World J Surg (2015) 39:856–864
DOI 10.1007/s00268-014-2638-4

# Perioperative Mortality Rate (POMR): A Global Indicator of Access to Safe Surgery and Anaesthesia

**David A. Watters · Michael J. Hollands · Russell L. Gruen · Kiki Maoate · Haydn Perndt · Robert J. McDougall · Wayne W. Morriss · Viliami Tangi · Kathleen M. Casey · Kelly A. McQueen**

Published online: 20 May 2014


**Abstract**

*Introduction* The unmet global burden of surgical disease is substantial. Currently, two billion people do not have access to emergency and essential surgical care. This results in unnecessary deaths from injury, infection, complications of pregnancy, and abdominal emergencies. Inadequately treated surgical disease results in disability, and many children suffer deformity without corrective surgery.

*Methods* A consensus meeting was held between representatives of Surgical and Anaesthetic Colleges and Societies to obtain agreement about which indicators were the most appropriate and credible. The literature and state of national reporting of perioperative mortality rates was reviewed by the authors.

*Results* There is a need for a credible national and/or regional indicator that is relevant to emergency and essential surgical care. We recommend introducing the perioperative mortality rate (POMR) as an indicator of access to and safety of surgery and anaesthesia. POMR should be measured at two time periods: death on the day of surgery and death before discharge from hospital or within 30 days of the procedure, whichever is sooner. The rate should be expressed as the number of deaths (numerator) over the number of procedures (denominator). The option of before-discharge or 30 days is practical for those low- to middle-income countries where postdischarge follow-up is likely to be incomplete, but it allows those that currently can report 30-day mortality rates to continue to do so. Clinical interpretation of POMR at a hospital or health service level will be facilitated by risk stratification

D. A. Watters (✉)
Deakin University and Barwon Health, Royal Australasian College of Surgeons, 1 Spring Street, Melbourne, VIC 3000, Australia
e-mail: watters.david@gmail.com

M. J. Hollands
Royal Australasian College of Surgeons, 1 Spring Street, Melbourne, VIC 3000, Australia

R. L. Gruen
Royal Australasian College of Surgeons, National Trauma Research Institute, Level 4, 89 Commercial Road, Melbourne, VIC, Australia

K. Maoate
Children's Specialist Centre, 58 Colombo Street, Cashmere, Christchurch, New Zealand

H. Perndt
School of Medicine, Royal Hobart Hospital, The University of Tasmania, GPO Box 1061 L, Hobart, TAS, Australia

R. J. McDougall
The Royal Children's Hospital Melbourne, Flemington Road, Parkville, Melbourne, VIC, Australia

W. W. Morriss
Christchurch Hospital, Riccarton Avenue, Addington, Christchurch, New Zealand

V. Tangi
Ministry of Health, Taufa'ahau Road, Nuku'alofa, Tonga

K. M. Casey
American College of Surgeons, 633 N. Saint Clair Street, Chicago, IL, USA

K. A. McQueen
Vanderbilt University Medical Centre, 1211 Medical Centre Drive, Nashville, TN, USA

using age, urgency (elective and emergency), procedure/procedure group, and the American Society of Anesthesiologists grade.

*Conclusions* POMR should be reported as a health indicator by all countries and regions of the world. POMR reporting is feasible, credible, achieves a consensus of acceptance for reporting at national level. Hospital and Service level POMR requires interpretation using simple measures of risk adjustment such as urgency, age, the condition being treated or the procedure being performed and ASA status.

## Introduction

A significant proportion of the global burden of surgical disease is treatable [1–3]. Someone in need of emergency or essential surgery has no therapeutic alternative to a surgical procedure. Thus, adequate primary health care for such patients demands a triage and referral system that leads to a timely operation and, with it, the safe administration of anaesthesia. Such a system will result in fewer deaths and a better chance of living without deformity or disability.

In many low- and middle-income countries (LMICs), the infrastructure, facilities, and expertise are inadequate to deliver needed essential or emergency surgical procedures and safe anaesthesia. Only 8.1 million (3.5 %) of the world's 230 million surgical procedures performed annually take place in LMICs [4], whilst it is estimated that 2 billion of the world's 7 billion people do not have access to safe surgery and anaesthesia. Each year this results in an estimated 60,000 unnecessary maternal deaths (25 % of 250,000 per annum) [1]. There are 2 million potentially avoidable deaths amongst the 5 million annual deaths due to injury [5], and many more among the growing burden of noncommunicable diseases such as cardiovascular disease, diabetes, and cancer, some of which can be ameliorated by surgery [1–3, 6]. If the anaesthesia-associated mortality rate is about 1:500 in developing countries [7], and half of the deaths were avoidable, we estimate each year there are 35,000 avoidable anaesthetic deaths among the 35 million operations in LMICs.

