician anaesthetists who attended the inaugural course in Uganda were excluded from analysis, due to their pre-existing interest and training in paediatric anaesthesia.

Secondary analysis of routine course evaluation data was performed to explore the impact of the SAFE course, and identify any generalisable findings about interventions to improve anaesthetic practice. All data were anonymised and entered into Excel for Mac v16.22 (Microsoft®, Redmond, WA, USA). Quantitative data analysis was performed using descriptive statistics and paired t-tests. A directed content analysis was completed for qualitative elements of course feedback and from interview data. Data were coded into themes by one of the authors (ES), and reviewed by a second author (NB) to identify the most common areas of behaviour change highlighted by course participants [12].

All data were collected in accordance with local and UK ethical principles and anonymised. The Chair of the Ethics Committee at the University of Manchester deemed that ethical approval was not required for this secondary analysis of anonymised course data.

Results

A total of 381 participants attended 11 SAFE paediatric anaesthesia courses over a 15-month period from January 2016 to March 2017. Following the inaugural course in Uganda, further courses were held in Ethiopia (1), Kenya (2), Malawi (2), Uganda (3) and Zambia (2). Three hundred and thirty-five course participants (88%) were non-physician anaesthetists (Table 1). Five Train-the-Trainer courses were conducted, training 59 new faculty members. Of these, 46 (78%) went on to teach on a SAFE paediatric course as part of this project.

Follow-up at 3–6 months was completed by SAFE fellows for courses in Malawi (ES), Uganda (JT, MN) and Zambia (NS, MZ; Table 2). Follow-up was not possible in Ethiopia due to a state of emergency, and in Kenya due to extended healthcare worker strikes. After exclusion of the physician participants from the inaugural course, 192 participants were eligible for follow-up. A review of theatre logbooks from the preceding 3 months indicated that paediatric surgery had been performed in 123 (98%) of participants' hospitals, with a median (IQR [range]) number of operations of 6 (1–25 [0–340]) children < 1 year old, 17 (8–46 [0–240]) children aged 1 to < 5 years and 28 (8–74 [0–600]) children aged 5 to < 16 years in each centre.

Level 1 Reaction data were collected from 252 (66%) participants, with a feedback score of 10 (9–10 [5–10]) across all sessions. Level 2 Learning evaluation included MCQ and OSCE skills testing. After exclusion of the physician participants from the inaugural course, data from 357 participants were eligible for analysis. Complete pre- and post-course MCQ datasets were recorded for 333 (93%) participants (Table 1). Missing data were mainly due to

