

Original Article

Addressing priorities for surgical research in Africa: implementation of a multicentre cloud-based peri-operative registry in Ethiopia

On behalf of the Network for Peri-operative Critical care (N4PCC)*

Debre Birhan University and Debre Birhan Comprehensive Specialized Hospital, Ethiopia

Summary

In resource-constrained settings, where inequalities in access to and quality of surgical care results in excess mortality, peri-operative care registries are uncommon. A south-south collaboration supported the implementation of a context specific, clinician-led, multicentre real-time peri-operative registry in Ethiopia. Peri-operative information, including the Ethiopian Ministry of Health's national 'Saving Lives through Safe Surgery initiative', was linked to real-time dashboards, providing clinicians and administrators with information on service utilisation, surgical access, national surgical key performance indicators and measures of quality of care. We recruited four hospitals representing 285 in-patient beds from the Amhara and Southern Nations Nationalities and Peoples regions and Addis Ababa city, and reported on 1748 consecutive surgical cases from April 2019 to April 2020. Key performance indicators included: compliance with the World Health Organization's Surgical Safety Checklist in 1595 (92.1%) surgical cases; adverse events during anaesthesia in 33 (3.1%) cases; and surgical site infections in 21 (2.0%) patients. This collaboration has successfully implemented a multicentre digital surgical registry that can enable measurement of key performance indicators for surgery and evaluation of peri-operative outcomes. The peri-operative registry is currently being rolled out across the Amhara region and Addis Ababa city administration. It will provide continuous granular healthcare information necessary to empower clinicians to drive context-specific priorities for service improvement and research, in collaboration with national stakeholders and international research consortiums.

Correspondence to: Network for Perioperative Critical care

Email: fitsum@n4pcc.com

Accepted: 21 December 2020

Keywords: anaesthesia; clinical registries; postoperative morbidity; quality of care; surgery

*See Appendix S1 for working group members.

This article is accompanied by an editorial by Kluys and Biccard, *Anaesthesia* 2021; **76**: 888-91.

Twitter: @Net4PCC

Introduction

In 2015, the World Health Assembly called for emergency and essential surgical care to be included as a component of universal health coverage [1]. In low- and middle-income countries (LMIC), there has been a substantial focus on improving access to surgical services. More recently, the Lancet Commission on Global Surgery articulated a vision of achieving universal access to safe, affordable surgical care [2]. However, the degree to which improving access to

healthcare results in an improvement in morbidity and mortality is limited by the quality of care delivered, especially in LMICs [3]. It is estimated that 23 million disability-adjusted life years are lost each year due to in-hospital adverse events, and that the greatest proportion of these occur in LMICs [4].

There is a growing acknowledgement of the importance of quality of peri-operative care on mortality, morbidity and measures of health-related quality of life.

Despite this, very little is known about the quality of peri-operative care in LMICs. The lack of reliable granular and national data pertaining to outcomes and care processes disempowers stakeholders, clinicians and academics from identifying health system-specific research priorities and hampers the implementation and evaluation of quality improvement initiatives [4,5]. In sub-Saharan African countries, investment in infrastructure to enable data-driven evaluation of quality of care and effectiveness of quality improvement interventions are a priority. Without such infrastructure, there is a risk that national surgical plans and initiatives will be unrealistic, or poorly implemented [6]. This gap in information to enable robust evaluation of existing care and data-driven improvement was recognised by the African Peri-operative Research Group in a recent Delphi exercise in which consensus priorities for the peri-operative research agenda in Africa were identified. Priorities 8, 9 and 10 recommended the following: the establishment of a minimum dataset surgical registry; a quality improvement programme to improve implementation of the World Health Organization's (WHO) Surgical Safety Checklist; and measures of peri-operative outcomes associated with emergency surgery [7].

In Ethiopia, the Federal Ministry of Health partnered with non-government organisations to prioritise national improvement initiatives that improve surgical safety and operating capacity. It established recommendations for standards of peri-operative care in partnership with the 'Saving Lives through Safe Surgery' initiative; this was launched to streamline efforts to improve surgical care, and endorsed monthly key performance indicators (KPIs) to assess the quality and capacity of surgical services within hospitals.