In the last two decades (1995–2014) the Millennium Development Goals (MDG) defined the key global strategies, including health interventions, that impacted economic well-being. While the MDGs were based on an appreciation of health needs of the early 1990s, the exclusive commitment to these goals in many LMICs resulted in scant attention to the diagnosis and treatment of surgical disease. Surgery and anaesthesia were only broadly and inferentially included under MDG 6, which contained the goal of treating "other diseases." Even the provision of emergency surgery was largely neglected, and nowhere is this more obvious than for MDG 5, which addressed maternal health, including the widely accepted metric of maternal mortality rates (MMR). Despite considerable improvements in MMR as a result of recommendations for prenatal assessment and the presence of a skilled birth attendant, further significant reductions in maternal mortality will be limited without addressing access to and safety of surgery and anaesthesia for the 15 % of pregnancies that require a procedure to manage the complications of preeclampsia, obstructed labour, or haemorrhage. In the absence of safe surgery and anaesthesia, entire communities bear the burden of disability, deformity, and death from pregnancy.

Strengthening surgical care in LMICs requires both improving access to surgical and anaesthetic services and improving the safety of those services. Little is known about surgical and anaesthetic outcomes in LMICs as these are not formally reported [8, 9]. As the United Nations [10], World Health Organization (WHO), and Ministries of Health prepare to define post-2015 global health priorities under the umbrella of universal health coverage, specific goals for access to and safety of surgery and anaesthesia are needed. In this article we describe how a key indicator of safety—the perioperative mortality rate (POMR)—may be used to improve the quality of care received by patients everywhere, and especially in resource-poor settings.

## The perioperative mortality rate (POMR)

Global health metrics are usually summarized using health indices. Some, such as life expectancy and infant and MMR, are often used as proxy measures for overall health status. These indices enable comparisons of the causes of ill health and benchmarking of the impact of health interventions. Health indicators provide data for evaluation of population health at all levels—local, national, regional, and global.

Surgical disease affects both genders and all decades of life. Therefore, a health index applicable to surgery has been challenging to define, even more so because surgery covers a diverse range of conditions and diseases. However, a "surgical" health index is necessary for the evaluation and ultimate improvement of surgical and anaesthetic interventions directed at the burden of surgical disease. The POMR has been proposed by several independent groups interested in surgical and anaesthesia outcomes [7, 11, 12], and we advocate that the POMR should be recognized as a health indicator of the quality and safety of surgery and anaesthesia.

The POMR is defined as death following surgery and anaesthesia within two time periods: on the day of surgery (including death in the operating theatre) and before

**Table 1** Measuring perioperative mortality rates

| | Definition | Rationale for use | Data sources | Comments |
|---|---|---|---|---|
| Number of surgical procedures done in an operating room per year | The absolute number of all surgical procedures, defined as the incision, excision, or manipulation of tissue that requires regional or general anaesthesia or profound sedation to control pain, undertaken in an operating room | Surgical volume is an indication of the access to and use of health care, particularly surgical services | Hospital records and routine health service statistics | Invasive procedures that meet the definition but are done in a procedure room not suitable for more extensive operations should not be considered in the total number of surgical procedures. If, however, they are done in the operating room, they should be counted |
| Day-of-surgery death ratio | Number of deaths on the day of surgery, irrespective of cause, divided by the number of surgical procedures in a given year or period, reported as a percentage | Day-of-surgery death ratios allow the health system to assess its performance and the state of health of the population | Administrative and hospital records based on health service statistics | Death on the day of surgery often reflects the comorbidities and physiological disorders of the patient, the quality and complexity of surgical care, or the risks of anaesthesia. It cannot be used to compare one site, facility, or country with another without appropriate, validated, and time-consuming risk adjustment |
| Perioperative in-hospital death ratio | Number of deaths in the hospital following surgery, irrespective of cause and limited to 30 days, divided by the number of surgical procedures done in a given year or period, reported as a percentage | Understanding the in-hospital death ratio after surgery provides insight into the risks associated with surgical intervention | Administrative and hospital records based on health service statistics | Patients who undergo surgery and die outside a health facility or after readmission to the same or a different facility are important to record in postoperative mortality assessments. Facilities should be encouraged to gather such information. Neither circumstance is included in this statistic, however |

Table has been adapted from Weiser et al. [7]. A procedure is included in the count if it is performed within an operating facility and requires the administration of sedation or anaesthesia, whether local, regional, or general. To better interpret the contribution that a procedure makes to risk, the determining procedure ideally should be the first definitive procedure that a patient receives during an episode of care

discharge from hospital or within 30 days of surgery, whichever is sooner. These definitions of perioperative mortality have been previously proposed by the Safe Surgery Saves Lives initiative of WHO's Patient Safety Programme [13]. While the POMR, like MMR and other critical health indices, is not specific, it has the potential to be a valuable indication of surgical and anaesthesia safety. The two death measurements represent two standardized public health metrics for surgical care that are applicable worldwide and are further defined in Table 1 [7].

