



## Original Article

# Global obstetric anaesthesia: bridging the gap in maternal health care inequities through partnership in education

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## ABSTRACT

Maternal mortality rates are unacceptably high globally. Low- and middle-income countries (LMICs) face challenges of an inadequate anaesthesia workforce, under-resourced healthcare systems and sub-optimal access to labour and delivery care, all of which negatively impact maternal and neonatal outcomes. In order to effect the changes in surgical-obstetric-anaesthesia workforce numbers advocated by the Lancet Commission on Global Surgery to support the UN sustainable development goals, mass training and upskilling of both physician and non-physician anaesthetists is imperative. The implementation of outreach programmes and partnerships across organisations and countries has already been shown to improve the provision of safe care to mothers and their babies, and these efforts should be continued. Short subspecialty courses and simulation training are two cornerstones of modern obstetric anaesthesia training in poorly resourced environments. This review discusses the challenges to accessing quality maternal healthcare in LMICs and the use of education, outreach, partnership and research to protect the most vulnerable women from coming to harm in the peripartum period.

## Introduction

The risk of death during, or as a result of, pregnancy remains unacceptably high. The Global Burden of Disease study reported that, in 2015, across 195 countries more than a quarter of a million women died during or after pregnancy, mostly from preventable or treatable causes.<sup>1</sup> The majority of maternal deaths continue to occur in low- and middle-income countries (LMICs), with 415 maternal deaths per 100 000 live births in these regions compared with 7–10 maternal deaths per 100 000 live births in Europe, Australia and New Zealand.<sup>2</sup> Disparity in maternal mortality rates (MMR) also exists between racial and ethnic groups within high-income countries, and whilst global MMR has decreased, the United States of America (USA) is experiencing an unprecedented increase in maternal deaths among non-Hispanic Black women.<sup>3,4</sup> The Mothers and Babies: Reducing Risk Through Audits and Confidential Enquiries across the UK, the MBRRACE-UK philosophy to “recognise and respect every maternal death as a young woman who has died before her time” looks beyond the numbers and demands a call to action to improve maternal outcomes globally.<sup>5</sup>

The World Health Organization (WHO) defines maternal mortality as death while pregnant or within 42 days of termination of pregnancy, irrespective of the duration and site of the pregnancy, from

any cause related to or aggravated by the pregnancy or its management but not from accidental or incidental causes. Maternal mortality may be due to direct obstetric causes, or indirect pre-existing conditions, and beyond the six-week period is recognised as a late maternal death.<sup>6</sup> The threat to pregnant women is, however, not limited to death alone. “Maternal near misses” are an indicator of maternal health-related outcomes defined as “a woman who nearly died but survived with a complication” in the same time-frame as defined for a mortality.<sup>7</sup> The ratio of maternal near misses to mortality has been proposed as a marker for measuring the quality of care provided to pregnant women. The United Nations (UN) Millennium Development Goal number 5 aimed to address issues related to poor maternal health care by reducing the global MMR by 75% by 2015. Whilst huge strides have been made to this end, there is still a long way to go.<sup>8</sup> The UN has further recognised that maternal health is paramount to sustainable global development, with the focus shifting to wellbeing and gender equality as we move towards 2030.<sup>9</sup>

As obstetric anaesthetists, we often find ourselves at the centre of the efforts to improve peripartum care. While striving to provide the best care for our patients on a daily basis, we also have to acknowledge the unyieldingly high MMR and the great disparity in maternal anaesthesia care that exists globally. To that end, the questions we should

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strive to answer in our daily practice are: 1. how do we improve access to quality maternal healthcare; and 2. what mechanisms do we have in place to educate and strengthen our anaesthesia workforce, in an attempt to save mothers' lives?