We report on the establishment, initial output and utility of a collaborative, co-designed, multicentre peri-operative registry in Ethiopia. This south-to-south partnership brought together Ethiopian stakeholders from Debre Berhan University who formed a collaborative 'Network for Peri-operative Critical care' (N4PCc) with NICS–MORU, a Sri-Lankan based non-profit organisation that supports health system improvement and research in LMICs. The registry, co-designed by stakeholders, leveraged the design and expertise of the NICS-MORU registry platform [5], which (under the Umbrella of Oxford University) currently supports acute care registries in 14 LMICs across Asia and Africa, and is a founding member of Linking of Global Intensive Care, an international consortium for acute and critical care data spanning four continents (<https://www.icubenchmarking.com>).

The N4PCc registry included four referral level hospitals in Addis Ababa and the Amhara and Southern

Nations Nationalities and Peoples regions. In Addis Ababa, Saint Peter's Hospital is a comprehensive specialised hospital overseen by the Federal Ministry of Health. Debre Berhan Comprehensive Specialised Hospital is a specialised hospital governed by the Amhara Regional Health Bureau. Dilla University Referral Hospital receives patients from a cluster of referring hospitals from the Gedio zone in the Southern Nations Nationalities and Peoples' region, each governed by the respective regional health bureau. Yekatit is similarly a referral hospital, serving Addis Ababa city and governed by the Addis Ababa Health Bureau.

Methods

We facilitated the development of a context-specific data registry within Ethiopia through incorporating national surgical quality and safety indicators. The core dataset, co-designed in partnership with N4PCc stakeholders, enabled evaluation of the conformity of care processes and outcomes using the national peri-operative guidelines. The dataset included case-mix and clinical characteristics and care processes along the continuum of peri-operative care, from before admission through to outcomes up to hospital discharge. The dataset was mapped to 11 of the 15 international surgical indicators selected by the Federal Ministry of Health and from the WHO's 'Safe Surgery Saves Lives' initiative, which includes the WHO Surgical Safety Checklist (Box 1) [8]. Each participating centre contributed information voluntarily through a secure cloud-based portal [5]. Data were captured throughout the patients' peri-operative encounter: on admission; intra-operatively; during and at discharge from the post-anaesthesia care unit (PACU); at 48 h post-surgery; and at hospital discharge.

A series of build-measure-learn loops facilitated the refinement and implementation of the registry platform. This design-based approach enabled the collaborative to be responsive to the feedback from users, facilitating site level adoption, data acquisition, quality and utility. Clinical stakeholders (nurses and anaesthesia providers) were locally appointed as centre co-ordinators during site recruitment and were co-ordinated by N4PCc. Centre co-ordinators led local implementation and supported data collection, using an Android application with offline functionality, and also assisted colleagues with dashboard navigation. Data collection was by trained data collectors, who were either final year anaesthetic trainees on placement in the hospital or research assistants appointed to the N4PCc team. Online training, quick reference guides and regular telephone and instant messaging follow-up led by the centre co-ordinators, were used to monitor patient

Box 1 Key performance indicators of the Ethiopian 'Saving Lives through Safe Surgery' initiative included in the Debre Berhan University–Network for Peri-operative Critical Care dashboard

- Surgical, anaesthesia and obstetric provider density
- Surgical volume
- Peri-operative mortality
- Safe surgery checklist utilisation
- Surgical site infection
- Anaesthetic adverse outcomes
- Surgical bed occupancy rate
- Delay for elective surgical admission
- Blood availability ratio
- Emergency (2 h) surgical access
- Mean duration of in-hospital pre-elective operative stay

recruitment, data quality and to provide assistance with troubleshooting during implementation and scale up. These methods have been used by NICS-MORU during implementation in Asia.

Given the intended use of the data to drive evaluation and improvement, mechanisms inbuilt within the registry facilitated improved data quality. To improve completeness and reliability of data, mandatory fields and drop-down menus were used to guide the user logically through the dataset. Data trends were displayed through site-level descriptive analytic dashboards, which guided participating units towards completeness and enabled comparison of case-mix and activity over time. Data quality dashboards were reviewed by the collaboration to assess completeness, accuracy and replicability of data.

The registry has a federated approach to data storage and management, ensuring participating units retain ownership of their information whilst enabling interoperability of metadata for sites choosing to participate in national and international research. Contributing sites have full access to all data submitted from their site, but do not have access to raw data submitted by other contributing hospitals.