The POMR is expected to transcend country and cultural issues and allow comparison within and between countries and regions, with the potential to be used in similar fashion to the MMR.

## Measuring POMR

POMR has the advantage that its numerator, death, is easily defined, and even in the most remote locations, it is either already recorded or there is great value in doing so. The denominator is the number of procedures. A procedure is defined as one that takes place in an operating room or theatre suite. Some patients will have more than one procedure during a hospital admission so the total number of procedures will exceed the total number of patients. This is analogous to MMR, where the number of live births (denominator) will exceed the number of women having given birth. For input to the numerator, the outcome of death should be applicable only once, even for a patient who has multiple procedures.

There are a number of alternative time periods that could be used to report perioperative mortality. Death on the day of surgery was chosen instead of the alternatives: death within 24 or 48 h. Death on the day of surgery allows the use of the calendar day, avoiding having to calculate when 24 or 48 h has passed, and will include most or all deaths within the operating room. For those countries that have already established systems to report death within 24 or 48 h rather than on the day of surgery, there should be no difficulty in identifying those patients who die on the same calendar day. In acknowledgement of these different time periods, one option would be to call this particular POMR 24, meaning 24 h. We believe there will be good correlation between rate on the day of surgery and rate in 24 h, though this remains to be proven by further study.

Death before discharge from hospital was chosen rather than within 30 days because of the challenge of following up patients after discharge in many parts of the world, particularly in developing countries whose hospitals serve remote and rural village populations. Recording a 30-day mortality rate may be achievable only in well-resourced countries that have the ability to conduct reliable postdischarge follow-up. In higher-income countries it may be possible to electronically link the Death Certification process to a hospital procedure, at least within the public health system. This would enable recording of postoperative deaths after discharge from hospital. It is acknowledged that 30-day mortality is often perceived as a standard and already reported in many countries, including some LMICs. It is particularly relevant at the level of a hospital or surgical service auditing mortality, where there is great value in continuing with 30-days as the cutoff rather than death before discharge to inform the continuous quality improvement process locally. However, for a credible indicator at the population level, many LMICs would struggle to report 30-day mortality. For these reasons we believe that POMR 30 should be the term used, but that death before discharge be used as a proxy for 30-day mortality where 30-day mortality rates are not currently feasible. Unpublished data suggest there is reasonable correlation between death before discharge when less than 30 days and death within 30 days, though this will require confirmation by further study.

In regions where hospitals transfer large numbers of cases after primary surgery to a referral hospital, the regional POMR will still reflect access to safe surgery and anaesthesia for the system as a whole. The individual hospital rate may require interpretation in the light of transfer patterns, but this should be achievable by the relevant lead clinicians and service managers.

## Does POMR really measure access and safety?

Perioperative mortality is not only a measure of safety but also an indirect measure of access since the number of procedures performed must be known to calculate it. Lack of access to safe surgery and anaesthesia will result in delayed presentations, which correlate with both a higher mortality rate and fewer procedures. A system that fails with respect to both safety and access will have a higher mortality rate and fewer procedures per head of population. Further valuable information regarding access to surgical services may be gleaned by reporting the number of procedures per 10,000 or 100,000 population. The procedures per population rate (PPR) will identify those hospitals that do few procedures and thus fall short in providing access to emergency and essential surgery. Other ways to measure access may still need to be considered, for example, the percentage of a population that has access to emergency and essential surgery within a particular time period. This may require agreeing to minimum standards as to how to deliver and what constitutes emergency and essential surgery. This latter option has the disadvantage of introducing more measures and being subject to point prevalence bias as to the time when any survey is conducted.

## POMR and risk adjustment

POMR is a tool to evaluate care at the population level, rather than providing individual case review. Risk adjustment is required to compare POMR between jurisdictions. Collection of POMR should be expected of every country and region, and it is hoped that POMR reporting will become the norm for every member nation of WHO. Initially, not every hospital will be able to collect the necessary data to risk-adjust, but this will not diminish the importance of the identifying strategies to ensure this additional information can be derived. Ultimately, risk adjustment will be what convinces clinicians of the veracity of the data, whether they are surgeons, anaesthetists, or public health physicians.

