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Original Article

Global anaesthesia practice using inguinal hernia surgery as a tracer condition: a secondary analysis of an international prospective cohort study

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Summary

Introduction Restoration of surgical capacity is essential to post-COVID-19 recovery. This study explored the use and safety of anaesthesia options for inguinal hernia surgery, a common tracer condition, to describe current global practice and highlight opportunities to build the capacity of health systems.

Methods This is a secondary analysis of an international prospective cohort study of consecutive patients who underwent elective inguinal hernia surgery. We used a consensus process to define generalisable outcomes to measure patient selection, utilisation of hospital capacity and peri-operative safety in patients who received locoregional, spinal or general anaesthesia for their surgery.

Results In total, 16,554 patients from 83 countries were included. Locoregional anaesthesia was performed in 1536 (9.2%) of patients, compared with 9165 (55.4%) who had general and 55,853 (35.4%) who had spinal anaesthesia. Patient selection outcomes were comparable across anaesthesia groups. As a measure of hospital capacity, adjusted day-case rates were higher for locoregional anaesthesia (OR 6.62, 95%CI 5.13–8.54, $p < 0.001$) but not for spinal anaesthesia (OR 0.97, 95%CI 0.84–1.12, $p = 0.68$) compared with general anaesthesia. Complications were lower in patients who underwent locoregional anaesthesia (OR = 0.67, 95%CI 0.52–0.87, $p = 0.001$) but not for spinal anaesthesia (OR = 0.90, 95%CI 0.77–1.05, $p = 0.167$) compared with general anaesthesia after risk adjustment.

Discussion This study has filled knowledge gaps of anaesthesia practice in common surgeries across the world. Locoregional and spinal anaesthesia could be adopted as safe options to increase surgical volume when there is limited access to general anaesthesia.

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Introduction

The COVID-19 pandemic reduced elective surgical capacity and led to a backlog of cases [1]. This has added to the global burden of surgical morbidity, with an estimated 143 million people in low- and middle-income countries (LMICs) now in need of elective surgery [2]. Patients waiting for elective surgery are more likely to suffer from disability and present as an emergency, with increased pressure on services and risk to patients [3]. To meet the global surgical burden, the volume and availability of elective surgery must be increased safely.

Anaesthesia workforce constraints remain one of the main limitations to upscale global surgical capacity [4, 5]. Low-income countries (LICs) have an estimated 0.3 anaesthetists per 100,000 population, far fewer than the recommended 20/100,000 [2, 6]. Within LMICs, first referral hospitals are less likely than referral hospitals to have a full-time anaesthetist [7]. Anaesthetic delivery is further constrained by infrastructure, medication availability and hospital bed capacity [8, 9].

Several solutions have been proposed to address these constraints. Non-physician anaesthetic providers may share some tasks (e.g. spinal anaesthesia) for selected cases, although appropriate supervision models from medically trained anaesthetists are essential [10]. For example, task sharing of spinal anaesthesia by non-anaesthetic physicians was shown to be non-inferior to spinal anaesthesia delivered by consultant anaesthetists for patients who underwent selected surgical procedures in India [11]. Spinal anaesthesia is popular in resource-limited settings as it requires minimal equipment and is safe [8]. Previous work suggests that surgeons could share workload with anaesthetists through delivery of local-only anaesthesia for carefully selected cases, with appropriate monitoring escalation plans in place [12]. To date, however, few studies have explored international variation in anaesthesia delivery across common surgery types.

We proposed that inguinal hernia surgery was an appropriate tracer condition to research global anaesthesia practice; this procedure can be performed under general, spinal or locoregional anaesthesia. Inguinal hernias are common and contribute substantially to surgical waiting lists [13–15]. This study aimed to describe global delivery of anaesthesia for inguinal hernia surgery. To capture patient and system-level data, we assessed composite outcomes of patient selection, capacity utilisation and peri-operative safety across anaesthetic modalities. This was a secondary analysis of a previously described international prospective cohort study of inguinal hernia surgery [13].

Methods

Full details on ethical approval are available from the published study protocol [16]. In brief, where possible, this study was registered as a clinical audit. If formal ethical approval was required, the local principal investigator sought this according to national and hospital regulations. No data were uploaded until proof of appropriate study registration was shown. Informed patient consent was obtained in hospitals that required it. A reflexivity statement for global health research is available in online Supporting Information Appendix S2.

An international, multicentre prospective cohort study of patients who underwent inguinal hernia surgery was conducted. Full methods including robust data management procedures have been reported previously [16]. In summary, any hospital that performed inguinal hernia repair was considered eligible. For this secondary analysis, consecutive patients of any age and ASA physical status 1–4 who underwent elective primary laparoscopic, robotic or open inguinal hernia repair between 30 January and 21 May 2023 were included. Open surgeries via a midline incision were not included due to the added complexity of surgery.

Anaesthetic delivery was defined as general anaesthesia (including inhaled or total intravenous anaesthesia); spinal anaesthesia; and locoregional anaesthesia (including locally infiltrated anaesthetic or regional blocks). For this study, anaesthesia was classified by primary mode of delivery. We did not collect data on anaesthesia failure or cross-over. Sedation-only surgeries were not included due to low numbers and incomplete data on airway management for these cases. Anaesthesia provider was binary, defined as either ´operating surgeon´ or ´anaesthetist/anaesthetic nurse/anaesthetic technician´ (undifferentiated). The study did not further differentiate between clinical and non-clinical providers of anaesthesia.