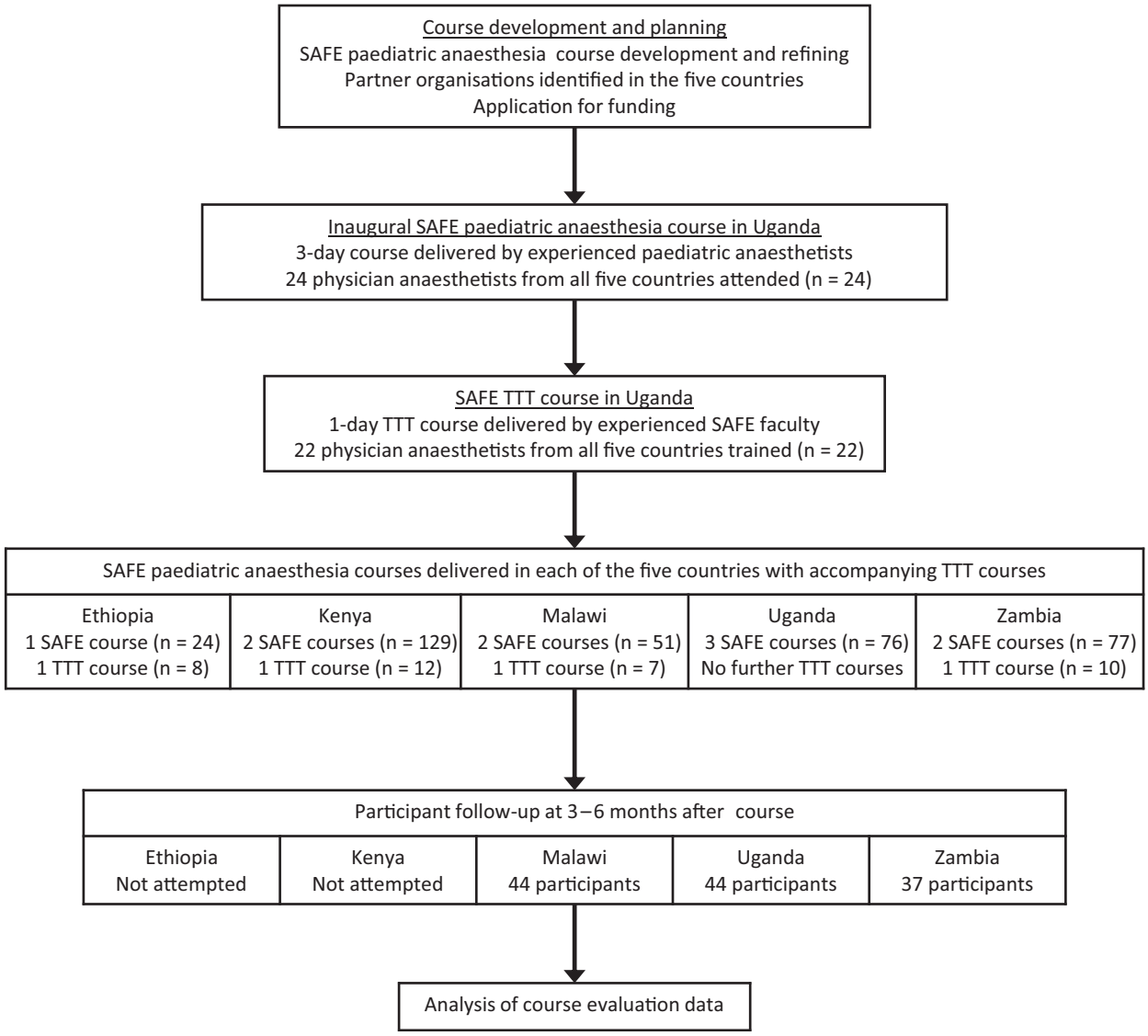

Figure 1 Flow chart showing sequence of courses delivered. SAFE, Safer Anaesthesia From Education; TTT, Train-the-Trainer.

Table 1 Scores for pre-course, post-course and follow-up MCQ and OSCE. Values are mean (SD).

	Country					
	Ethiopia n = 24	**Kenya n = 129**	**Malawi n = 51**	**Uganda n = 100**	**Zambia n = 77**	**Total n = 381**
Pre-course MCQ (0–50)	35.5 (3.6)	39.5 (4.5)	38.4 (4.2)	34.9 (3.6)	37.1 (4.8)	37.5 (4.7)
Post-course MCQ (0–50)	41.1 (4.6)[a]	44.3 (2.8)[a]	44.2 (3.1)[a]	42.3 (3.4)[a]	42.6 (3.8)[a]	43.2 (3.5)[a]
Pre-course OSCE (0–10)	–	5.9 (2.1)	6.5 (2.0)	5.0 (1.8)	5.4 (1.8)	5.7 (2.0)
Post-course OSCE (0–10)	8.9 (1.0)	8.0 (1.7)[a]	8.3 (1.4)[a]	7.6 (1.5)[a]	8.1 (1.3)[a]	8.0 (1.5)[a]
Followed up	n = 0	n = 0	n = 44	n = 45	n = 37	n = 126
Follow-up MCQ (0–50)	–	–	43.7 (3.8)[a]	40.1 (5.3)[a]	40.5 (4.9)[a]	41.5 (5.0)[a]
Follow-up OSCE (0–10)	–	–	8.3 (1.4)[a]	7.8 (1.6)[a]	8.5 (1.3)[a]	8.3 (1.4)[a]

MCQ, multiple choice questions; OSCE, objective structured clinical examinations.
[a]$p < 0.0001$ vs. pre-course score.