Whatever method of risk adjustment is used, it needs to be simple yet robust. The necessary data must be easy to collect and preferably not require any laboratory tests, as these are not universally available. We recommend limiting risk adjustment of POMR to four simple variables: age, urgency (elective or emergency), name or code of procedure/procedure group, and American Society of Anesthesiologists (ASA) status [14, 15]. The ASA [physical status] score is simple, has been accepted for over 50 years, and has been shown to be applicable in LMICs as well as in the world's most developed G20 nations. The ASA score is a measure of comorbidity and physiological disturbance that does not have the complexity of the Elixhauser et al. [16] or Charlson et al. [17] comorbidity indices, for example, that require multiple variables and would be much more difficult, if not impossible, to roll out globally. Anaesthesia providers everywhere already use or can be taught to use ASA scoring. These advantages outweigh some potential limitations in precision or interrater consistency [18, 19].

New Zealand's Perioperative Mortality Review Committee (POMRC) has established a national framework for reporting perioperative mortality. They have stratified risk based on age, urgency of admission, ASA, and procedure

[11]. A large, multicentre, North American series based on the National Safety and Quality Improvement Program (NSQIP) reported that surgical mortality could be predicted on the basis of urgency, ASA, and a three-point grading of procedure risk into low, medium, or high [20]. The NSQIP data are strongly supportive of age being a significant predictor of risk for every decade over 65.

The POMR on the same day of surgery, as it is within 24 h of a procedure, is reflective of the clinical decision to perform a procedure at all, the ability to prepare and/or resuscitate a patient, the safety of the anaesthetic and procedure, and the immediate postoperative care and the ability to respond to clinical deterioration. A New Zealand review looked at the POMR on the day of the procedure and found an overall rate of 1 in 1,000 (0.1 %), with 5 in 1,000 (0.5 %) for emergency surgery and 0.22 per 1,000 (0.022 %) for elective surgery [11]. The review reported mortality was related to age and ASA [11, 21], but failed to demonstrate a relationship with ethnicity or deprivation index [11].

### Misinterpreting perioperative mortality

There exists a risk of misinterpreting data. This was seen recently in Europe when a report of mortality after surgery was based on inaccurate data, resulting in embarrassment to the health services of a number of European countries. The report was purported to be a study of the outcome of surgery in a 7-day period and measured in-hospital mortality, duration of hospital stay, and admission to critical care [22]. There were wild fluctuations in perioperative mortality that should have alerted the authors as to the unreliability of their data collection method, with mortality ranging from an anticipated rate of 1.2 % to as high as 21.5 % in some countries. The article provoked a string of letters [23–27]. The actual mortality rates are more likely to be in the range of 0.5–1.2 %. For example, the POMR in Poland was actually 0.98 % of 22,000 operations and not the 17.5 % reported by the authors [25].

### What POMR do we expect?

In 2008, clinical trials of WHO's surgical safety checklist in eight hospitals across the world reported a reduction in in-hospital mortality from 1.5 to 0.8 % and a drop in complications from 11 to 7 % [28]. The perioperative in-hospital mortality rate reported in the eight hospitals ranged from 0.28 to 1.45 % [7]. These findings were corroborated in the Netherlands where similar reductions in mortality (1.5–0.8 %) and complications (15.4–10.6 %) were reported [29]. It would be reasonable, based on the above studies, to expect the POMR before discharge from hospital to be in the 0.5–1.5 % range, depending on the case mix. The actual rate will be determined by the proportion of emergency and elective procedures and the age and comorbidity of the patients (the latter is included in the ASA physical status score).

Bainbridge et al. [30] performed a systematic review and meta-analysis on perioperative and anaesthetic-related mortality in developed and developing countries. They described a tenfold reduction in perioperative mortality over the past 50 years with respect to deaths related to anaesthesia and total perioperative mortality, though much of this was attributable to improved results in developed countries. They reported a tenfold decline in POMR from 10,600 in 1,970–1,176 per million procedures in 1990–2000. During the same period, the anaesthesia-related mortality dropped from 357 to 34 per million procedures [30].

Perioperative mortality varies according to case mix, and therefore among specialties, particularly surgically remediable conditions such as fractured neck of femur or colorectal cancer. The literature contains a number of reports on perioperative mortality after cardiac, vascular, and general surgery, with the latter two specialties managing a high proportion of emergencies. Table 2 gives a selection of reported POMRs as a guide to what might be expected in developed nations, the very nations that would be expected to provide leadership in reporting POMR.

Although one might expect developing nations to report far higher rates, which is the current situation with IMR and MMR, a 30-day mortality rate following surgery in Zambia in 1990 was only 1.7 % [39], which is not that different from current day rates in the US of 1.4 % for general/vascular [40] and 1.32 % for noncardiac surgery [20].

Reviews of anaesthesia-related mortality in New South Wales, Australia (2006–2010), suggested that of 939 deaths within 24 h of an anaesthetic, <20 % were related to anaesthesia or have anaesthesia-related factors [40].