A steering group, consisting of a diverse network of anaesthetists and peri-operative clinicians from high-, middle- and low-income countries, was formed to define outcome measurements. The steering group was constructed using members of the National Institute for Health and Care Research Global Health Unit on Global Surgery network, who have participated in previous research outputs [17, 18]. Outcomes were organised into three domains: patient selection; utilisation of hospital bed and workforce capacity; and peri-operative safety. Measures of patient selection included patient and disease-related factors used commonly in decision-making about anaesthesia modality, such as age; sex; ASA physical status; comorbidities; hernia size; and indication for surgery. Day-case rates as a primary outcome and anaesthetic administrator grade as a secondary outcome were chosen as proxies of hospital capacity to deliver surgery. Measures of safety were assessed at 30 days and included Clavien-Dindo score for overall complication rate [19]; postoperative infection; or re-operation. Surgical site infection was assessed according to the US Centers for

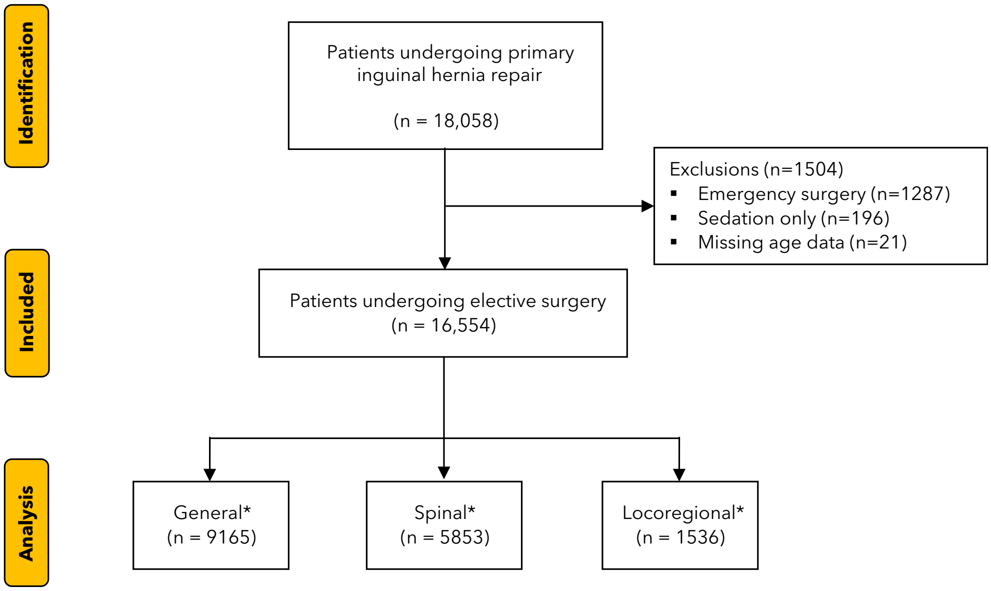

Figure 1 Flow chart of included patients. Patients with sedation only (without local anaesthesia) not included due to low numbers and as we were unable to ascertain if they underwent tracheal intubation.

Disease Control and Prevention definition, as described previously [20].

Non-parametric data were explored using the Mann–Whitney U-test and parametric data analysed using two-tailed Student's *t*-test or one-way analysis of variance depending on the number of comparator groups. Categorical variables were presented as frequencies and proportions and were analysed using the χ^2 test. Countries were mapped to country income groups defined by the World Bank: LICs; LMICs; upper-middle income countries (UMICs); and high-income countries (HIC). We also classified countries by their Human Development Index (HDI), a summary metric of health, standard of living and education indices [21]. This is a holistic metric to describe development, reflecting investment in human capital. The Human Development Index ranges from 0.4 to 1.0; countries < 0.550 are classified as low HDI; 0.550–0.699 as medium HDI; 0.700–0.799 as high HDI; and > 0.800 as very high HDI [21]. Multilevel logistic regression models were created using hospitals within countries as random effects, and results presented with 95%CIs. Statistical analysis was performed using R (Version 4.02, R Foundation for statistical computing, Vienna, Austria). A p-value of < 0.05 was considered statistically significant.

Results

The study included data from 16,554 patients from 640 hospitals in 83 countries (Fig. 1). Overall, 9165/16,554 (55.4%) of patients had general, 5853/16,554 (35.4%) had spinal and 1536/16,554 (9.24%) had locoregional anaesthesia. General anaesthesia was more common in HICs and UMICs while spinal was more common in LMICs and LICs (Table 1, Fig. 2). Tertiary hospitals (838/10,663, 7.9%) and private hospitals (60/833, 7.2%) were less likely to perform inguinal hernia surgery under locoregional anaesthesia than other hospital types. Total intravenous anaesthesia was used more commonly in HICs (online Supporting Information Table S1). Mean (SD) age was similar across general, spinal and locoregional anaesthesia (47.3 (26) y, 56.5 (17.9) y and 57 (18.6) y, respectively); however, children aged < 16 were much more likely to have general anaesthesia than other modalities (online Supporting Information Table S2). Comorbidities and ASA physical status were comparable across anaesthetic groups; most patients had no comorbidities and were ASA physical status 1–2 (Table 2). Hernia size was also very similar across anaesthetic modalities, with most limited to the inguinal region.