### Access to quality maternal care

Worldwide, the most common point of intersect between anaesthesia providers and pregnant women is the operating theatre, a stage upon which lives may be either saved or lost. Caesarean delivery (CD) is recommended as an essential surgical service by the Lancet Commission on Global Surgery, but access to, and the quality of, this procedure are not uniformly equal for all women.<sup>10</sup> The African Surgical Outcomes Study obstetric data highlighted the fact that women in Africa are 50 times more likely to die after CD than their counterparts in high-income countries (HICs).<sup>11</sup> The most common causes of death for these women are attributed to major obstetric haemorrhage and anaesthesia complications. Caesarean delivery rates are on the rise globally, a rise that inevitably involves anaesthesia provision. In a recent report on global CD trends, data from 169 countries, representing 98.4% of the world's births, estimated that in 2015 there were 29.7 million CDs (21.1%, 95% CI 19.9 to 22.4), almost double the 16.0 million (12.1%, 95% CI 1.9 to 13.3) reported in 2000.<sup>12</sup> The increase was influenced by a rise in facility-based births and by more CDs conducted within facilities.<sup>13</sup> The WHO recommends a CD rate of 10% at a population level in order to effect changes in MMR.<sup>12</sup> There is a huge variation in CD rates, with under- and over-utilisation, between, and within, LMICs. In Latin America and the Caribbean, CD is 10-fold higher (44.3%) than in West and Central Africa (4.1%). It is also higher among wealthy and educated women, in urban areas, and in private hospitals, particularly in Brazil and China.<sup>12,14</sup>

Operative delivery can be life-saving, especially for conditions such as antepartum haemorrhage and fetal distress, however in some LMICs, CD is in part driven by non-medical indications, possibly leading to unnecessary complications.<sup>12,13</sup> Caesarean delivery is associated with higher maternal mortality and morbidity (from haemorrhage, infection, and thrombo-embolism) compared with vaginal birth and leads to future risks for abnormal placentation such as placenta praevia and placenta accreta spectrum disorder in subsequent pregnancies. A systematic review and meta-analysis of 116 studies from LMICs reported that the risk of maternal death during CD was higher in low-income than in middle-income countries ( $P = 0.012$ ) and in teaching and tertiary hospitals ( $P = 0.014$ ). For every 1000 women undergoing a CD in LMICs, nearly eight died (7.6, 95% CI 6.6 to 8.6).<sup>15</sup> Women undergoing emergency CD in LMICs were twice as likely to die as those delivering by elective CD. A third (32%, 95% CI 27% to 37%) of all maternal deaths following CD were attributed to postpartum haemorrhage (PPH).<sup>15</sup> This is supported by the findings of the African Surgical Outcomes Study where haemorrhage accounted for 70% of complications and 25% of maternal deaths.<sup>11</sup>

Global Surgery 2030 defines access to timely essential surgery as the "proportion of the population that can access, within two hours, a facility that can do caesarean delivery, laparotomy, and treatment of open fracture (the Bellwether Procedures)" and aims to achieve a minimum of 80% surgical and anaesthesia cover, per country, by 2030.<sup>10</sup> Low CD rates, whilst massively problematic, do not tell the whole story. Assessment of access to emergency obstetric care in Uganda, Kenya, South Sudan and Rwanda reported that as few as 2.0–18.5% of expected direct obstetric complications are treated.<sup>16</sup> The improvement of access for women in LMICs is reliant on scaling up of care to an extent which is, unfortunately, unlikely to happen by 2030. The escalation and development of health infrastructure is inextricably tied to financial means. Mongolia has, through partnership between the Mongolian Society of Anaesthesiologists and the World Federation of Societies of Anaesthesiologists (WFSA), improved

access to anaesthesia and surgical care dramatically, making it a "high performing LMIC."<sup>10,17</sup> Between 2008 and 2015 surgical mortality in Mongolia has decreased by >50%, from 0.53% to 0.2%. Whilst this is likely multifactorial, Mongolian physician anaesthetist numbers had almost doubled, from 106 in the early 2000s to 200 in 2017, or 6.76 per 100 000 population. This may have had a role to play.<sup>17</sup> In order to match this level of scale-up of surgical services, including CD, would cost 420 billion dollars for 88 LMICs. Sadly, this represents only 1% of total annual health care expenditure of upper middle-income countries.<sup>10</sup>

The barriers to access to intrapartum care have been described using the three-delay model.<sup>18</sup> The three critical phases at which interventions should be aimed are: 1. the delay in the decision to seek care; 2. the delay in identifying and reaching a healthcare facility; and 3. the delay in receiving appropriate therapy after arrival at a healthcare facility. These delays often result in sub-optimised high-risk parturients presenting for urgent CD to facilities which are grossly under-resourced. This compounds the barriers to safe anaesthesia care presented by workforce shortages and inadequate training. The aim of the model is to attempt to prevent maternal deaths in a three-tiered approach at a household, community and health systems level. It is clear then that in order to improve access to essential life-saving care and procedures for women and their babies, some creativity and innovation is necessary. We will examine the anaesthesia workforce, education, and training and outreach partnerships as a means of bridging the equity gap in maternal care for parturients in LMICs.