To facilitate audit and feedback, observational data collected from each site underwent automated analysis and were fed back to stakeholders via cloud-based live dashboards. The dashboards' descriptive analytics were co-designed with clinical and administrative stakeholders. The dashboards provided site-level and aggregated trends regarding the quality of data collected, KPI reports, the

incidence of postoperative morbidity, including items aligned with the postoperative morbidity survey [9], and clinical outcomes. Users could sort the aggregate information by week, month or by admission characteristics (e.g. emergency vs. planned), depending on their requirements.

We obtained ethical clearance from the ethical review committee of Debre Berhan University; permissions were also obtained from the quality and research offices and administrators of participating hospitals and the university.

Results

We recruited four referral level hospitals in Ethiopia with a combined capacity of 285 beds. The collaborative has reported on 1748 surgical care episodes through the registry from April 2019 to April 2020; 1079 (62.7%) patients were women, and median (IQR [range]) age was 30 years (23–45 [1–98]) years.

Emergency surgery took place in 1024 (62.7%) of reported cases, the majority of which were for gynaecological and obstetric surgery ($n = 1196$ (68.4%)). General and hepatobiliary surgery was undertaken in 257 (14.7%) cases, with orthopaedic and trauma surgery in 89 (5.1%) patients and surgery related to neuro-trauma in 28 (1.6%). A total of 909 patients (54.3%) underwent general anaesthesia, while spinal anaesthesia was used in 659 (39.3%) and ketamine analgo-sedation in 41 (2.4%). Median (IQR [range]) length of inpatient stay was 4 (3–7 [1–98]) days. Median in-hospital wait time before surgery was 1 (1–3 [-0–70]) days. No patients included in the registry were discharged without surgery.

Descriptive dashboards enabled users to have direct access to information, enabling them to evaluate KPIs of peri-operative care quality and safety. Indicators reported included compliance with the WHO Surgical Safety Checklist in 1732 (92.1%) patients, adverse events during anaesthesia in 33 (3.1%) patients, and surgical site infections in 21 patients (2%). The prevalence of measures of postoperative morbidity at 24 and 48 h after surgery were 54.9% and 43.8%, respectively. Postoperative morbidity measures are further described in Table 1. Ten patients (0.9%) died in hospital. Aggregate information viewed through the dashboards was accessible online (<http://n4pcc.com>) and continues to facilitate identification of hospital level priorities for actionable improvement by the clinical team.

Discussion

This collaboration has been successfully piloted at four sites, and demonstrates the feasibility of using a clinician co-

designed electronic registry. Development of this dataset represents an early step towards building a national peri-operative registry and surgical outcomes database, a consensus priority for the peri-operative research agenda [7], and a recommendation of the Global Surgery 2030 roadmap [10]. Key learning from implementing the N4PCc registry included: the use of a stakeholder-designed narrow dataset that was consistent with their priorities, thereby reducing the burden of data capture and minimising wasted data collection; and a user-friendly mobile application-based platform which overcame the need for extensive end-user training or installation of software. In addition, offline functionality was essential for overcoming interrupted internet connectivity, a significant challenge in the region. This learning mirrored the experience from implementation of registries by members of both this collaboration and others in LMICs [11,12]. The real-time component enabled stakeholders to 'see' their information, and thereby increased buy-in from frontline users as well as improving data completeness, validity and usability for service planning and delivery of clinical care. Cloud hosting with inbuilt descriptive and analytic dashboards, as well as the ability for pre-specified users to download their own data, promoted accessibility of data for users, ensuring ownership of data and promoting the FAIR (findability, accessibility, interoperability and reusability) principles of data in health service improvement [13].

The case-mix reported through the registry demonstrated a high proportion of obstetrics and gynaecology and trauma cases, reflective of the most common surgical procedures globally and a high volume of trauma in the African continent [14]. Reported compliance with the WHO Surgical Safety Checklist at the facilities within the registry suggests adoption of the recently implemented national 'Saving Lives through Safe Surgery' programme. Limited data exist on the incidence of anaesthetic adverse events and critical incidents in Africa. Anaesthetic adverse events were reported in 3.1% of cases, in comparison with reported rates of 0.94% in Zimbabwe [15] and 6.1% in Nigeria [16], although variations in rates could be attributed to different reporting systems and reporting reliability. Similarly, peri-operative mortality rates often used as an indicator of quality of surgical services [17] have wide variation in both definition [18] and rates [19] across LMICs. Peri-operative mortality is reported to be increased in LMICs [20] and across the African continent [21]. In-hospital mortality was 0.9% in this dataset, equivalent to 9/1000. This was lower than reported rates of around 2% in Uganda [22], Tanzania [23] and the multi-country African Surgical Outcomes Study [21], albeit with a smaller cohort of