Most patients who had locoregional anaesthesia went home the same day (1151/1536, 75.1%); day-case rates were lower in patients who had general anaesthesia (5036/9165, 55.0%) and spinal anaesthesia (2626/5853, 45.0%) (Table 3). Compared with general anaesthesia, patients receiving locoregional anaesthesia were significantly more likely to undergo day-case procedures (OR 6.62, 95%CI 5.13–8.54, p < 0.001), while those with spinal anaesthesia

Table 1 Country and hospital characteristics across types of anaesthetic. Values are number (proportion).

	General n = 9165	Spinal n = 5853	Locoregional n = 1536	Total n = 16,554
Income group				
LIC	252 (2.7%)	491 (8.4%)	61 (4.0%)	804 (4.9%)
LMIC	1382 (15.1%)	1720 (29.4%)	445 (29.0%)	3547 (21.4%)
UMIC	1771 (19.3%)	1127 (19.3%)	177 (11.5%)	3075 (18.6%)
HIC	5760 (62.8%)	2515 (43.0%)	853 (55.5%)	9128 (55.1%)
HDI group				
Low	295 (3.2%)	562 (9.6%)	214 (13.9%)	1071 (6.5%)
Medium	924 (10.1%)	1275 (21.8%)	248 (16.1%)	2447 (14.8%)
High	1670 (18.2%)	1096 (18.7%)	143 (9.3%)	2909 (17.6%)
Very high	6269 (68.5%)	2920 (49.9%)	931 (60.6%)	10,120 (61.2%)
Hospital type				
Primary	765 (8.4%)	404 (7.0%)	184 (12.0%)	1353 (8.3%)
Secondary	2321 (25.6%)	1551 (26.7%)	510 (33.3%)	4382 (26.7%)
Tertiary	5975 (65.9%)	3850 (66.3%)	838 (54.7%)	10,663 (65.0%)
Hospital funding				
Public	7422 (81.9%)	4889 (84.2%)	1374 (89.7%)	13,685 (83.5%)
Private	1136 (12.5%)	646 (11.1%)	98 (6.4%)	1880 (11.5%)
Public–private	503 (5.6%)	270 (4.7%)	60 (3.9%)	833 (5.1%)
Hospital payment				
Other	344 (3.8%)	272 (4.7%)	46 (3.0%)	662 (4.0%)
Other insurance	970 (10.7%)	236 (4.1%)	79 (5.2%)	1285 (7.8%)
Government insurance	7206 (79.5%)	4737 (81.6%)	1199 (78.3%)	13,142 (80.1%)
Cost borne by patient	541 (6.0%)	560 (9.6%)	208 (13.6%)	1309 (8.0%)

LIC, low-income countries; LMIC, low or middle-income countries; UMIC, upper middle-income countries; HIC, high-income countries; HDI, Human Development Index.

were less likely (OR 0.97, 95%CI 0.84–1.12, p = 0.68) (Fig. 3). In 1087/1536 (70.8%) of patients, locoregional anaesthesia was performed without an anaesthetist, compared with 422/9165 (4.6%) in general and 257/5853 (4.4%) in spinal anaesthesia (Table 3). Complications between patients who had a surgeon or anaesthetic provider deliver anaesthesia were comparable when grouped by anaesthetic modality (online Supporting Information Table S3).

Most patients experienced no complications (14,503/16,554, 87.6%). Crude complication rates between locoregional (178/1536, 11.6%), general (991/9165, 10.8%) and spinal (859/5853, 14.7%) anaesthesia were compared (Table 3). Multilevel logistic regression showed that locoregional anaesthesia had a significant reduction in complications (OR = 0.67, 95%CI 0.52–0.87, p = 001). Spinal anaesthesia did not have a significant reduction in complications (OR = 0.90, 95%CI 0.77–1.05, p = 0.167) compared with general anaesthesia, after adjustment for: income group; age; ASA physical status; contamination; bowel resection; mesh use; and hernia size (online Supporting Information Figure S1). Re-operation rates were very low (81/16554, < 1.0%) and comparable across all groups.

Sevoflurane was the most common anaesthetic volatile agent used in HICs (2570/3107, 82.7%), UMICs (1059/1386, 76.4%) and LMICs (748/1239, 60.4%), but LICs used more halothane (84/199, 42.4%) than sevoflurane (76/199, 38.2%) (online Supporting Information Figure S2). Nitrous oxide use was very low across all country groups, ranging from 7/1386 (0.5%) in UMICs to 61/3107 (2.0%) in HICs (online Supporting Information Table S4).

Discussion

This study shows a wide variation of anaesthetic delivery across the world for a single procedure. Overall, use of locoregional anaesthesia was low, although patients who had this were less likely to stay in hospital overnight or have complications. This adds to existing literature suggesting