### The anaesthesia workforce

Access to care is heavily reliant on a dense and functional surgical – obstetric – anaesthesia (SOA) workforce. The WFSA recommends that, in order to achieve a moderate increase in anaesthesia services in LMICs, a physician anaesthesia provider density of 5 per 100 000 population should be targeted.<sup>19</sup> A global workforce survey performed by the WFSA from 2015–2016 collected data from 153 countries, representing 97.5% of the global population. The authors report a global anaesthesia workforce density of 6.09 providers per 100 000 population, however when considering workforce density, 77 countries had a workforce density less than the recommended 5 per 100 000. Physician anaesthesia providers comprised 355 381 (81.4%) anaesthesiologists, 71 990 trainee anaesthesiologists (16.5%), and 9225 (2.1%) non-specialist physician providers.<sup>20</sup> The global distribution of physician anaesthesia providers is shown in Fig. 1.

A systematic review revealed that, in LMIC, the availability of trained anaesthesiologists ranged from 0 to 4.9 per 100 000, well short of the WFSA goal.<sup>21</sup> The anaesthesia workforce needs to be up-scaled in numbers, but efforts should also be made to ensure ongoing training and education, development of professional societies and implementation of regulatory mechanisms, with active attention paid to recruitment and retention of skilled staff. Global surgery 2030 aims to attain an SOA density of 20 practitioners per 100 000 population by the year 2030. In order to achieve this, for LMICs, it equates to the training of an additional 1.27 million practitioners globally, at a cost which cannot be absorbed by these regions independently.<sup>10</sup>

The paucity of physician anaesthetists, in areas other than large medical centres, may contribute to the higher MMR in LMICs, where anaesthesia is a leading cause of maternal deaths.<sup>15</sup> In South Africa, the Confidential Enquiry into Maternal Deaths for the 2014–2017 triennium revealed that whilst the overall MMR has decreased, the deaths attributable to anaesthesia had increased alarmingly and that 71% of these were directly related to the lack of availability of a skilled medical practitioner.<sup>22</sup> Anaesthetic complications account for 10% of maternal deaths in Africa.<sup>11</sup> The risks of general anaesthesia in pregnant women are well documented. Parturients are at increased risk of peri-procedural aspiration,<sup>23</sup> and have an 8-fold increased risk of