Table 2 Characteristics of participants visited in their workplace 3–6 months following the course in Malawi, Uganda and Zambia. Values are median (IQR [range]) or number (proportion).

	Malawi n = 44	Uganda n = 45	Zambia n = 37	Total n = 126
Age; years	40 (32–44.5 [27–56])	35 (31–39 [26–52])	40 (34–48.5 [27–59])	36 (32–45 [26–59])
Sex; male	35 (80%)	27 (60%)	32 (86%)	94 (75%)
Grade				
Physician	2 (4%)	2 (4%)	4 (11%)	8 (6%)
Non-physician	32 (73%)	7 (16%)	33 (89%)	72 (57%)
Non-physician (student)	10 (23%)	36 (80%)	0	46 (37%)
Practice experience; years	5 (2–13 [1–25])	1 (1–2 [1–20])	7 (4–12 [1–27])	4 (1–10 [1–27])
Type of hospital				
National	19 (43%)	22 (49%)	4 (11%)	45 (36%)
Regional	9 (21%)	5 (11%)	18 (48%)	32 (25%)
District	11 (25%)	5 (11%)	13 (35%)	29 (23%)
Health centre	5 (11%)	3 (7%)	1 (3%)	9 (7%)
Other (e.g. private)	0	10 (22%)	1 (3%)	11 (9%)

the late arrival of course delegates. Overall, mean (SD) scores increased from 37.5 (4.7) pre-course to 43.2 (3.5) post-course, a mean score change of 5.7 (95%CI 5.3–6.1; $p < 0.0001$). For participants visited at follow-up, complete MCQ data were recorded for 121 (96%) of participants. The MCQ score at follow-up was 41.5 (5.0), a mean score increase of 4.0 (95%CI 4.3–5.8; $p < 0.0001$) when compared with pre-course scores. Pre- and post-course OSCE skills tests were complete for 311 (87%) eligible candidates. Missing data were mainly due to late arrival of course delegates and lost data sheets. Overall, scores increased from 5.7 (2.0) pre-course to 8.0 (1.5) post-course, a mean score change of 2.3 (95%CI 2.1–2.5; $p < 0.0001$). For participants visited at follow-up, complete OSCE skills data were recorded for 119 (94%) participants. OSCE scores at follow-up were 8.3 (1.4), showing a mean score increase of 2.7 (95%CI 2.4–3.0; $p < 0.0001$) compared with pre-course scores.

Level 3 Behaviour was evaluated from follow-up interviews, including a review of the participant's SAFE logbook. One hundred and twenty-six (99%) participants visited at follow-up completed a structured qualitative interview with the SAFE fellow. Content analysis of interview data identified six broad domains of behaviour change: preparation; peri-operative care; resuscitation; management of the sick child; communication; and teaching (Table 3). Regarding preparation, participants highlighted changes to their pre-assessment of children (n = 16), fasting before surgery (n = 16) and changes to anaesthetic equipment (n = 32), such as ensuring there is "*always an Ambu® bag and correctly sized tracheal tubes before starting*" (anaesthetist, Malawi). Within the domain of peri-operative care, participants discussed making improvements to warming during surgery (n = 10), improved fluid management (n = 13), improved analgesia management (n = 21) and changes to their drug dosing (n = 27). Examples included "*giving drugs according to the weight of the child*" (anaesthetist, Malawi) and "*using multi-modal analgesia*" (anaesthetist, Uganda). Within the domain of resuscitation, 12 participants discussed improved basic life support in children, and 35 highlighted improvements in neonatal resuscitation. On management of the sick child, participants discussed reducing drug doses for these patients (n = 9), and using a structured approach to assess these children (n = 31). Improved communication was a common theme, highlighted by 34 participants at follow-up, such as making sure that "*people can speak up if they have a problem*" (anaesthetist, Malawi).

