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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

NIHR Global Health Research Unit on Global Surgery

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ABSTRACT

First referral hospitals, often known as district hospitals, are neglected in the discourse on universal health coverage in low-income and middle-income countries (LMICs). However, these hospitals are important for delivering safe surgery for 313 million people. This study aims to understand the structures, processes and outcomes of patients undergoing surgery in these centres in LMICs. This is a preplanned secondary analysis using data from two high-quality randomised controlled trials undergoing major abdominal surgery across six LMICs. Type of hospital was the main explanatory variable, defined according to the WHO taxonomy as first referral (ie, district or rural) and referral (ie, secondary or tertiary). Of the included 15 657 patients across 80 hospitals from 6 countries, 3562 patients underwent surgery in first referral and 12 149 patients underwent surgery in referral centres. First referral centres have lower full-time surgeons (median: 1 vs 20, p<0.001) and medically trained anaesthetists (28.6% vs 87.1%, p<0.001) compared with referral centres. Patients undergoing surgery in first referral centres were more likely to have lower rates of American Society of Anaesthesiologist (ASA) grades III–V (8.1% vs 22.7%, p<0.001), but higher rates of emergency procedures (65.1% vs 56.6%, p<0.001). In first referral centres, there was a significantly higher use of WHO surgical safety checklist (99.4% vs 93.3%, p<0.001) compared with referral centres. In adjusted analyses, there were no differences in 30-day mortality (OR 1.09, 95% CI 0.73 to 1.62) and surgical site infection (OR 1.30, 95% CI 0.89 to 1.90) between first referral and referral centres. Postoperative mortality and surgical site infection remain similar between first referral and referral centres in LMICs. There may be a clear need to upscale surgical volume safely in first referral centres to meet global surgical needs. High-quality research is needed to drive safe expansion of surgical workforce and strengthen referral pathways within these surgical health systems in LMICs.

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ To date, first referral hospitals, also known as district hospitals, play a crucial role in providing surgical care in low-income and middle-income countries (LMICs). However, these hospitals are often overlooked in the discourse on universal health coverage despite being integral to delivering safe surgery to a significant population. Previous published studies highlighted postoperative mortality and surgical site infections were critical issues in both first referral and higher-level referral hospitals in LMICs. There was a clear need for studies focused on understanding the structures, processes and outcomes of surgeries performed in first referral hospitals to guide improvements in surgical care delivery.

INTRODUCTION

The Lancet Commission on Global Surgery[1] launched Global Surgery 2030 to address inequities in the provision of safe, affordable surgical and anaesthesia care, especially in low-income and middle-income countries (LMICs). It was estimated that almost five billion people worldwide lack adequate access to safe surgical care, largely in LMICs. Here, the poorest third of the world's population receives only 3.5% of surgical operations done worldwide.[2–4] These surgical conditions comprise non-communicable diseases and injuries accounting for about 11% of the global burden of the disease.[5] Recent estimates would account for the prevention of 1.5 million deaths per year or 6%–7% of all deaths in LMICs only if accessible essential surgical care was tended (eg, obstructed labour, maternal haemorrhage, fractures and acute abdominal disorders like appendicitis).[6] The challenge is how

WHAT THIS STUDY ADDS

⇒ This study provides new insights by comparing the surgical care structures, processes and outcomes between first referral and higher-level referral hospitals in LMICs. First referral hospitals have fewer full-time surgeons and medically trained anaesthetists, perform more emergency surgeries and have a higher usage of the WHO surgical safety checklist compared with referral hospitals. Despite these differences, the study found no significant difference in 30-day postoperative mortality and surgical site infection rates between the two hospital types. This indicates that first referral hospitals can potentially manage surgical volumes safely if adequately supported.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ The findings of this study highlight the need to upscale surgical capacity and workforce in first referral hospitals to meet global surgical needs effectively. It underscores the importance of targeted interventions to improve surgical infrastructure and training in these hospitals. Policy-makers can use this evidence to advocate for increased investment in first referral hospitals, ensuring they are equipped to handle both routine and emergency surgeries safely. Additionally, this study emphasises the necessity for high-quality research to develop and implement strategies that can strengthen referral pathways and surgical systems in LMICs, ultimately contributing to better health outcomes and progress towards universal health coverage.

to provide such a surgical service. It is evident that improvement will need to be delivered through the district (non-referral) hospitals.