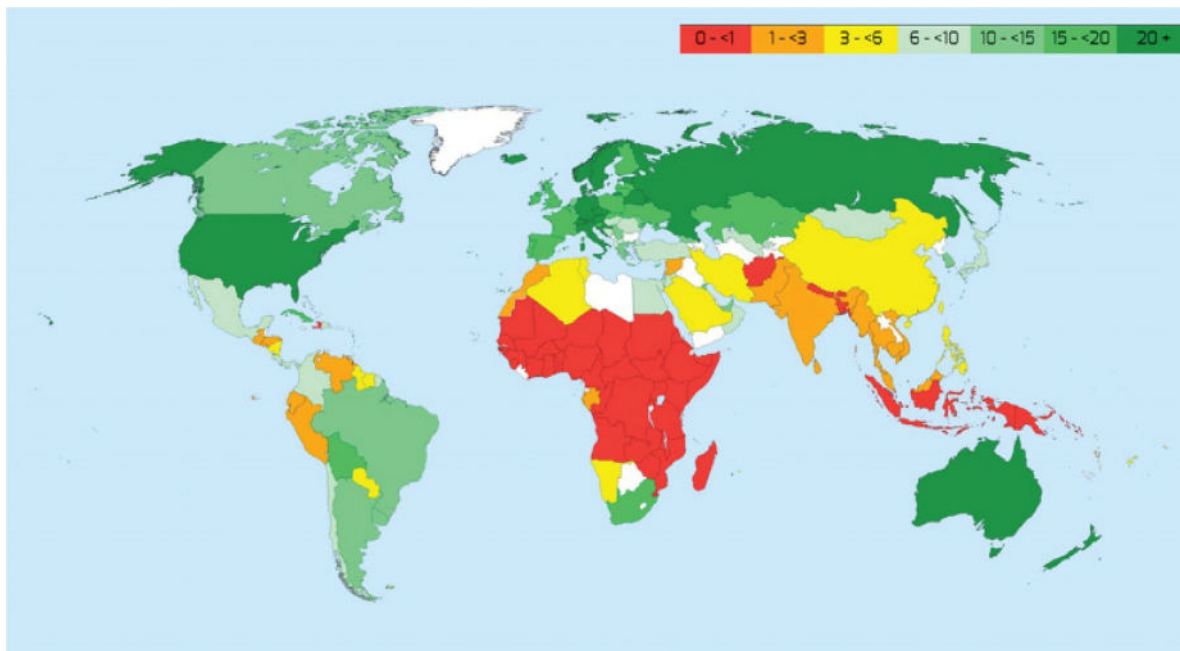


Fig. 1. Global distribution of physician anaesthesia providers per 100 000 population. White indicates no data. Taken from Kempthorne P, Morriss WW, Mellin-Olsen J, Gore-Booth J. The WFSA Global Anesthesia Workforce Survey. *Anesth Analg*. 2017;125:981–990

failed intubation.<sup>23–25</sup> In a systematic review and meta-analysis, Sobhy et al. report that anaesthesia related deaths occur more frequently when women undergo general rather than regional anaesthesia for CD.<sup>15</sup> These deaths are largely preventable with adequate training and availability of skilled providers.

In low resource countries the majority of anaesthetic care is provided by non-physician anaesthesia providers (NPAPs).<sup>26–28</sup> This term encompasses nurse anaesthetists, anaesthesia technicians or anaesthesia officers. Task shifting/sharing is defined by the WHO as moving tasks from high-skilled workers to workers with less experience in order to maximise the human resources available,<sup>29</sup> and enables hundreds of countries to meet the surgical demands of their population. Globally, training of NPAPs varies considerably.<sup>30–32</sup> Despite the high pre-operative maternal risk profile and complication rates, 23% of the anaesthetics for CD in the African Surgical Outcomes Study were administered by NPAPs.<sup>11</sup> It has been shown repeatedly that anaesthesia care provided by NPAPs in low resource settings results in worse maternal and neonatal outcomes at CD.<sup>11,27,33</sup> The difference between physician and NPAPs is, however, not evident for HICs, which speaks to the quality of training received by NPAPs in these regions where a task sharing, rather than shifting, model is followed.<sup>32,34</sup> Task sharing, as advocated for by the Lancet Commission on Global Surgery, implies that a qualified specialist anaesthetist takes on a mentorship role, and is heavily involved in the training and often direct supervision of NPAPs.<sup>10</sup> This model remains limited, however, by its requirement for an increase in the numbers of physician anaesthetists in order to provide continued training and supervision to NPAP colleagues.

## Training and education

### Improvement of skilled anaesthesia services

It is clear then that in order to improve access to adequate care and thereby effect a change in maternal outcomes, there is growing pressure to focus on the training and upskilling of both physician and non-physician anaesthesia providers. Anaesthesia curricula are non-uniform globally, and huge discrepancies in exposure and skill development between well- and scarcely-resourced areas exist. The

development of new anaesthesia curricula is a huge undertaking requiring strong anaesthesia leadership, international collaboration and funding.<sup>35,36</sup> Integral to the development of functional education systems and sustainable curricula is a strong leadership structure in the form of anaesthesia societies and regulatory bodies, a notion supported by WFSA.<sup>37</sup> The College of Anaesthesiologists for East, Central and Southern Africa (CANECSA), established in 2014, aims to provide this structure for 10 Sub-Saharan countries (Burundi, Ethiopia, Kenya, Malawi, Mozambique, Rwanda, Tanzania, Uganda, Zambia, and Zimbabwe), but faces the challenge of having very few specialist members who are able to implement curricular changes in their respective countries.<sup>37</sup> Other LMICs such as Mongolia, however, have managed to forge a successful path and established a successful society with the partnership and support of both the Australian Society of Anaesthetists and WFSA. In 2008 the Mongolian Society of Anaesthesia (MSA) steering committee together with the Australian Society of Anaesthetists developed a strategic plan for the development of anaesthesia services and training. They identified the need to apply context-sensitive education interventions, engaging with local stakeholders and thereby ensuring sustainability of a culturally sensitive anaesthesia education system that best serves the individual community.<sup>17</sup>