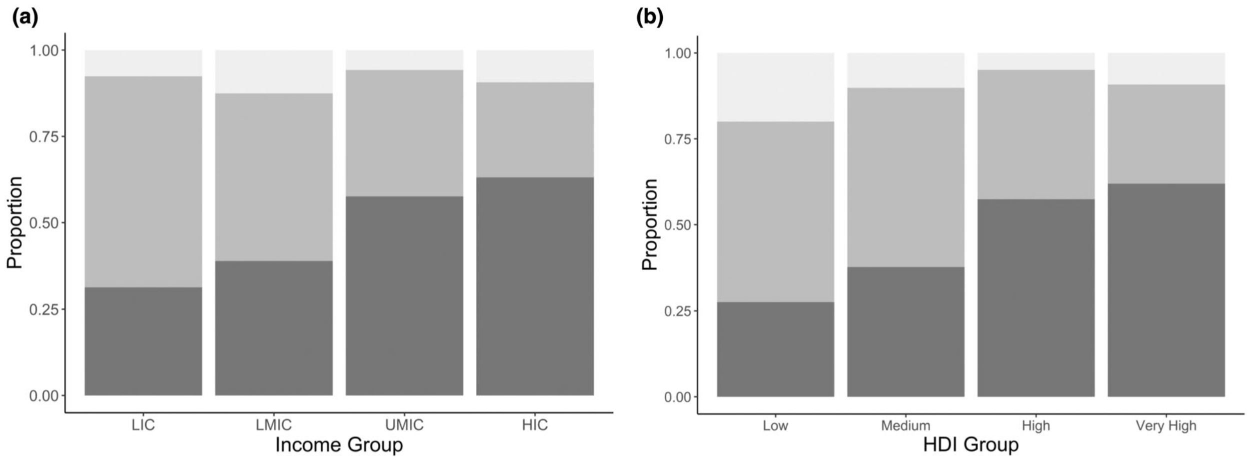

Figure 2 Anaesthesia delivery against (a) income group and (b) HDI group. Darkest shading, general anaesthesia; mid shading, spinal anaesthesia; light shading, locoregional anaesthesia; LIC, low-income countries; LMIC, low- or middle-income countries; UMIC, upper middle-income countries; HIC, high-income countries; HDI, Human Development Index.

Table 2 Measures of patient selection across types of anaesthetic. Values are mean (SD) or number (proportion).

	General n = 9165	Spinal n = 5853	Locoregional n = 1536	Total n = 16,554
Age; y	47.3 (26.0)	56.5 (17.9)	57.0 (18.6)	51.4 (23.3)
Age groups				
< 16	1780 (19.4%)	123 (2.1%)	37 (2.4%)	1940 (11.7%)
16–40	1051 (11.5%)	903 (15.4%)	224 (14.6%)	2178 (13.2%)
40–60	2608 (28.5%)	1906 (32.6%)	510 (33.2%)	5024 (30.4%)
60–80	3255 (35.5%)	2504 (42.8%)	634 (41.3%)	6393 (38.6%)
> 80	468 (5.1%)	414 (7.1%)	131 (8.5%)	1013 (6.1%)
Sex; male	8127 (88.7%)	5410 (92.4%)	1385 (90.2%)	14,922 (90.2%)
ASA physical status				
1–2	8004 (87.4%)	5112 (87.4%)	1349 (87.8%)	14,465 (87.4%)
3–4	1115 (12.2%)	726 (12.4%)	164 (10.7%)	2005 (12.1%)
Not recorded	44 (0.5%)	14 (0.2%)	23 (1.5%)	81 (0.5%)
Comorbidities				
0	7342 (80.1%)	4514 (77.1%)	1240 (80.8%)	13,096 (79.1%)
1	1415 (15.4%)	1026 (17.5%)	219 (14.3%)	2660 (16.1%)
2	309 (3.4%)	251 (4.3%)	63 (4.1%)	623 (3.8%)
≥ 3	92 (1.0%)	57 (1.0%)	12 (0.8%)	161 (1.0%)
Missing	7 (< 0.1%)	5 (< 0.1%)	1 (< 0.1%)	13 (< 0.1%)
Hernia size				
Limited to inguinal region	7362 (80.3%)	4333 (74.0%)	1212 (78.9%)	12,907 (78.0%)
Limited to scrotum	1749 (19.1%)	1425 (24.4%)	310 (20.2%)	3484 (21.1%)
Extend to mid-thigh or beyond	52 (0.6%)	94 (1.6%)	14 (0.9%)	160 (1.0%)
Asymptomatic hernia	1718 (18.7%)	896 (15.3%)	279 (18.2%)	2893 (17.5%)

that locoregional and spinal anaesthesia are safe options for selected patients and can boost global surgical capacity by reducing inpatient admissions [15, 22–25]. Further work is required to prospectively evaluate the selection, safety and acceptability of locoregional and spinal anaesthesia at scale.

Table 3 Peri-operative outcomes across types of anaesthetic. Values are number (proportion).

	General n = 9165	Spinal n = 5853	Locoregional n = 1536	Total n = 16,554
Day-case	5036 (55.0%)	2626 (45.0%)	1151 (75.1%)	8813 (53.3%)
Anaesthetic administrator				
Anaesthetist*	8742 (95.4%)	5596 (95.6%)	449 (29.2%)	14,787 (89.3%)
Surgeon	422 (4.6%)	257 (4.4%)	1087 (70.8%)	1766 (10.7%)
Clavien-Dindo complications	991 (10.8%)	859 (14.7%)	178 (11.6%)	2028 (12.3%)
1	764 (8.3%)	688 (11.8%)	132 (8.6%)	1584 (9.6%)
2	148 (1.6%)	130 (2.2%)	36 (2.3%)	314 (1.9%)
3a	32 (0.3%)	24 (0.4%)	9 (0.6%)	65 (0.4%)
3b	42 (0.5%)	15 (0.3%)	0	57 (0.3%)
4a	2 (< 0.1%)	0	1 (0.1%)	3 (< 0.1%)
5 (death)	3 (< 0.1%)	2 (< 0.1%)	0	5 (< 0.1%)
Postoperative infection	197 (2.2%)	232 (4.0%)	62 (4.0%)	491 (3.0%)
Re-operation	54 (0.6%)	24 (0.4%)	3 (0.2%)	81 (0.5%)

*Includes anaesthetists, anaesthetic nurses and anaesthetic technicians.