Mortality on the day of surgery or within 24 h (next day) has been reported by Médicins Sans Frontières (MSF) for nearly 20,000 operations in 13 countries between 2001 and 2008, of which 42 % were emergencies, with an impressive 0.2 % (range = 0–0.9 %) POMR [41]. The reported mortality rate within 24 h of surgery from sub-Saharan Africa suggests a rate of 0.2–0.6 % or 200–600 per 100,000 procedures or 1:150–1:500 anaesthetics (Table 3) [42–44].

The literature on POMR suffers due to lack of an agreed upon definition of early death and whether POMR should be reported on the day of surgery or within 24, 48 h, or 7 days. Anaesthesia-led studies have reported each of these different time periods. In Port Moresby, Papua New Guinea (2002), death within 48 h of anaesthesia was reported with

**Table 2** Thirty-day mortality reported by condition or procedure from developed nations

| Place | Year | Case mix | Number | Rate per 100 procedures | Reference |
|---|---|---|---|---|---|
| New Zealand | 2005–2009 | Acute admission for hip arthroplasty | 7,443 | 7.3 | POMRC NZ [11] |
| Australia, NSW | 2000–2009 | Hip fracture fixation | 42,764 | 8.6 | Harris et al. [31] |
| Australia | 2010 | Vascular | 42,653 | 1.2 | Beiles et al. [32] |
| Boston NSQIP | 2002–2004 | Colon | 405 | 3.2 | Gawande et al. [33] |
| Boston NSQIP | 2004 | General/Vascular | 767 | 1.4 | Gawande et al. [33] |
| ACS NSQIP | 2005–2007 | Noncardiac | 298,772 | 1.34 | Glance et al. [20] |
| ACS NSQIP | 2005–2008 | Colon, GB, hernia, pancreas | 200,036 | 1.35 | Vaid et al. [34] |
| Netherlands 90 hospitals | 2010 | Colon cancer | 6,161 | 4.5 | Kolfschoten et al. [35] |
| | | Rectal cancer | 2,419 | 2.3 | |
| Japan 6 hospitals | 1987–2007 | Gastric cancer | 1,708 | 2.6 | Haga et al. [36] |
| UK—212 centres | 2007 | Upper GI bleeding | 4,478 | 8.4 | Jairath et al. [37] |
| Australia NSW | 2000–2009 | Hip arthroplasty | 57,661 | 0.50 | Harris et al. [31] |
| US | 2000–2004 | Hip arthroplasty | 953,130 | 0.30 | Liu et al. S[38] |
| New Zealand | 2005–2009 | Elective knee arthroplasty > 45 | 25,617 | 0.20 | POMRC NZ [11] |
| New Zealand | 2005–2009 | Elective Colorectal | 10,226 | 2.1 | POMRC NZ [11] Table 15 |
| | | Emergency Colorectal | | 9.8 | |

**Table 3** Mortality on day of surgery or within 24 h

| Place | Year | Procedure | Sample | Rate per 100 procedures | Reference |
|---|---|---|---|---|---|
| New Zealand | 2005–2009 | Emergency general procedure | 132,669 | 0.5313 | POMRC [11] |
| New Zealand | 2005–2009 | Elective general procedure | 1,032,114 | 0.0661 | POMRC [11] |
| MSF | 2001–2008 | General and obstetric | 19,643 | 0.157 | Chu et al. [41] |
| Malawi | 1999 | All surgery within 6 months | 3,022 | 0.463 | Hansen et al. [42] |
| Togo | 2006 | All surgery | 1,464 | 0.667 | Ouru-Bang'na Mamam et al. [43] |
| Zimbabwe | 1992 | All surgery | 34,553 | 0.258 | McKenzie [44] |

a rate of 1:333 or 30/10,000 procedures [45]. A detailed study of 7-day mortality from the University Teaching Hospital in Zambia in 1987 reported a mortality rate of 0.76 %, showing what can be expected in developing countries despite the lack of resources and different case mix [46]. Thirty-five of the 80 deaths were classed as anaesthetic-related. A 7-day mortality rate of 0.34 % was also reported from Malaysia: 715 deaths after 211,354 procedures over 2 years (1992–1994) [47]. Interestingly, in the Malaysian study, 27 and 46 % of deaths in the first 7 days occurred on the day of surgery or the following day. It should be noted that 7-day mortality will be lower than that reported on discharge or at 30 days, though any relationship between 7- and 30-day mortality has not been widely reported. We recommend choosing the same calendar day of surgery rather than within 24 h.

We believe a POMR based on the number of deaths on the day of the procedure will be indicative of deaths arising from late presentation, poor decision making, inadequate resources (including human resources), inadequate preoperative preparation, and unsafe anaesthesia. Other causes of death, including the aforementioned five causes, will also be identified by reporting the in-hospital POMR (before discharge or within 30 days), as an admission outcome.