One of the challenges hampering improvement is the sociological phenomenon called the urban–rural divide, which creates disparities or inequalities in health outcomes and access to care between people living in urban and rural communities.[7] Rural surgery in developed countries, as in the USA and Australia, describes the practice of general surgery in rural areas or outside the metropolitan area.[8 9] For developing countries in Africa (eg, Malawi and Zambia), rural surgery includes task-shifting to non-physician clinicians.[10] In India, rural surgeons are trained general surgeons for rural practice, enabling the successful delivery of care in these settings.[11] Therefore, rapid growth and success of the rural surgery movement is associated with its geographical setting, where these areas have a common 'landmass' which makes resource sharing easier. Further, rural surgery activities are based on National Surgical, Obstetric and Anaesthesia Plans created and in force by these countries. For instance, this may include increasing capacity for surgical volume and workforce in these settings.

The increasing surgical activity within hospitals in rural settings is important for several reasons. These include close proximity to patients, less risk of second delay, lower risk of catastrophic expenditure and relieving burden on referral facilities so they can provide specialist care. These are all important in the agenda for expanding Global Surgery.[12] To safely scale surgical activity in first referral hospitals (ie, rural and district settings), understanding structures, processes and outcomes in these hospitals is important. Although global data exist, they are limited to single country evaluation[13 14] or lack patient-level data to understand how structures and processes impact on clinical outcomes.[15] Therefore, the aim of this study is to define structures, processes and outcomes of patients undergoing surgery in first referral hospitals, according to the Donabedian model for measuring quality of care. This study uses data from two high-quality randomised controlled trials (RCTs) undergoing major abdominal surgery across six LMICs.

METHODS

Study design and participants

This secondary preplanned analysis included patients from two published RCTs examining ways to reduce surgical site infections (SSIs). First, FALCON (Reducing surgical site infections in low-income and middle-income countries)[16] was a two-by-two factorial RCT done in 54 centres from 7 LMICs (Benin, Ghana, India, Mexico, Nigeria, Rwanda and South Africa) between 10 December 2018 and 7 September 2020. This trial assessed whether a combination of four interventions for skin preparation and sutures before skin closure can significantly reduce SSIs compared with current practice. These combinations were as follows: (1) 2% alcoholic chlorhexidine and non-coated suture; (2) 2% alcoholic chlorhexidine and triclosan-coated suture; (3) 10% aqueous povidone-iodine and non-coated suture or (4) 10% aqueous povidone-iodine and triclosan-coated suture. Second, ChEETAh (Routine sterile glove and instrument change at the time of abdominal wound closure to prevent surgical site infection)[17] was a cluster RCT done in 81 centres from 7 LMICs (Benin, Ghana, India, Mexico, Nigeria, Rwanda and South Africa) between 24 June 2020 and 31 March 2022. This trial assessed whether routine changes of sterile gloves and instruments (needle holder, forceps and scissors) before abdominal wall closure significantly reduces SSIs compared with current practice.

Both the FALCON and CHEETAH included children and adult patients undergoing elective or emergency abdominal surgery for a clean-contaminated, contaminated or dirty operation for any indication (ie, benign or cancer) with an abdominal incision of 5 cm or greater. Operations were classified as clean-contaminated if gastrointestinal or genitourinary tracts were entered, but no spillage occurred; contaminated if there was a minor spillage of gastrointestinal or genitourinary contents; and dirty if there was a gross spillage of gastrointestinal or genitourinary contents or established peritonitis. The full protocol[16] and results[16 17] of both these clinical trials have been published.

Explanatory variable

The main explanatory variable in this analysis was hospital type, defined according to the WHO taxonomy system as

first referral and referral.[18 19] First referral hospitals were defined as hospitals at the first referral level responsible for a district or a defined geographical area containing a specific population, governed by a politico-administrative organisation such as a district health management team. Referral hospitals were defined as secondary or tertiary centres providing specialist services. At present, there is no worldwide agreed definitions for the hospital type (ie, first referral or referral). Therefore, to understand the type of hospital, a network survey was developed with the FALCON and CHEETAH study management group. This prospective survey was sent to all hospital leads involved in both the FALCON and CHEETAH RCT. This survey incorporated centre-level factors such as the availability of surgical and anaesthetic staff, presence of a blood bank, laboratory service and number of ventilated beds. A summary of questions is presented in online supplemental table S1. The type of centre was defined by the principal investigators, who are consultant surgeons, at each of the participating sites for both the FALCON and CHEETAH RCT.