In LICs, more inguinal hernia surgeries are performed under spinal than general anaesthesia. This finding is supported by other studies in LMICs, particularly for obstetric surgery [8, 26]. Spinal anaesthesia in low-resource settings may be preferred by providers as it is safe and requires less equipment, such as ventilation, and by patients due to lower costs [27–29]. In our study, patients given spinal anaesthesia were less likely to go home the same day, reducing bed capacity and increasing the chance of future elective list cancellation. However, this finding may be confounded by unmeasured factors, such as limited planned day-case lists in these regions.

In HICs, use of general anaesthesia was more common than spinal. General anaesthesia makes use of greenhouse gases, which contribute to climate change [30]. Of all anaesthetic volatile agents, desflurane has the highest global warming potential, 2540 times more than carbon dioxide and 20 times more than sevoflurane. In HICs, 11% of cases used desflurane, highlighting an urgent need to complete the transition to less polluting agents such as sevoflurane. Fortunately, our study also showed low global usage of nitrous oxide, which likewise has a high global warming potential, 273 times higher than carbon dioxide [30]. Halothane, an older anaesthetic agent which can cause liver injury, is still more common in LICs. This is particularly concerning as Piramal Pharma Ltd, one of the largest suppliers to sub-Saharan Africa, has recently stopped halothane production [31].

Global variation and low levels of locoregional anaesthesia use are likely due to surgeon, anaesthetist and patient preference [32]. Locoregional anaesthesia may be perceived by clinicians and patients to increase the risk of peri-operative pain, although this is not supported by the evidence [33, 34]. Regional block is a skill that needs to be learned and thus may not be suitable for all surgeons and practitioners. Target nerves, such as ilioinguinal, iliohypogastric and genitofemoral, follow aberrant courses frequently, and can be difficult to locate [35]. Adjuncts such as ultrasound can help the efficacy of the regional block, but this requires additional resources and training [36, 37]. Additionally, surgeons may prefer general or spinal anaesthesia; inguinal hernia surgery has a steep learning curve, and training is easier when the patient has received neuromuscular blocking drugs. This may be a particular barrier in HICs, where training opportunities are increasingly limited [38]. This study did not assess patient preferences; this is a key factor and requires more exploration globally.

Our study shows that 70% of cases using locoregional anaesthesia were performed by surgeons, although we are unable to comment on whether continuous intra-operative monitoring was performed, or on the availability of an anaesthetist in case of patient safety issues. Shared anaesthesia provision, for example with surgeon-delivered locoregional anaesthesia, may help circumvent workforce bottlenecks and free up senior anaesthetists to cover multiple operating theatres or support more complex procedures [39–41]. This may be particularly beneficial in LMICs, which have the lowest total number and lowest density of anaesthetists, well below the recommended 20 per 100,000 population, and the greatest burden of unmet surgery [2, 42].

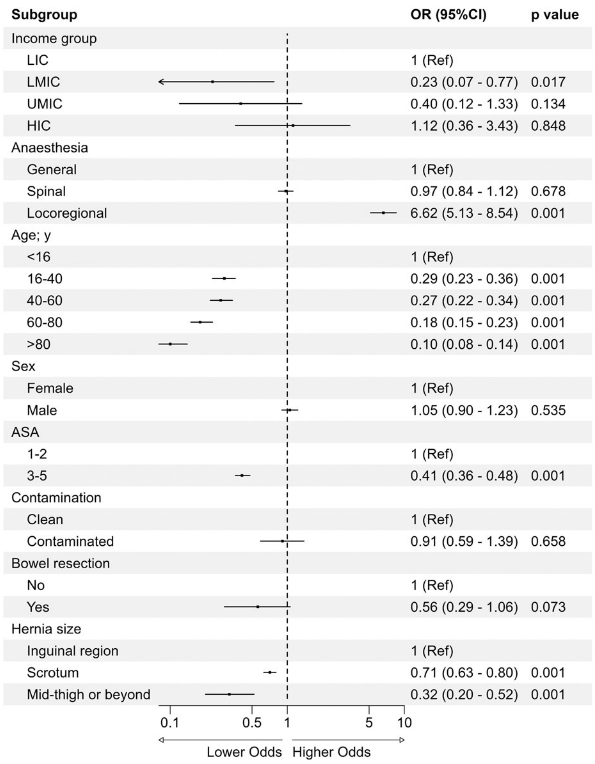

Figure 3 Multilevel logistic regression model showing odds ratios for day-case rates. LIC, low-income countries; LMIC, low- or middle-income countries; UMIC, upper middle-income countries; HIC, high-income countries.

In addition, our study showed relatively large numbers of surgeons who provided general and spinal anaesthesia. While this may represent practice in very remote regions with severe workforce constraints, supervision of all modes of anaesthesia delivery by trained anaesthetists is essential to ensure peri-operative safety and provide alternative anaesthetic options if required. Many countries have begun to `task-shift´ anaesthesia care to non-physician anaesthesia providers [10], with variability in safety and supervision models around this. Although guidance advocates for supervision of non-physicians by physician anaesthetists, non-physician anaesthesia providers may act unsupervised in some LMICs, due to the limited anaesthesia workforce [43–45]. Further research is needed to understand how current anaesthesia provision by physician and non-physician anaesthesia providers in these regions impacts patient selection, capacity and safety.