### Learning from perioperative mortality review

There is an opportunity for developed nations and referral hospitals in developing countries to take a lead in reporting perioperative mortality. We do not believe this will involve significant resources as the information is already being collected in some form in most hospitals. Ministries of Health will need to mandate that all hospitals report this information. Collecting and reporting POMR will impact only surgical and anaesthesia outcomes when reporting is mandatory and benchmarking is put into place for measuring the impact of interventions made within a surgical system. The pivotal point in the healthcare system in LMICs is at the District or First Referral Hospital where the needs are greatest. WHO has long recommended emergency and essential surgery be available at the District Hospital level. Yet, recent reports suggest that when surveyed, many of these hospitals do not provide access to safe surgery and anaesthesia when needed, even for trauma, obstructed labour, or abdominal emergencies, all conditions that present locally and require urgent treatment to prevent disability and death.

Eventually, of course, the POMR analysis will not result in improvements in the standards of anaesthesia and surgery unless review of individual cases takes place. The Scottish Audit of Surgical Mortality [48] and Confidential Enquiry into Perioperative Deaths (CEPOD) [49–51] are examples of how such reviews in developed nations can drive improvement. Audits of anaesthesia-related (within 24 h) and surgically related mortality have also resulted in improved quality of care in Australia [44] and resulted in reductions in mortality of surgical patients [52, 53].

Reviews of deaths within 24 h of surgery and anaesthesia in the State of New South Wales and elsewhere in Australia suggest that up to a quarter of deaths in the first 24 h are anaesthesia-related [32, 54]. The problems of anaesthesia delivery in developing countries can be defined [55, 56] and standards of safe anaesthesia have been established [57]. Similarly, there are tools and methodologies that can be used to assess surgical capability and capacity [8, 9, 58]. This suggests that, with a measure of access (possibly procedures per 100,000 population) and safety (POMR), there is the prospect of improving the quality of care for people requiring emergency and essential surgery.

### Access to safe surgery and anaesthesia when needed

Safe surgery and anaesthesia are not unaffordable luxuries reserved only for the health systems of high-income countries. They should be seen as an essential component within the Sustainable Development Goal of Universal Health Coverage. Everyone deserves them and their lack represents a significant cost in terms of life and disability to the communities that cannot access them. There are an increasing number of studies that suggest that surgery and anaesthesia can be delivered in LMICs both effectively and inexpensively, often at a cost ($11–35 per disability-adjusted life-year [DALY] averted) similar to that for measles vaccination, vitamin A supplementation, or bed nets to prevent malaria [59–63]. Therefore, the surgical management of injuries, infection, obstetric and abdominal emergencies, and many types of deformity is cost-effective and thus potentially deliverable for all. It is possible to provide safe surgery and anaesthesia cost-effectively, but to do so requires a commitment to provide the necessary facilities, resources, and skilled workforce. We believe POMR will draw attention to the need to do so and, in time, will be a credible [64] means of measuring improvement.

**Conflict of interest** The authors have no conflicts of interest or financial ties to disclose.

### References

1. Lozano R, Naghavi M, Foreman K et al (2012) Global and regional mortality from 235 causes of death from 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease study 2010. Lancet 380:2095–2128
2. Murray CL, Voss T, Lozano R et al (2012) Disability-adjusted life years (DALYs) for 291 diseases and injuries in 21 regions, 1990–2010: a systematic analysis for the Global Burden of Disease study 2010. Lancet 380:2197–2223
3. Vos T, Flazman AD, Naghawi M et al (2012) Years lived with a disability (YLD) for 1160 sequelae of 289 diseases and injuries 1990–2010: a systematic analysis for the GBDS 2010. Lancet 380:2163–2196
4. Weiser TG, Regenbogen SE, Thompson K et al (2012) An estimation of the global volume of surgery: a modeling strategy based on available data. Lancet 372:139–144
5. Mock C, Joshipura M, Arreola-Risa C et al (2012) An estimate of the number of lives that could be saved through improvements in trauma care globally. World J Surg 36:959–963. doi:10.1007/s00268-012-1459-6
6. Mock C (2013) Confronting the global burden of surgical disease. World J Surg 37:1457–1459. doi:10.1007/s00268-013-2102-x
7. Weiser TG, Makary MA, Haynes AB et al (2009) Standardised metrics for global surgical surveillance. Lancet 374:1113–1117
8. Linden AF, Sekidde FS, Galukande M et al (2012) Challenges of surgery in developing countries: a survey of surgical and anesthesia capacity in Uganda's public hospitals. World J Surg 36:1056–1065. doi:10.1007/s00268-012-1482-7
9. Notrica MR, Evans FM, Knowlton LM et al (2011) Rwandan surgical and anesthesia infrastructure: a survey of district hospitals. World J Surg 35:1770–1780. doi:10.1007/s00268-011-1125-4
10. United Nations, Technical Support Team: Health and Sustainable Development. http://sustainabledevelopment.un.org/index.php?menu=1549. Accessed July 2013
11. POMRC 2011, Perioperative Mortality in New Zealand. Inaugural report of the perioperative mortality review committee, Wellington, Health Quality and Safety Commission. http://www.