Morris et al. have previously described the education paradox in LMICs, namely “Health workers in the places that most need to train people do not have the time or resources to do it”.<sup>37</sup> In these resource-limited settings we encounter three main training categories: 1. countries with no organised training programme and very few specialist anaesthetists; 2. countries with an established, organised training programme but who have significant educational needs and a limited number of specialists; and 3. countries with an organised training programme and adequate trainers but lacking in skills, oversight or resources.<sup>36</sup> The regions where organised training programme are established vary significantly in their entry criteria, length of training and content taught, without sufficient regulation by independent bodies.<sup>38</sup> Modern medical educational models emphasise the importance of competency-based training, that is the acquisition of knowledge is deemed useless if the student is unable to apply that knowledge in a manner that translates to quality patient care.<sup>39</sup> Essential competencies in anaesthesia extend beyond clinical knowledge acquired to good

communication, situational awareness, effective teamwork and other non-technical skills. The development of a competency-based curriculum, however, is once again dependent on strong national anaesthesia leadership, local faculty development and regulatory bodies, to ensure the highest standard of training is upheld.<sup>40,41</sup>

#### *The Safer Anaesthesia from Education (SAFE) obstetrics refresher short course*

The question remains: how do we best educate skilled obstetric anaesthesia providers? The training of sub-specialist anaesthetists and NPAPs will differ, but there are core similarities which apply to both subsets of healthcare providers. Short sub-specialty courses are a vehicle for knowledge and skills transfer on a large scale. There is a body of evidence to suggest that in LMICs sub-specialty courses, including those in obstetric anaesthesia, bridge the gaps which exist in anaesthesia education, although there are no good quality long-term follow up studies on their effects on patient outcomes.<sup>42</sup>

Perhaps the most prominent and well-studied short course for obstetric anaesthesia education is the Safer Anaesthesia From Education – Obstetrics (SAFE-OB) course.<sup>42–44</sup> This course has been implemented in 47 countries, and to date has trained 3846 people in delivering obstetric and paediatric anaesthesia, as well as training 1164 trainers (personal communication, WFSA, January 2023). The SAFE-OB course was developed by the Association of Anaesthetists of Great Britain and Ireland in conjunction with WFSA in 2010, and the first course was conducted in Uganda in 2011. Aimed at both physician and NPAPs, the course has a modular approach to the common issues identified as contributing to an increase in maternal morbidity and mortality. Over three days candidates engage with the topics presented through a combination of traditional and modern educational methods such as didactic lectures, small group learning sessions, simulation-based training and self-reflection. Course lecturers are often from outside the centre where the programme is being offered, and language barriers are a challenge. Short lectures with visual aids aim to bridge the gap. While the main focus of the programme is the delivery of safe anaesthesia through the acquisition of clinical skill and knowledge, there is also emphasis on the development of non-technical skills and improving communication. The basic outline of the course is predefined, however providers are able to tailor content somewhat to suit the context of their learners and environment. The core topics covered in each course are presented in [Table 1](#).

Importantly, sustainability of skills development and ongoing training is ensured through a “Training of Trainers” component at each course. These workshops identify local leaders in anaesthesia who are able to continue obstetric anaesthesia education in their institutions long after the course has been completed, thus increasing the capacity of safe anaesthesia providers in poorly resourced settings. The SAFE-OB course is also distinct in having a robust monitoring and evaluation system. Participants are evaluated via pre-and post-course multiple choice questionnaires and skills tests. Ongoing post-course learning is encouraged through peer support, reflective journals and a log-book, discussion of challenging cases with colleagues in similarly resourced settings, and working towards context-sensitive solutions to improve maternal healthcare. Since its implementation in

2010, SAFE-OB has been presented in a number of African countries including Rwanda, Democratic Republic of Congo, Madagascar and Ethiopia, amongst others. Evaluation of both the short- and longer-term effects of course attendance have shown that the personal and organisational changes and retention of knowledge is maintained at 12–18 months post-participation, while participants report improved confidence, teamwork and communication at follow-up.<sup>37,45,46</sup>