Inclusion and exclusion criteria

For this secondary preplanned analysis, all patients undergoing major abdominal surgery with complete patient-level and hospital-level data were included. Patients were excluded if they underwent clean (non-contaminated) surgery or caesarean section because patients undergoing the latter were not included in the CHEETAH trial. Therefore, to prevent imbalances between the cohorts, the latter group was excluded (figure 1).

Measuring quality of care

To measure the performance of quality of care across different surgical systems, the Donabedian model was used. This model uses key metrics to assess structures, processes and outcomes within health systems. To ensure relevance to surgical systems, key metrics were identified and mapped to each of these domains through a consensus process with the trial management group, with expertise in surgery, perioperative care, public health and methodology. Briefly, key metrics mapped were as follows: (1) structure was assessed by availability of trained consultant surgeons and anaesthetists; (2) process was assessed by the casemix of surgery being performed defined as the proportion of patients with ASA grades III–V, emergency surgery and use of the WHO surgical safety checklist and (3) outcomes defined as postoperative mortality and SSI.

Postoperative mortality was defined as death within 30 days of surgery. SSI up to 30 days from surgery was defined by the US Centers for Disease Control and Prevention definition of deep incisional or superficial incisional SSI as follows: (1) the infection occurred within 30 days of the index operation; (2) the infection involved the skin, subcutaneous, muscular or fascial layers of the incision; (3) the patient had at least one of purulent drainage from the wound, organisms detected by wound swab, diagnosis clinically or at imaging, or wound opened

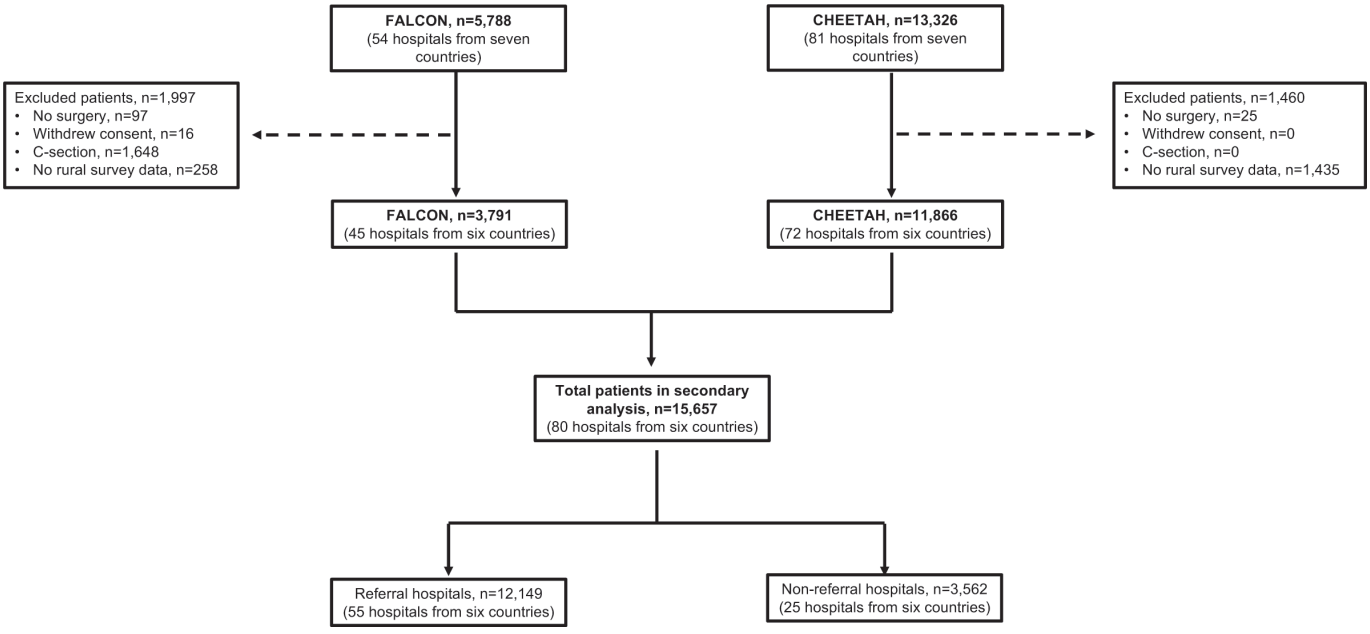

Figure 1

Figure 1: Flow chart of patient inclusion into the study

FALCON (Reducing surgical site infections in low-income and middle-income countries); ChEETAh (Routine sterile glove and instrument change at the time of abdominal wound closure to prevent surgical site infection)

spontaneously or by a clinician and (4) the patient had at least one of pain, tenderness, localised swelling, redness, heat at the wound site or systemic fever (>38°C). In both the FALCON and CHEETAH trials, outcome assessors underwent rigorous training to conduct follow-up assessments, either face to face or via telephone, employing a set of predefined questions to ensure consistency and accuracy in data collection.