hqsc.govt.nz/assets/POMRC/Publications/POMRC-2011-Report-Lkd.pdf. Accessed February 2012
12. Watters DA (2013) Access to safe surgery and anaesthesia when needed. Surgical News 2013:12–13. Royal Australasian College of Surgeons, Melbourne. www.surgeons.org/media/…/art_2013-05-15_surgical_news_may.pdf. Accessed July 2013
13. World Alliance for Patient Safety. Global patient safety challenge 2007–08: Safe Surgery Saves Lives, 2007. World Health Organisation, Geneva. http://www.who.int/patientsafety/challenge/safe.surgery/en/. Accessed July 2013
14. Dripps RD, Lamont A, Eckenhoff JE (1961) The role of anesthesia in surgical mortality. JAMA 178:261–266
15. Dripps RD (1963) New classification of physical status. Anaesthesiology 24:111
16. Elixhauser A, Steiner C, Harris DR et al (1998) Comorbidity measures for use with administrative data. Med Care 36:8–27
17. Charlson ME, Pompei PF, Ales KL et al (1987) A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. J Chronic Dis 40:373–383
18. Owens WD, Felts JA, Spitznagel EL (1978) ASA physical status classification: a study of consistency of ratings. Anaesthesiology 49:239–243
19. Davenport DL, Bowe EA, Henderson WG et al (2006) National Surgical Quality Improvement Program (NSQIP) risk factors can be used to validate American Society of Anesthesiologists Physical Status Classification (ASA PS) levels. Ann Surg 243:636–644
20. Glance LG, Lustik SJ, Hannan EL et al (2012) The surgical mortality probability model. Derivation and validation of a simple risk prediction rule for noncardiac surgery. Ann Surg 255:696–702
21. Perioperative Mortality Review Committee (2012) Perioperative Mortality in New Zealand, Second Report of the Perioperative Review Committee, Wellington: Health Quality and Safety Commission
22. Pearse RM, Moreno RP, Bauer P et al (2012) Mortality after surgery in Europe: a 7 day cohort study. Lancet 380:1059–1065
23. Brodner G, Van Aken H (2013) Mortality after surgery in Europe. Lancet 381:370
24. Van Schalkwyk JM, Campbell D (2013) Mortality after surgery in Europe. Lancet 381:370
25. Franek E, Osinska B, Czech M et al (2012) Mortality after surgery in Europe. Lancet 381:369–370
26. Mikstacki A (2013) Mortality after surgery in Europe. Lancet 381:369
27. Pupelis G, Vanags I (2013) Mortality after surgery in Europe. Lancet 381:369
28. Haynes AB, Weiser TG, Berry WR et al (2009) A surgical safety checklist to reduce morbidity and mortality in a global population. NEJM 360:491–499
29. de Vries EN, Hollmann MW, Smorenburg SM et al (2008) Development and validation of the surgical patient safety system (SURPASS) checklist. Qual Saf Health Care 18:121–126
30. Bainbridge D, Martin J, Arango M et al (2012) Perioperative and anaesthetic-related mortality in developed and developing countries: a systematic review and meta-analysis. Lancet 380:1075–1081
31. Harris I, Madan A, Naylor J et al (2012) Mortality rates after surgery in New South Wales. ANZ J Surg 82:871–877
32. Beiles CB, Bourke B, Thomson I (2012) Results from the Australasian vascular surgical audit: the inaugural year. ANZ J Surg 199:105–111
33. Gawande AA, Kwaan MR, Regenbogen SE et al (2007) An Apgar score for surgery. J Am Coll Surg 204:201–208
34. Vaid S, Bell T, Grim R et al (2012) Predicting risk of death in general surgery patients on the basis of preoperative variables using American College of Surgeons National Surgical Quality Improvement Program data. Perm J 16:10–17
35. Kolfschoten NE, Marang van de Mheen PJ, Gooiker GA et al (2011) Variation in case-mix between hospitals treating colorectal cancer patients in the Netherlands. Eur J Surg Oncol 37:956–963
36. Haga Y, Wada Y, Takeuchi H et al (2012) Evaluation of modified estimation of physiologic ability and surgical stress in gastric carcinoma surgery. Gastric Cancer 15:7–14
37. Jairath V, Kahan BC, Logan RF et al (2012) National audit of the use of surgery and radiological embolization after failed endoscopic haemostasis for non-variceal upper gastrointestinal bleeding. Br J Surg 99:1672–1680
38. Liu SS, Della Valle AG, Besculides MC et al (2009) Trends in mortality, complications, and demographics for primary hip athroplasty in the United States. Int Orthop 33:643–651
39. Watters DA, Bem C, Echun DA et al (1991) Audit of 'surgery in general' in an African teaching hospital. J R Coll Surg Edinb 36:402–404
40. Clinical Excellence Commission (CEC) (2012) Activities of the Special Committee Investigating Deaths under Anaesthesia—2010. CEC, Sydney
41. Chu KM, Ford N, Trelles M (2010) Operative mortality in resource-limited settings. Arch Surg 145:721–725
42. Hansen D, Gausi SC, Merikebu M (2000) Anaesthesia in Malawi: complications and deaths. Trop Doct 30:146–149
43. Ouro-bang'na Mamam AF, Tomta K, Ahouangbevi S et al (2005) Deaths associated with anaesthesia in Togo West Africa. Trop Doct 35:220–222
44. McKenzie AG (1996) Mortality associated with anaesthesia at Zimbabwean teaching hospitals. S Afr Med J 86:338–342
45. Paiva H (2003) Perioperative Mortality in Papua New Guinea. MMed Thesis, University of Papua New Guinea
46. Heywood AJ, Wilson IH, Sinclair JR (1989) Perioperative mortality in Zambia. Ann R Coll Surg Engl 71:354–358
47. Inbasegaran K, Kandasami P, Sivalingam N (1998) A 2-year audit of perioperative mortality in Malaysian hospitals. Med J Malays 53:334–342
48. Thompson AM, Ashraf Z, Burton H et al (2005) Mapping changes in surgical mortality over 9 years by peer review audit. Br J Surg 92:1449–1452
49. Lunn JN (1998) The history and achievements of the National Confidential Enquiry into perioperative deaths. J Qual Clin Pract 18:29–35
50. Derrington MC, Gallimore S (1997) The effect of the National Confidential Enquiry into perioperative deaths on clinical practice. Anaesthesia 52:3–8
51. Cain D, Ackland G (2012) Knowing the risk? NCEPOD 2011: a wake up call for perioperative practice. Br J Hosp Med 73:262–264
52. North JB, Blackford FJ, Wall D et al (2013) Analysis of the causes and effects of delay before diagnosis using surgical mortality data. Br J Surg 100:419–425
53. Azzam DG, Neo CA, Itotoh FE et al (2013) The Western Australian audit of surgical mortality: outcomes from the first 10 years. Med J Aust 8:539–542
54. Gibbs N, Rodoreda P (2005) Anaesthetic mortality rates in Western Australia 1980–2002. Anaesth Intens Care 33:616–622
55. Hodges SC, Mijumbi C, Okello M et al (2007) Anaesthesia services in developing countries: defining the problems. Anaesthesia 62:4–11
56. Merry AF, Cooper JB, Soyannwo O et al (2010) An iterative process of global quality improvement: the International Standards for a safe practice of anesthesia 2010. Can J Anaesth 57:1021–1026