#### *Simulation training in obstetric anaesthesia*

Central to modern anaesthesia training is the utilisation of simulated scenarios in order to teach critical knowledge and develop non-technical skills, particularly for emergency situations that carry a high risk of patient morbidity and mortality.<sup>47,48</sup> Simulation training lends itself particularly well to education in obstetric anaesthesia, and has been shown to improve skill and result in sustained knowledge retention amongst obstetric anaesthesia residents in HICs.<sup>49,50</sup> Repeated sessions performing general anaesthesia for CD on a patient simulator up-skilled residents to the skill and knowledge level of an attending anaesthesiologist, and participants retained the skill at eight months post initial training.<sup>50</sup> Scavone et al. used similar simulation models to not only train residents, but to evaluate competency in the performance of general anaesthesia for CD, a skill which is generally underdeveloped due to regional anaesthesia being more often employed in real life practice.<sup>51</sup> These studies, however, were conducted in highly specialised university simulation centres able to create an obstetric theatre environment with a high fidelity life-sized patient computerised mannequin. In poorly resourced environments access to these advanced educational tools is near impossible.

It is not, however, always necessary to perform simulation training in a high-tech, high-fidelity environment. Inexpensive, readily available supplies can be used to create low-cost, immersive simulations which still carry high-fidelity benefits.<sup>52</sup> Using nothing more than a basic mannequin and a hollowed-out cantaloupe melon to simulate an atonic uterus and obstetric haemorrhage scenario for resident trainees, Ramseyer et al. showed that all participants reported a perceived improved competency in managing the emergency at hand.<sup>53</sup> The Vital Anaesthesia Simulation Training (VAST) is a three-day course which utilises low-fidelity simulation to provide multidisciplinary training in anaesthesia and resuscitation for obstetrics, paediatrics and trauma, as well as safe general surgery and pre- and post-operative care, with an underlining focus on non-technical skills. The VAST course simulates activity at the district level hospital in a poorly resourced setting.<sup>54</sup> Alexander et al. used simulation to test the usability of a context-relevant obstetric anaesthesia checklist for CD specific to two commonly encountered obstetric emergencies in LMICs, namely pre-eclampsia and postpartum haemorrhage. Simulations carried out amongst nurse anaesthetist students in Kenya showed that the implementation of the obstetric crisis checklist improved performance in a high-fidelity simulation environment. The authors compared practice with that observed in the clinical setting without the checklist, and found an improvement in the preparation for and management of CD, as well as improved adherence to the management steps for the emergencies studied.<sup>55</sup> As simulation develops in anaesthesia and obstetric education programmes, these types of collaborative interventions to train diverse groups of physician and non-physician healthcare providers involved in the peripartum care of women and their babies should be implemented in an attempt to improve maternal and neonatal outcomes.

#### **Global outreach and partnership**

Throughout this text we have explored the concepts of collaboration, co-ordination and competency-based training as the cornerstones of developing a self-sustaining anaesthesia workforce. The Lancet

**Table 1**

Core topics presented in the WFSA SAFE-OB course

Pre-operative preparation	General anaesthesia	Pre-eclampsia and eclampsia
Airway assessment	Spinal anaesthesia	Neonatal resuscitation
Difficult airway	Critical care and resuscitation	WHO Surgical checklist
Anaesthesia for obstetric emergencies	Obstetric haemorrhage	Teamwork and communication

Commission on Global Surgery advocates for the development of National Surgical Obstetric and Anaesthesia Plans (NSOAPs). These plans aim to identify the health care priorities of the region and align educational efforts to these needs.<sup>10</sup> Some LMICs are, unfortunately, unable to effect the changes to training, workforce structure and access to care necessary to improve the situation for women of child-bearing age entirely on their own. As alluded to, the financial means, health-care leadership and infrastructural needs are just not available to the most poorly resourced areas in which the greatest need for improvement of care exists. There are multiple instances of such successful partnerships and support systems between HICs and LMICs, each with their own strengths and weaknesses.