While external stressors on health systems such as COVID-19 increased delays and cancellations for elective surgery, it is possible the pandemic had a divergent effect on anaesthesia capacity in some settings. Retraining and redeployment of the healthcare workforce into anaesthesia and critical care roles and strengthening of infrastructure (e.g. for piped oxygen supply) may have boosted net overall capacity for peri-operative services in some hospitals [46]. Despite this, many health systems are still to reach pre-pandemic levels of activity [47].

This study has both strengths and limitations. We present, to our knowledge, the largest prospective cohort study describing the variety of anaesthetic practice in inguinal hernia surgery. This captures data from a wide range of healthcare facilities and countries. However, the study over-represents tertiary referral hospitals; primary and secondary referral hospitals perform the most elective surgery and are the least resourced. Our pragmatic cohort study was not able to collect specific anaesthetic complications (e.g. haematoma, local anaesthesia toxicity). However, the Clavien-Dindo classification system is agnostic to causes of adverse events and captured both surgery and/or anaesthesia-related complications. Patients were not contacted routinely 30 days following surgery and readmissions were not recorded so some complications may have been missed. However, major complications resulting in re-admissions were recorded. Due to heterogeneity in country participation, different practices might be over-represented. This study also did not capture data on conversion from local to general or spinal anaesthesia; presence of intra-operative monitoring; or postoperative pain. These factors may be influenced by anaesthesia technique, and/or patient and healthcare worker preferences. Additionally, we did not record whether patient tracheas were intubated; the grade of anaesthetist; whether anaesthesia was delivered by a non-physician or non-specialty trained physician; or the selection criteria used when deciding the modality of anaesthesia. More detailed exploration of the safety of non-physician anaesthesia providers is a timely and important focus for future research. We used a pragmatic definition of general anaesthesia which did not mandate the use of cuffed tracheal tubes; this may have meant that some patients given intravenous drugs did not have a protected airway. To address this, we did not include patients who were coded as `sedation only´.

In conclusion, this study describes measures of patient selection, capacity and safety across global anaesthesia delivery for a single common general surgical procedure. Future studies are required to determine if local and spinal anaesthetic procedures are acceptable to patients and can be upscaled to potentially increase capacity. There is an opportunity for reverse innovation and learning about anaesthetic delivery from the global south to north.

Surgical volume may be increased by the adoption of context-sensitive approaches that may include locoregional anaesthesia and/or spinal anaesthesia lists in some regions.