Discussion

The SAFE paediatric anaesthesia course is the first anaesthesia short course that addresses the training needs of non-physician anaesthetists caring for children in LMICs. This paper describes the educational impact following delivery and expansion of the course in five East African countries. Three hundred and eighty-one anaesthesia providers were trained over a 15-month period, with the majority of the 59 new faculty members going on to deliver a SAFE course, mentored by international trainers. Course evaluation data showed that this 3-day course was relevant to participants, and led to improvements in knowledge and skills. Encouragingly, we have shown that both knowledge and skills improvements were maintained at follow-up months later, as well as finding evidence of a number of positive changes in workplace behaviour.

Table 3 Content analysis from structured interviews categorised into six broad domains. N = number of anaesthetists reporting change in practice in this domain. Example quotes from participants are displayed in the final column (M = Malawi, U = Uganda, Z = Zambia).

Domain	Sub-domain	N	Examples
Preparation	Equipment	39	M17: I have organised equipment into an emergency airway trolley
			M10: I ensure that I have an Ambu® bag and correctly sized tracheal tube before I start now. This is why I have asked for more, I realised I did not have all the sizes
	Pre-assessment	16	Z15: I try and see all the children on the ward
	Fasting	16	U20: I try to ensure that children are first on the list
			M26: I developed a fasting guideline for sedation, before we did not have one
	Weight	7	M16: All children now get weighed; they go through the out-patient department where the scales are before they get admitted.
	Theatre	4	M2: I have locked one door into theatre to reduce traffic as it is much less distracting
Peri-operative care	Warming	10	U37: I switch off the [air conditioning] for neonates now
	Antibiotics	5	M9: Now think about prophylactic antibiotics before surgery especially for ventriculoperitoneal shunts and orthopaedic procedures
	Monitoring	9	Z30: Before I did MUAs on the ward with no monitoring. Now they come to theatre starved and use my Lifebox and some oxygen if necessary.
			M32: I have employed a new recovery nurse so that the patients can be monitored postoperatively
	Fluids	13	M24: I use dextrose containing fluids for neonates
			M13: Previously I would hang a litre bag, several times the child ballooned. Once the child was really struggling to breathe and the District Health Officer was going to refer to [a central hospital]. I knew it was fluid overload so gave some furosemide and it got better.
	Drugs	27	M6: I give drugs according to the weight, before when I had a problem I would give drugs undiluted and not the right dose. This caused problems like too much tachycardia.
			Z22: I use the precise dose, before the course I would just guess.
	Analgesia	21	M7: I do not give neonates any analgesia as I am too concerned with apnoeas on the ward.
			U38: When it is available I use multi-modal analgesia with paracetamol, diclofenac and sometimes opiates for the older children.
Resuscitation	Neonatal resuscitation	35	Z13: Before I did not help the midwives at all, now I listen out and if the baby is not crying I go and help.
			M15: Since the course I have organised for a fully trained midwife to come to theatre for all caesarean sections for fetal distress
			M13: I have stuck the neonatal life support algorithm next to the Resuscitaire® to remind us what to do
	Basic life support	12	M35: I have much improved my preparation and communication. With the surgeon we managed a bleeding patient, I focused on the airway and giving blood whilst he was looking for the bleeding source. It worked really well and I felt much more confident after the course.
			U23: I have a much clearer sequence to follow. I am not longer scared to help.
Management of sick child	Structured ABC approach	31	M16: 2 year old boy with severe burns, I was called to help with cannulation. After the course I did a quick ABCDE assessment and realised the patient was very unwell. I gave oxygen as he was very tachypnoeic and then as the rest of the team was unsure how to calculate the percentage burns I used the SAFE handbook. This helped us to work out how much fluid to give.

(continued)

Table 3 (*continued*)

Domain	Sub-domain	N	Examples
	Reduced drug dosing	9	Z33: I used low-dose ketamine for induction of a nine year old with a typhoid perforation
			M10: I have stopped using suxamethonium for burns patients
	Transfer	5	M4: I transferred a patient to the central hospital, I was much more prepared in terms of equipment and drugs. I remembered to call the ICU so they were expecting the patient. I have organised a spare cylinder of oxygen so that transfers are safer.
	Escalation of care/ ICU	7	M35: Around the bed space when there is a baby I tell everyone that we need to have everything ready e.g. tracheal tube, Ambu® bag, drugs. I presented 'how to prepare a bed space' to all the nurse.
Communication		34	M8: The surgeons now give me the theatre list the day before so I can pre-assess my patients. This helps me to anticipated problems and means I can talk to the District Health Officer about potential difficult cases.
			M2: Before the course I had seen a baby die without even realising the midwife was struggling. Since the course I try and make sure that people can speak up if there is a problem.
Teaching		19	M10: I am training the midwives in neonatal life support with our obstetrician