Kybele, Inc. is a non-governmental organisation founded in 2001 to improve childbirth safety in LMICs through on-site, hands-on, educational partnerships. It is a multinational, interdisciplinary organisation with teams composed of obstetric anaesthesiologists, obstetricians, neonatologists, nurses, midwives, implementation scientists, and others. Kybele works collaboratively with government and/or local hospital leaders to develop country-specific programmes designed to impact national healthcare standards. Challenges and solutions are jointly identified at the local level in countries with sufficient infrastructure to sustain progress after training. Programmes have included training in advanced clinical techniques such as spinal and epidural anaesthesia, obstetric ultrasound, neonatal resuscitation, clinical guideline development, quality improvement, advocacy, and research. Kybele has accumulated wide-ranging experience with high-level results through successful operations in LMICs countries. The frequent aims of the collaborations were to increase the use of labour analgesia and regional anaesthesia for CD in targeted hospitals, to increase the availability of medication and supplies through proper local channels, and to introduce evidence-based standards of care.<sup>56</sup>

Kybele works within and through the local infrastructure to promote change. To illustrate, Kybele conducted a programme in the Republic of Georgia from 2006-2009 to encourage the use of regional anaesthesia techniques for labour analgesia and CD.<sup>57</sup> At the onset of the programme, 10% lidocaine was the only local anaesthetic available and regional anaesthesia was seldom used. Kybele sought permission from Ministry of Health officials initially to bring bupivacaine, ephedrine and other supplies into the country for teaching demonstrations. Local physicians saw the immediate benefit of regional anaesthesia techniques and joint advocacy persuaded the Health Ministry to include these medications on the national formulary. As a result, regional anaesthesia techniques significantly increased, supply chains improved and costs for epidural kits and spinal needles decreased across the country. Had Kybele operatives continued to bring in supplies, the vast improvements may have never materialised. Similarly, in Armenia, a five-year partnership culminated in a significant increase in the use of regional anaesthesia for CD and the development of national guidelines in obstetric anaesthesia, the first guidelines for any field of medicine in the country.<sup>58</sup> These mentorship programmes have not only benefited LMICs. Eight Croatian hospitals demonstrated a significant increase in their rates of neuraxial anaesthesia for CD after a two-week Kybele outreach programme was conducted.<sup>59</sup> Kybele typically conducts one- to two-week training programmes at regular intervals in a country over several years. This builds relationships and trust with local hosts, encouraging long-term sustainability. It is vitally important to observe medical practices within host hospitals as care is actually provided: only there can gaps between theoretical knowledge and practical application be observed. Individuals involved both teach and learn in global health settings through the provision of clinical care, education, equipment distribution, and research. It is imperative that these endeavours primarily benefit the needs of the host community, as voiced by the host community, and not the needs and egos of the donors. To be most effective, teaching must be tailored to the environment, teachers must be flexible and adaptable to unfamiliar and austere settings, local champions must

be found to be the ultimate change agents, and ongoing commitment and continuity are encouraged. This ultimately requires personal commitment of participants beyond the excitement of the initial interaction and a willingness to repeat the journey, often sacrificing vacation and personal time.<sup>56</sup> Since September 2004, Kybele has enlisted 377 trainers from 110 institutions to conduct 129 missions or site visits to 19 LMICs. Nearly half of these individuals have made multiple visits, building a task force of globally minded healthcare professionals, committed to improving the well-being of pregnant patients and their newborns. Kybele has additionally sponsored more than 30 physician and midwife leaders for observational visits to North American- and UK-based institutions to further build relationships and broaden learning opportunities.

Whilst the Kybele organisation provides outreach to many countries, other models also exist for maintaining long-standing partnerships between one HIC and one LMIC. For more than 20 years Belgium has provided outreach assistance to Abomey-Calavi University in Cotonou, Republic of Benin, training anaesthesia specialists for Sub-Saharan, French-speaking African countries. The training programme, funded almost entirely by the Belgian government, spans four years, one year of which is spent in a better-resourced environment, often a French-speaking European hospital. 'Teaching missions' carried out three times a year by Belgian educators impart clinical knowledge but also support local coordinators. By 2018 the Cotonou program had trained 123 specialist anaesthesiologists, and it runs a centre for the training of nurses as NPAPs. Graduates have gone on to train NPAPs in Burkina Faso, Chad, Congo, Gabon, Haiti, Mali, Niger, and Togo, contributing to the growth of a sustainable pool of competent anaesthesia providers in the region. A major issue remains retention of skilled workers, with 18% of programme trainees lost to France post-qualification.<sup>60</sup> Migration of skilled anaesthesia providers out of poorly resourced environments remains a challenge for many LMICs. Another excellent example of global partnership is detailed in the Rwandan experience of establishing an anaesthesia curriculum.<sup>35</sup> After its civil war, Rwanda found itself bereft of specialist anaesthesia practitioners: in 1994 there was only one fully trained anaesthesiologist in the country. The Canadian Anaesthesiologists' Society International Education Foundation (CASIEF) and the Global Humanitarian Outreach Committee developed a collaborative relationship with Rwanda in 2006, and in 2012 a Rwandan anaesthesia curriculum was created. The programme now enrolls up to 15 anaesthesia students a year. Residents in the programme are able to participate in short-term electives in Canada, and are tasked with training colleagues, NPAPs and teaching at WFSA-approved courses. While CASIEF provides ongoing support, the programme is now entirely led by Rwandans.