Data collection and definitions

Both the FALCON and CHEETAH datasets were combined to include patient-level and operative-level characteristics. Patient-level variables included were age (ie, child, adult), gender (ie, male, female), smoking status (ie, ex-smoker (>6 weeks), current or ex-smoker <6 weeks or never smoked), ASA grade, presence of diabetes and HIV status (ie, known negative, known positive and status not known). Operative-level variables include timing of surgery (ie, elective and emergency), indication of surgery, type of operation, degree of contamination, prophylactic antibiotics (was defined as the use of antibiotics up to 60 min before surgery), hair removal at the site of the wound, use of the WHO surgical safety checklist, intraoperative pulse oximetry, and glove and instrument change.

Statistical analysis

Categorical variables were compared using the χ^2 test. Non-normally distributed data were analysed using the Mann-Whitney U test. Survival was estimated using Kaplan-Meier survival curves and compared using the log-rank test. Time to death was calculated as time from surgery to death within 30 days after surgery. Patients who were alive were censored at 30 days. In this study, a multilevel Cox (for 30-day mortality) and logistic (for 30-day SSI) regression model were used to account for key confounding variables and bias that could have been introduced by the clustered nature of both trials. These models accounted for confounding variables such as smoking status (current, ex-smoker and never-smoker), ASA grade (I, II, III and IV/V), timing of surgery (ie, elective vs emergency), type of surgery (gastrointestinal vs non-gastrointestinal), surgical approach (open midline vs open non-midline vs laparoscopic), wound contamination (clean-contaminated vs contaminated-dirty), malignant indication (no vs yes), use of WHO checklist (no vs yes) and change of glove and instrument (no vs yes) as fixed effects. Hospital levels were included as random effects. A p<0.05 was considered statistically significant. Data analysis was performed using R Foundation Statistical software (R V.3.2.2) with TableOne, ggplot2, Hmisc and survival packages (R Foundation for Statistical Computing, Vienna, Austria).

Role of the funding source

The sponsor of the study had no role in study design, data collection, data analysis, data interpretation or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Patient and public involvement

No patients or the public were involved at any stage during the production of this paper.

RESULTS

Study characteristics

Of the 19 089 patients from the FALCON and CHEETAH RCT, a total of 3432 patients were excluded from the final analysis because of no surgery (n=100), withdrew consent (n=16), underwent C-section (n=1648) and no survey data to compliment patient-level data (n=1668). Therefore, this secondary preplanned analysis included 15 657 patients across 80 centres from 6 countries (figure 1). A summary of patients and hospitals included in both the FALCON and CHEETAH RCTs is presented in online supplemental table S2.

Structure measures

Of the centres involved within FALCON and CHEETAH, complete survey-level data were available for 80 centres, of which 25 centres (31.3%) were classified as first referral. First referral centres had significantly lower number of full-time surgeons (median: 1 vs 20, p<0.001) and medically trained anaesthetists (28.6% vs 87.1%, p<0.001) compared with referral centres. First referral centres also had significantly lower volume of annual surgical procedures >500 (22.9% vs 82.3%, p<0.001), lower rates of blood bank or blood storage unit (74.3% vs 96.8%, p=0.003) and ventilated beds outside operating theatres (37.1% vs 83.9%, p<0.001) compared with referral centres (table 1, figure 2).

Process measures

Patients who underwent surgery in first referral centres were more likely to be female patients (59.2% vs 51.3%, p<0.001) and non-smokers (93.6% vs 90.3%, p<0.001) compared with referral centres. However, patients undergoing surgery in first referral centres were more likely to have lower rates of ASA grades III–V (8.1% vs 22.7%, p<0.001) and diabetes (3.3% vs 6.5%, p<0.001). There was no difference in the proportion of children and adults between referral and first referral centres (table 2, figure 2). Patients undergoing surgery in first referral centres were more likely to be emergency (65.1% vs 56.6%, p<0.001), for benign disease (94.2% vs 76.5%, p<0.001) and dirty operations (23.7% vs 22.1%, p<0.001) compared with referral centres. In first referral centres, there was a significantly higher use of WHO surgical safety checklist (99.4% vs 93.3%, p<0.001) compared with referral centres. However, rates of hair removal before surgery were lower in first referral centres compared with referral centres (26.8% vs 49.6%, p<0.001). There were no differences in the rates of prophylactic antibiotics and intraoperative pulse oximetry between first referral and referral centres (table 3).