57. Merry AF, Cooper JB, Soyannwo O et al (2010) International standards for a safe practice of anesthesia 2010. Can J Anaesth 57:1027–1034
58. Natuzzi ES, Kushner A, Jagilly R et al (2011) Surgical care in the Solomon Islands: a road map for universal surgical care delivery. World J Surg 35:1183–1193. doi:10.1007/s00268-011-1097-4
59. Gosselin RA, Thind A, Bellardinelli BA (2006) Cost/DALY averted in a small hospital in Sierra Leone: what is the relative contribution of different services? World J Surg 30:505–511. doi:10.1007/s00268-005-0609-5
60. Gosselin RA, Heitto M (2008) Cost-effectiveness of a district trauma hospital in Battambang, Cambodia. World J Surg 32:2450–2453. doi:10.1007/s00268-008-9708-4
61. Gosselin RA, Maldonado A, Elder G (2010) Comparative cost-effectiveness analysis of two MSF surgical trauma centres. World J Surg 34:415–419. doi:10.1007/s00268-009-0230-0
62. Gosselin RA, Gialamas G, Atkin DM (2011) Comparing the cost-effectiveness of short orthopaedic missions in elective and relief situations in developing countries. World J Surg 35:951–955. doi:10.1007/s00268-010-0947-9
63. Grimes CE, Henry JA, Maraka J et al (2014) Cost-effectiveness of surgery in low- and middle-income countries: a systematic review. World J Surg 38:252–263. doi:10.1007/s00268-013-2243-y
64. Shiffman J, Smith S (2007) Generation of political priority for global health initiatives: a framework and case study of maternal mortality. Lancet 370:1370–1379