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References

1. COVIDSurg Collaborative. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. *Br J Surg* 2020; **107**: 1440–9. https://doi.org/10.1002/bjs.11746.
2. Meara JG, Leather AJM, Hagander L, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. *Lancet* 2015; **386**: 569–624. https://doi.org/10.1016/S0140-6736(15)60160-X.
3. GlobalSurg Collaborative. Mortality of emergency abdominal surgery in high-, middle- and low-income countries. *Br J Surg* 2016; **103**: 971–88. https://doi.org/10.1002/bjs.10151.
4. Haider A, Scott JW, Gause CD, et al. Development of a unifying target and consensus indicators for global surgical systems strengthening: proposed by the Global Alliance for Surgery, obstetric, trauma, and Anaesthesia care (the G4 Alliance). *World J Surg* 2017; **41**: 2426–34. https://doi.org/10.1007/s00268-017-4028-1.
5. World Health Organization. World Health Assembly Resolution 68.15: Strengthening emergency and essential surgical care and anaesthesia as a component of universal health coverage. 68th World Health Assembly; May 2015. https://apps.who.int/gb/ebwha/pdf_files/WHA68/A68_R15-en.pdf.
6. Law TJ, Lipnick MS, Morriss W, et al. The global anesthesia workforce survey: updates and trends in the anesthesia workforce. *Anesth Analg* 2024; **139**: 15–24. https://doi.org/10.1213/ANE.0000000000006836.
7. Kamarajah SK, Alexander P. NIHR Global Health Research Unit on Global Surgery. Structures, processes and outcomes between first referral and referral hospitals in low-income and middle-income countries: a secondary preplanned analysis of the FALCON and ChEETAh randomised trials. *BMJ Glob Health* 2024; **9**(Suppl 4): e015599. https://doi.org/10.1136/bmjgh-2024-015599.
8. Ariyo P, Trelles M, Helmand R, et al. Providing anesthesia care in resource-limited settings: a 6-year analysis of anesthesia services provided at Médecins Sans Frontières facilities. *Anesthesiology* 2016; **124**: 561–9. https://doi.org/10.1097/ALN.0000000000000985.
9. Glasbey JC, Abbott TEF, Ademuyiwa A, et al. Elective surgery system strengthening: development, measurement, and validation of the surgical preparedness index across 1632 hospitals in 119 countries. *Lancet* 2022; **400**: 1607–17. https://doi.org/10.1016/S0140-6736(22)01846-3.
10. Bognini MS, Oko CI, Kebede MA, Ifeanyichi MI, Singh D, Hargest R, Friebel R. Assessing the impact of anaesthetic and surgical task-shifting globally: a systematic literature review. *Health Policy Plan* 2023; **38**: 960–94. https://doi.org/10.1093/heapol/czad059.
11. Menon N, George R, Kataria R, et al. Task-sharing spinal anaesthesia care in three rural Indian hospitals: a non-inferiority randomised controlled clinical trial. *BMJ Glob Health* 2024; **9**: e014170. https://doi.org/10.1136/bmjgh-2023-014170.
12. Kudsk-Iversen S, Shamambo N, Bould MD. Strengthening the anesthesia workforce in low- and middle-income countries. *Anesth Analg* 2018; **126**: 1291–7. https://doi.org/10.1213/ANE.0000000000002722.
13. NIHR Global Health Research Unit on Global Surgery. Access to and quality of elective care: a prospective cohort study using hernia surgery as a tracer condition in 83 countries. *Lancet Glob Health* 2024; **12**: e1094–103. https://doi.org/10.1016/S2214-109X(24)00142-6.
14. Li L, Pang Y, Wang Y, Li Q, Meng X. Comparison of spinal anesthesia and general anesthesia in inguinal hernia repair in adults: a systematic review and meta-analysis. *BMC Anesthesiol* 2020; **20**: 64. https://doi.org/10.1186/s12871-020-00980-5.
15. Prakash D, Heskin L, Doherty S, Galvin R. Local anaesthesia versus spinal anaesthesia in inguinal hernia repair: a systematic review and meta-analysis. *Surgeon* 2017; **15**: 47–57. https://doi.org/10.1016/j.surge.2016.01.001.
16. NIHR Global Health Research Unit on Global Surgery. Hernias, pathway and planetary outcomes for inguinal hernia surgery 2023. https://www.globalsurgeryunit.org/clinical-trials-holding-page/hippo/.
17. National Institute for Health and Care Research Global Health Research Unit on Global Surgery. Reducing the environmental impact of surgery on a global scale: systematic review and co-prioritization with healthcare workers in 132 countries. *Br J Surg* 2023; **110**: 804–17. https://doi.org/10.1093/bjs/znad092.
18. National Institute for Health Research Global Health Research Unit on Global Surgery. Prioritizing research for patients requiring surgery in low- and middle-income countries. *Br J Surg* 2019; **106**: e113–20. https://doi.org/10.1002/bjs.11037.
19. Clavien PA, Strasberg SM. Severity grading of surgical complications. *Ann Surg* 2009; **250**: 197–8. https://doi.org/10.1097/SLA.0b013e3181b6dcab.
20. Kachapila M, Oppong R, Ademuyiwa AO, et al. Routine sterile glove and instrument change at the time of abdominal wound closure to prevent surgical site infection (ChEETAh): a model-based cost-effectiveness analysis of a pragmatic, cluster-randomised trial in seven low-income and middle-income countries. *Lancet Glob Health* 2024; **12**: e235–42. https://doi.org/10.1016/S2214-109X(23)00538-7.
21. United Nations Development Programme. Human Development Index. https://hdr.undp.org/data-center/human-development-index#/indicies/HDI (accessed 25/03/2025).
22. Nordin P, Zetterström H, Gunnarsson U, Nilsson E. Local, regional, or general anaesthesia in groin hernia repair: multicentre randomised trial. *Lancet* 2003; **362**: 853–8. https://doi.org/10.1016/S0140-6736(03)14339-5.
23. O'Dwyer PJ, Serpell MG, Millar K, et al. Local or general anesthesia for open hernia repair: a randomized trial.