Table 1 Centre-level factors associated with referral and first referral centres

Label	Levels	First referral centre, n=25	Referral centre, n=55	P value
Number of surgical procedures	<200	2 (8.0%)	1 (1.8%)	
	200–500	15 (60.0%)	7 (12.7%)	<0.001
	>500	8 (32.0%)	47 (85.5%)	
Full-time consultant surgeons who are staff	Median (IQR)	2 (1, 3)	25 (8.5, 40)	<0.001
Presence of a medically trained anaesthetist		9 (36.0%)	48 (87.3%)	<0.001
Presence of an anaesthetic technician/nurse		23 (92.0%)	53 (96.4%)	0.6
Blood bank or blood storage unit in your hospital		17 (68.0%)	54 (98.2%)	<0.001
Ventilated beds outside of the operating theatre		13 (52.0%)	48 (87.3%)	<0.001

Outcome measures

In the unadjusted analysis, rates of 30-day postoperative mortality were lower in first referral centres compared with referral centres (4.6% vs 7.6%, p<0.001). A summary of hospital-level, patient-level and operative-level factors associated with postoperative mortality is presented in online supplemental tables S3–S6. In adjusted analyses clustered by hospital, there was no significant difference in the rates of postoperative mortality between first referral and referral centres (OR 1.09, 95% CI 0.73 to 1.62) (figure 3). In the unadjusted analysis, rates of SSI were lower in first referral centres compared with referral centres (14% vs 21%, p<0.001). A summary of patient-level and operative-level factors associated with postoperative SSI is presented in online supplemental table S7. In adjusted analyses clustered by hospital, there was no significant difference in the rates of postoperative SSI between first referral and referral centres (OR 1.30, 95% CI 0.89 to 1.90) (online supplemental figure 1).

DISCUSSION

These preplanned secondary analyses including 15 657 patients from 2 major surgical trials in global surgery aimed to examine structures, processes and outcomes between first referral and referral centres in LMICs. This study identified three principal findings. First, the workforce of trained consultant surgeons and anaesthetists is lower in the first referral centres. Second, first referral centres have higher rates of low-risk, benign operations and emergency cases compared with high-risk, elective and cancer operations in referral centres. Finally, postoperative mortality and SSIs were similar between first referral and referral centres, even after adjusting for