patients. Infection is the most common postoperative complication reported across Africa, with rates of 6.8–26% reported [24]. The N4PCc registry described an in-hospital surgical site infection rate of 2%, lower than the 10.2% reported in the African Surgical Outcomes Study [21].

Postoperative morbidity indicators reported in the N4PCc registry highlighted potential deficiencies in pain management and incidents of low oxygen saturations in the immediate postoperative period. Work is underway to strengthen reporting confidence and evaluate the processes of care which may inhibit or enable quality of postoperative care and patient recovery.

Stakeholders within the collaboration met on a bi-weekly basis via video conferencing to discuss data quality and implications for practice as a precursor to setting goals for quality improvement interventions. This process was supported by surgical, peri-operative and research mentors familiar with or working in resource-constrained healthcare. At Debre Berhan University, priorities for improvement identified by the anaesthesia, gynaecology/obstetrics and surgery departments, in partnership with higher education institutions responsible for anaesthesia training included: postoperative PACU management; step-down to ward level care; and reduction in postoperative morbidity. Registry data and feedback to anaesthesia students and nurses during lectures are guiding implementation and adoption of pain assessment using visual analogue scales. Similarly, the collaboration has identified variation in decision-making regarding readiness to step down from PACU to the ward; this has prompted the co-design and piloting of tools to support assessment of readiness for discharge. The collaborative adapted the registry to include a PACU discharge assessment tool, and set targets for greater compliance with pain assessment using a visual analogue scale. Implementation of these initiatives and trends in postoperative morbidity incidence are reported through the dashboards. In addition, the information is used for teaching and empowering the research capacity of medical and health sciences students and staff at Debre Berhan University. The peri-operative registry's output is available online to the Federal Ministry of Health and reports admission and occupancy rates for surgical services and monthly KPIs. The remaining four 'Saving Lives through Safe Surgery' initiative KPIs – patient satisfaction; delay for elective surgical admission; rate of first elective case on time performance; and protection against catastrophic expenditures are being implemented through the registry.

This collaboration provides the infrastructure to enable high-quality replicable data capture to enable evaluation of

Table 1 Prevalence of postoperative morbidity indicators from April 2019 to April 2020. Values are number (proportion) or median (IQR [range]).

Morbidity indicator	Data entries No. of subjects in dataset	No. of subjects in which indicator reported
Postoperative morbidity survey in PACU		
Haematological		
Blood product transfusion	1649	19 (1.2%)
Hypoxia		
Oxygen saturations < 92% requiring intervention	1534	116 (7.6%)
Anti-emetics		
Postoperative nausea and vomiting requiring anti-emetics	1604	38 (2.4%)
Pain assessment		
Postoperative pain assessed using visual analogue scale	1534	481 (31.4%)
Pain management		
Pain management intervention	1655	883 (53.4%)
Postoperative morbidity survey at 48-h follow-up		
Hypoxia		
Oxygen saturations < 92% requiring intervention	1542	28 (1.8%)
Cardiovascular		
Haemodynamic or cardiac instability	1542	13 (0.8%)
Delirium and confusion		
New onset delirium or confusion	1532	15 (1.0%)
Pain assessment		
Postoperative pain assessed using visual assessment scale	1532	46 (3.0%)
Gastro-intestinal		
Ability to eat and drink	1537	582 (37.9%)
Mobility		
Ability to walk independently	1536	704 (45.8%)
Key performance indicators		
Duration of in-hospital pre-elective stay; days	645	1 (1-3 [0-70])
Duration in theatre for elective patients; mins	679	60 (45-90 [5-120])
Rate of WHO Surgical Safety Checklist utilisation	1732	1595 (92.1%)
Adverse anaesthetic events	1056	33 (3.1%)
Surgical site infection rate	1074	21 (2.0%)

PACU, post-anaesthesia care unit.

the existing quality of patient care and the identification of priorities for context-specific improvement. There remain challenges in harnessing the registry to generate new evidence to enable peri-operative care and policy change. The most robust health systems globally have developed the capacity to measure and use health data such as that generated through registries, to learn about patient care and drive forward improvement. Empowering healthcare workers to improve the quality of healthcare delivery requires them to have the skills to evaluate existing care, identify drivers to change and to design and implement interventions for improvement across the trajectory of peri-operative care. This collaboration seeks to partner with

existing peri-operative and LMIC-based researchers to establish the infrastructure, mentorship and expertise to achieve actionable improvements in the quality of peri-operative care across Africa.