The WFSA continues to work to improve education, training and clinical services in LMICs. The WFSA fellowship program allows trainees to embark on clinical attachments, including in obstetric anaesthesia, for up to 12 months. Trainees are encouraged to apply for fellowships in areas close to their base hospital. Obstetric anaesthesia fellowships have been offered in Malaysia, Morocco, Nigeria and Colombia.<sup>61</sup>

## Research and innovation

Apart from education, global health research partnerships are equally important for improving obstetric outcomes. For example, the WOMAN trial found that the early administration of tranexamic acid reduced deaths due to bleeding from postpartum hemorrhage (PPH) by one third.<sup>62</sup> Based on these findings, WHO recommended the early use of tranexamic acid in PPH.<sup>63</sup> The WOMAN trial was an international, multicentre trial, and most of the trial sites were in LMICs, making it a classic example of research collaboration between HICs and LMICs.

The African Surgical Outcomes Study showed that hypertensive disorders were the leading cause of maternal deaths after CD.<sup>11</sup> This indicates that collaborative clinical trials are also needed for hypertensive disorders of pregnancy. A retrospective audit found that for eclamptic patients undergoing CD, neuraxial anesthesia was superior to general anesthesia in terms of maternal and neonatal outcomes, but the evidence was weak.<sup>64</sup> Therefore, a multicentre randomised clinical trial would be an ideal study design to prove or refute the above hypothesis. However, it is impossible for researchers from LMICs to conduct a large-scale clinical trial due to a lack of research capacity, resources, and funding. Consequently, global health research grants and projects are desperately needed to improve the health and wellbeing of patients in LMICs.

The use of novel and innovative techniques such as e-logbooks, tele-medicine, and virtual reality may strengthen the quality and safety of obstetric practices. A hybrid distance-blended learning course was conducted in Nepal, in which initially a team of physician anaesthesiologists from Nepal and overseas trained the NPAPs working in rural parts of the country. Later, tablet e-logbooks were provided to the participants to record their cases and discuss the management of difficult cases with their assigned mentors. A total of 4143 cases were e-logged by the 14 NPAPs during the study period, of which 34% were related to CD. Eighteen patients required general anaesthesia for CD, and there were no anaesthesia-related deaths. The authors suggested that such a modality of training should be incorporated into the continuous professional development of healthcare professionals providing anaesthesia in rural areas.<sup>65</sup>

## Conclusion

Looking to the future, unacceptably high rates of maternal mortality must be addressed as a global obstetric and anaesthesia priority. This is particularly true for LMICs, which face challenges of an inadequate anaesthesia workforce, under-resourced healthcare systems and sub-optimal access to labour and delivery care, all of which may negatively impact maternal and neonatal outcomes. In order to effect the changes in surgical-obstetric-anaesthesia workforce numbers suggested by the Lancet Commission on Global Surgery to support the UN sustainable development goals, mass training and upskilling of both physician and non-physician anaesthetists is imperative. The implementation of outreach programmes and partnerships across organisations and countries has already been shown to improve the provision of safe care to mothers and their babies, and these efforts should be continued. Short subspecialty courses and simulation training are two cornerstones of modern obstetric anaesthesia training in poorly resourced environments. However, creativity in education should be used to broaden and deepen anaesthesia knowledge and safety in the regions where it is most needed. Novel interventions, adapted to the context of the learner, may be our only way forward. The time has come to use education, outreach, partnership and research as tools to protect the most vulnerable women amongst us from coming to harm in the peripartum period.

## Declaration of interests

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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