Ann Surg 2003; **237**: 574–9. https://doi.org/10.1097/01.SLA.0000059992.76731.64.
24. van Veen RN, Mahabier C, Dawson I, et al. Spinal or local anesthesia in Lichtenstein hernia repair: a randomized controlled trial. *Ann Surg* 2008; **247**: 428–33. https://doi.org/10.1097/SLA.0b013e31815b6f7f.
25. Reece-Smith A, Maggio A, Tang T, Walsh S. Local anaesthetic vs. general anaesthetic for inguinal hernia repair: systematic review and meta-analysis. *Int J Clin Pract* 2009; **63**: 1739–42. https://doi.org/10.1111/j.1742-1241.2009.02131.x.
26. Gerber C, Bishop DG, Dyer RA, et al. Method of anesthesia and perioperative risk factors, maternal anesthesia complications, and neonatal mortality following cesarean delivery in Africa: a substudy of a 7-day prospective observational cohort study. *Anesth Analg* 2024; **138**: 1275–84. https://doi.org/10.1213/ANE.0000000000006750.
27. Mgbakor AC, Adou BE. Plea for greater use of spinal anaesthesia in developing countries. *Trop Doct* 2012; **42**: 49–51. https://doi.org/10.1258/td.2011.100305.
28. Schnittger T. Regional anaesthesia in developing countries. *Anaesthesia* 2007; **62**: 44–7. https://doi.org/10.1111/j.1365-2044.2007.05297.x.
29. Schuster M, Gottschalk A, Berger J, Standl T. A retrospective comparison of costs for regional and general anesthesia techniques. *Anesth Analg* 2005; **100**: 786–94. https://doi.org/10.1213/01.ANE.0000148685.73336.70.
30. Sherman J, Le C, Lamers V, Eckelman M. Life cycle greenhouse gas emissions of anesthetic drugs. *Anesth Analg* 2012; **114**: 1086–90. https://doi.org/10.1213/ANE.0b013e31824f6940.
31. Gelb AW, Vreede E. Availability of halothane is still important in some parts of the world. *Can J Anaesth* 2024; **71**: 1427–8. https://doi.org/10.1007/s12630-024-02836-9.
32. White PF. Optimizing anesthesia for inguinal herniorrhaphy: general, regional, or local anesthesia? *Anesth Analg* 2001; **93**: 1367–9. https://doi.org/10.1097/00000539-200112000-00001.
33. Tabiri S, Russell KW, Gyamfi FE, Jalali A, Price RR, Katz MG. Local anesthesia underutilized for inguinal hernia repair in northern Ghana. *PLoS One* 2018; **13**: e0206465. https://doi.org/10.1371/journal.pone.0206465.
34. Wongyingsinn M, Kohmongkoludom P, Trakarnsanga A, Horthongkham N. Postoperative clinical outcomes and inflammatory markers after inguinal hernia repair using local, spinal, or general anesthesia: a randomized controlled trial. *PLoS One* 2020; **15**: e0242925. https://doi.org/10.1371/journal.pone.0242925.
35. Rab M, Ebmer JM, Dellon AL. Anatomic variability of the ilioinguinal and genitofemoral nerve: implications for the treatment of groin pain. *Plast Reconstr Surg* 2001; **108**: 1618–23. https://doi.org/10.1097/00006534-200111000-00011.
36. Singh GP, Kuthiala G, Shrivastava A, Gupta D, Mehta R. The efficacy of ultrasound-guided triple nerve block (ilioinguinal, iliohypogastric, and genitofemoral) versus unilateral subarachnoid block for inguinal hernia surgery in adults: a randomized controlled trial. *Anaesthesiol Intensive Ther* 2023; **55**: 342–8. https://doi.org/10.5114/ait.2023.122504.
37. Faisal H, Qamar F, Martinez S, Razmi SE, Oviedo RJ, Masud F. Learning curve of ultrasound-guided surgeon-administered transversus abdominis plane (UGSA-TAP) block on a porcine model. *Heliyon* 2024; **10**: e25006. https://doi.org/10.1016/j.heliyon.2024.e25006.
38. Ueda J, Yoshida H. Learning curve of resident surgeons for open mesh repair of inguinal hernia. *Int Surg* 2022; **107**: 1–7. https://doi.org/10.9738/INTSURG-D-21-00070.1.
39. LeBrun DG, Saavedra-Pozo I, Agreda-Flores F, et al. Surgical and anesthesia capacity in Bolivian public hospitals: results from a national hospital survey. *World J Surg* 2012; **36**: 2559–66. https://doi.org/10.1007/s00268-012-1722-5.
40. Harris MJ, Kamara TB, Hanciles E, Newberry C, Junkins SR, Pace NL. Assessing unmet anaesthesia need in Sierra Leone: a secondary analysis of a cluster-randomized, cross-sectional, countrywide survey. *Afr Health Sci* 2015; **15**: 1028–33. https://doi.org/10.4314/ahs.v15i3.43.
41. Groen RS, Kamara TB, Dixon-Cole R, et al. A tool and index to assess surgical capacity in low-income countries: an initial implementation in Sierra Leone. *World J Surg* 2012; **36**: 1970–7. https://doi.org/10.1007/s00268-012-1482-1.
42. Khan FA, Merry AF. Improving anesthesia safety in low-resource settings. *Anesth Analg* 2018; **126**: 1312–20. https://doi.org/10.1213/ANE.0000000000002728.
43. World Federation of Societies of Anaesthesiologists. WFSA releases position statement on anaesthesiology and universal health coverage (UHC), 2020. https://wfsahq.org/news/wfsa-releases-position-statement-on-anaesthesiology-and-universal-health-coverage-uhc/ (accessed 15 January 2025).
44. Shahbaz S, Howard N. Anaesthesia delivery systems in low and lower-middle-income Asian countries: a scoping review of capacity and effectiveness. *PLOS Glob Public Health* 2024; **4**: e0001953. https://doi.org/10.1371/journal.pgph.0001953.
45. Steffner KR, McQueen KA, Gelb AW. Patient safety challenges in low-income and middle-income countries. *Curr Opin Anaesthesiol* 2014; **27**: 623–9. https://doi.org/10.1097/ACO.0000000000000121.
46. Vera San Juan N, Clark SE, Camilleri M, Jeans JP, Monkhouse A, Chisnall G, Vindrola-Padros C. Training and redeployment of healthcare workers to intensive care units (ICUs) during the COVID-19 pandemic: a systematic review. *BMJ Open* 2022; **12**: e050038. https://doi.org/10.1136/bmjopen-2021-050038.
47. COVIDSurg Collaborative. Nowcasting waiting lists for elective procedures and surgery in England: a modelling study. *Lancet* 2023; **402**(Suppl 1): S74. https://doi.org/10.1016/S0140-6736(23)02073-1.

Supporting Information

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

Plain Language Summary.

Appendix S1. Authorship.

Appendix S2. Reflexivity statement.

Figure S1. Multilevel logistic regression model showing odds ratios for complications against types of anaesthetic.

Figure S2. Map showing halothane use globally.

Table S1. Country and hospital characteristics across anaesthetic groups.

Table S2. Country, hospital and patient selection, capacity and safety outcomes across paediatric age groups.

Table S3. Subgroup table of complications in locoregional anaesthesia across anaesthesia provider, grouped by anaesthetic type.

Table S4. Anaesthetic volatile agents and gases across income groups.