Our study has some limitations. To date, patient outcomes after hospital discharge are not known. Work is underway to follow-up with patients after hospital discharge to assess quality of recovery after surgery. The methods will build on those successfully used by the NICS-MORU network in Sri Lanka [25].

The collaboration will next focus on recruiting additional centres in Ethiopia; North Shewa zone in Amhara region, Southern Ethiopia Gedeo zone; and other hospitals

in Addis Ababa. The N4PCc has, as part of a consortium with Mahidol Oxford Tropical Medicine Research Unit, successfully sought funding from the National Institute of Health Research and the UK Research Council, to adapt the existing registry network to include surveillance of severe acute respiratory infections and to extend the network to include intensive care units. The collaboration is working in partnership with the Federal Ministry of Health, Ministry of Science and Higher Education, Ministry of Innovation and Technology and other governmental and non-governmental organisations to create a sustainable partnership whereby the registry provides a mechanism for evidence-based health improvement initiatives. The registry aligns with Federal Ministry of Health proposals for a surgical surveillance system to scale up the use of the national Hospital Assessment Tool.

Acknowledgements

The Network for Perioperative and Critical care (N4PCc) authorship includes co-ordinators and collaborators for the Ethiopian registry. AB is Chair and First Trustee of the Network for Improving Critical Care Systems and Training (UK Charity) and a volunteer with NICS-MORU. RH is First Trustee of the Network for Improving Critical Care Systems and Training (UK Charity) and a Director (honorary) at NICS-MORU. NICS-MORU is a not-for-profit organisation based in Sri Lanka, which supported this pilot project and from which the registry originated. The pilot project has been supported by NICS-MORU, which also partially supported FK's fellowship period in Sri Lanka, key to the knowledge exchange and establishment of a community of practice. The project's implementation and scale up is championed by DBU and FMOH.