Children have a significantly higher peri-operative risk in LMICs than in high resource settings [13–17]. The reasons for this are multifactorial, but include: increased severity of illness due to poor access to surgery; low numbers of physician anaesthetists; limited training for non-physician providers; limited continuing professional development opportunities; and poor equipment and drug supplies [10, 15, 18–21]. The SAFE paediatric anaesthesia course was developed in response to the need for training and continuing professional development opportunities. Qualitative interviews conducted 3–6 months following training showed changes in behaviour relating to pre-operative preparation, peri-operative care, resuscitation, management of the sick child, communication and teaching, all factors associated with improved outcomes after surgery. Participants described changes in practice that reflect the specific needs of children, such as adoption of appropriate fasting times, weight-based administration of drugs, recognition of the need to procure appropriate equipment and improved knowledge and resuscitation skills, which are all factors known to be associated with improved outcomes.

Short courses are one method to address training gaps, and have shown encouraging results [7, 22–24]. Systematic review and meta-analysis of attendance at adult advanced cardiac life support courses have been shown to have a positive effect on patient outcomes [22]. Maternal outcomes were improved following delivery of the Advanced Life Support in Obstetrics course in four low-income countries [23]. Additionally, evaluation of the Primary Trauma Course showed evidence of improved individual management of cases, and also resulted in beneficial effects at the participants' host institutions in terms of staffing, equipment and training [7]. The SAFE paediatric anaesthesia course was developed along the same lines as the SAFE obstetric anaesthesia course (9), with care taken to ensure the materials were tailored to the needs of participants. This project used a scaling-up method to implement training in five countries, using coaching and mentorship by experienced trainers to maintain the quality of the training delivered and strengthen existing international and regional partnerships.

There may be a number of limitations to our approach. The course was developed by physician anaesthetists, and the content may not be optimal for non-physician course participants. Feedback was obtained at all stages of course development to check relevance to the participants, and modified accordingly. Knowledge assessment using MCQ testing is only one measure of learning and, although piloted during course development, there may still have been limitations in both understanding of questions and MCQ technique. A possible factor for an improvement in the OSCE testing may be increased familiarity with the manikins during the course teaching, or unconscious bias by the assessors. We aimed to minimise this by ensuring that stations were standardised, and using a structured scoring system. Not all participants were visited in their workplace, and this may have introduced bias into follow-up data. However, significant effort was made to visit participants in a range of health facilities and grades. Finally, changes in behaviour described at follow-up were self-reported, and may be vulnerable to reporting bias. Course participants were not observed in the workplace before training, and no attempt

was made to collect patient outcomes before and after training. However, wherever possible, information that was reported was triangulated during the visit to the work environment. Translating knowledge into practice is an important outcome of training, and course participants provided specific examples of change in practice, with adoption of new procedures and protocols. Further research, therefore, should focus on collecting more evidence of behaviour change and influences on change, as well as linking behaviour change with impact on patient outcome.

In summary, the SAFE paediatric anaesthesia course is the first short course focusing on paediatric anaesthesia that is specifically designed for anaesthesia providers in LMICs. We describe successful implementation to providers from a range of hospital settings, resulting in improvements in knowledge and skills that were retained over time, as well as positive changes in behaviour at the institutional level. The SAFE paediatric anaesthesia course is an effective way to deliver training in paediatric anaesthesia, and could be adopted more widely to help strengthen emergency and essential surgical care for children as a component of universal health coverage in LMICs.

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Supporting Information

Additional supporting information may be found online in the Supporting Information section at the end of the article.

Appendix S1. SAFE Paediatric anaesthesia course structure.

Appendix S2. SAFE paediatric course follow-up questionnaire.