References

- Price R, Makasa E, Hollands M. World Health Assembly Resolution WHA68. 15: "Strengthening emergency and essential surgical care and anesthesia as a component of universal health coverage"—addressing the public health gaps arising from lack of safe, affordable and accessible surgical and anesthetic services. *World Journal of Surgery* 2015; **39**: 2115–25.
- Meara JG, Leather AJ, Hagander L, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet* 2015; **386**: 569–624.
- Das J. The quality of medical care in low-income countries: from providers to markets. *PLoS Med* 2011; **8**: e1000432.
- Jha AK, Larizgoitia I, Audera-Lopez C, Prasopa-Plaizier N, Waters H, Bates DW. The global burden of unsafe medical care: analytic modelling of observational studies. *British Medical Journal Quality & Safety* 2013; **22**: 809–15.
- Beane A, De Silva AP, Athapattu PL, et al. Addressing the information deficit in global health: lessons from a digital acute care platform in Sri Lanka. *British Medical Journal Global Health* 2019; **4**: 1–7.
- Gajewski J, Bijlmakers L, Brugha R. Global surgery—informing national strategies for scaling up surgery in sub-Saharan Africa. *International Journal of Health Policy and Management* 2018; **7**: 481–4.
- Biccard BM; African Peri-operative Research (APORG) working group. Priorities for peri-operative research in Africa. *Anaesthesia* 2020; **75**: e28–33.
- WHO Patient Safety and World Health Organization (WHO). WHO guidelines for safe surgery 2009: safe surgery saves lives. <https://apps.who.int/iris/handle/10665/44185> (accessed 02/12/2020).
- Grocott MP, Browne JP, Van der Meulen J, et al. The Postoperative Morbidity Survey was validated and used to describe morbidity after major surgery. *Journal of Clinical Epidemiology* 2007; **60**: 919–28.
- Ng-Kamstra JS, Greenberg SL, Abdullah F, et al. Global Surgery 2030: a roadmap for high income country actors. *British Medical Journal Global Health* 2016; **1**: e000011.
- Hashmi M, Beane A, Taqi A, et al. Pakistan Registry of Intensive Care (PRICE): expanding a lower middle-income, clinician-designed critical care registry in South Asia. *Journal of the Intensive Care Society* 2018; **20**: 190–5.
- CRIT CARE ASIA, Beane A, Dondorp AM, et al. Establishing a critical care network in Asia to improve care for critically ill patients in low- and middle-income countries. *Critical Care* 2020; **24**: 608.
- Wilkinson MD, Dumontier M, Aalbersberg IJ, et al. The FAIR Guiding Principles for scientific data management and stewardship. *Scientific Data* 2016; **3**: 160018.
- Norton R, Kobusingye O. Injuries. *New England Journal of Medicine* 2013; **368**(18): 1723–30.
- Madzimbamuto FD, Chiware R. A critical incident reporting system in anaesthesia. *Central African Journal of Medicine* 2001; **47**: 243–7.
- Agbamu PO, Menkiti ID, Ohuoba EI, Desalu I. Critical incidents and near misses during anesthesia: a prospective audit. *Journal of Clinical Sciences* 2017; **14**: 18–24.
- Watters DA, Hollands MJ, Gruen RL, et al. Perioperative mortality rate (POMR): a global indicator of access to safe surgery and anaesthesia. *World Journal of Surgery* 2015; **39**: 856–64.
- Ng-Kamstra JS, Greenberg SL, Kotagal M, et al. Use and definitions of perioperative mortality rates in low-income and middle-income countries: a systematic review. *Lancet* 2015; **385**: S29.
- Uribe-Leitz T, Jaramillo J, Maurer L, et al. Variability in mortality following caesarean delivery, appendectomy, and groin hernia repair in low-income and middle-income countries: a systematic review and analysis of published data. *Lancet Global Health* 2016; **4**: e165–e74.
- Bainbridge D, Martin J, Arango M, Cheng D; Evidence-based Peri-operative Clinical Outcomes Research (EPiCOR) Group. Perioperative and anaesthetic-related mortality in developed and developing countries: a systematic review and meta-analysis. *Lancet* 2012; **380**: 1075–81.
- Biccard BM, Madzimbamuto FD, Basenero A, et al. Perioperative patient outcomes in the African Surgical Outcomes Study: a 7-day prospective observational cohort study. *Lancet* 2018; **391**: 1589–98.
- Hewitt-Smith A, Bulamba F, Oluput C, Musana F, Ochieng JP, Lipnick MS, Pearse RM. Surgical outcomes in eastern Uganda: a one-year cohort study. *Southern African Journal of Anaesthesia and Analgesia* 2018; **24**: 122–7.
- Wurdeman T, Strader C, Alidina S, et al. In-hospital postoperative mortality rates for selected procedures in Tanzania's Lake Zone. *World Journal of Surgery* 2021; **45**: 41–9.

24. Ngaroua NJE, Bénét T, Djibrilla Y. Incidence of surgical site infections in sub-Saharan Africa: systematic review and meta-analysis. *Pan African Medical Journal* 2016; **24**: 171.
25. Benham-Mirando S, Abayadeera A, Kannangara S, et al. Patient-centred perioperative outcomes after major abdominal surgery in Sri Lanka: a multicentre registry. *British Journal of Surgery* 2020; **107**: e603–e4.

Supporting Information

Additional supporting information may be found online via the journal website.

Appendix S1. The Network for Perioperative and Critical care, Ethiopia (N4PCc)@Net4PCc working group.

Next Generation SedLine[®] Brain Function Monitoring and O3[®] Regional Oximetry

Available Together on the Root[®] Platform



Root with Next Generation SedLine and O3 provides a more complete picture of the brain through an instantly interpretable and adaptable display.

- > Next Generation SedLine helps clinicians monitor the state of the brain under anaesthesia with an enhanced signal processing engine and four leads of bilateral EEG
- > O3 monitors cerebral oxygenation in situations where pulse oximetry alone may not be fully indicative of the oxygen in the brain

Discover Brain Function Monitoring



www.masimo.co.uk

© 2021 Masimo. All rights reserved.

For professional use. See instructions for use for full prescribing information, including indications, contraindications, warnings, and precautions.