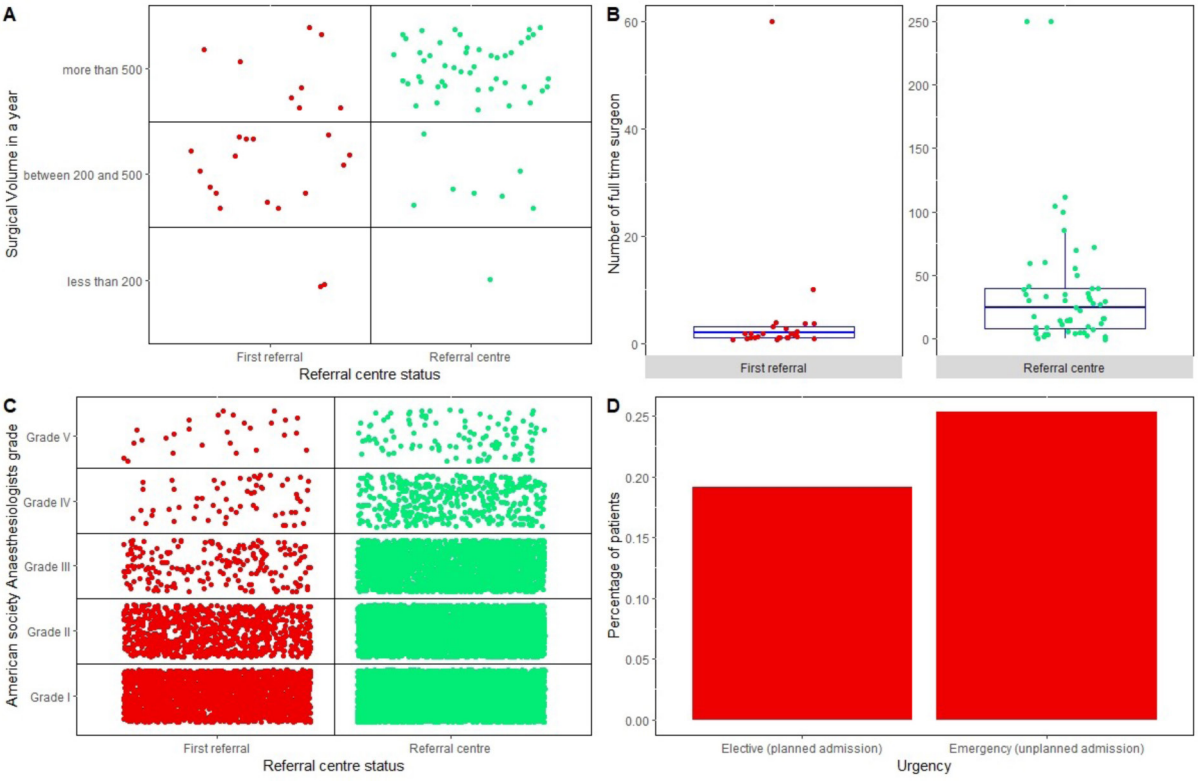

Figure 2

Table 2 Baseline patient-level and operative-level characteristics of patients undergoing major abdominal surgery from FALCON and CHEETAH by referral centre status

	First referral	Referral	P value
Age			
Child	471 (13.2)	1677 (13.9)	0.341
Adult	3091 (86.8)	10418 (86.1)	
Sex			
Male	1449 (40.8)	5885 (48.7)	<0.001
Female	2101 (59.2)	6189 (51.3)	
(Missing)	12	21	
Smoking status			
Ex-smoker (>6 weeks)	112 (3.2)	666 (5.5)	<0.001
Current or ex-smoker (<6 weeks)	114 (3.2)	509 (4.2)	
Never smoked	3324 (93.6)	10899 (90.3)	
(Missing)	12	21	
ASA grade			
Grade I	2360 (66.5)	4961 (41.1)	<0.001
Grade II	904 (25.5)	4361 (36.2)	
Grade III	198 (5.6)	2216 (18.4)	
Grade IV/V	86 (2.5)	526 (4.3)	
(Missing)	14	33	
Diabetes			
No	3432 (96.7)	11289 (93.5)	<0.001
Yes	117 (3.3)	785 (6.5)	
(Missing)	13	21	
HIV status			
Known negative	1725 (48.6)	6497 (53.8)	<0.001
Known positive	65 (1.8)	200 (1.7)	
Status not known	1760 (49.6)	5377 (44.5)	
(Missing)	12	21	

ASA, American Society of Anesthesiology; ChEETAh, Routine sterile glove and instrument change at the time of abdominal wound closure to prevent surgical site infection; FALCON, Reducing surgical site infections in low-income and middle-income countries.

hospital-level and patient-level differences. These findings support the rationale for the safely scale capacity of surgical care in first referral centres across wider surgical systems through high-quality health-systems research and advocacy.

Prioritising surgical and anaesthetic workforce remains one of the core agenda of the Lancet Commission on Global Surgery,[1] to ensure equitable access to meet surgical needs and universal health coverage. Although a target of 40 specialist surgeons, anaesthetists and obstetricians per 100 000 population has been indicated, significant disparities may exist in first referral centres, as highlighted in this study. Scaling up surgical workforce to meet demands in first referral centres of LMICs is urgently needed, but knowledge gaps remain. First, assessing safety and efficacy of task shifting common surgical procedures such as hernia, laparotomies and C-section through high-quality research is needed. A recent systematic review highlighted a need for randomised trials in this area.[20] Second, the implementation of safe training programmes for surgeons and anaesthetists, including components focused on rural training, is necessary. This training may benefit from a contextual adjustment, where hernia repairs are important in West Africa, whereas gallbladder disease is more prevalent in parts of India and South America. Third, more research will be needed to understand the effects on the wider referral pathway. On one hand, ensuring appropriate referrals from primary care will prevent district hospitals from being overburdened. On the other, these district hospitals may be best placed to deliver local, simple emergency surgical care, close to the patient freeing up referral hospitals to treat more complex patients. The unexpected consequences and right balance are likely to be context-specific and will benefit from monitoring in the future.

Table 3 Baseline operative-level characteristics of patients undergoing major abdominal surgery from FALCON and CHEETAH by referral centre status

	First referral centre	Referral centre	P value
Timing of surgery			
Elective	1242 (34.9)	5251 (43.4)	<0.001
Emergency	2320 (65.1)	6844 (56.6)	
Indication			
Malignant disease	111 (3.1)	2185 (18.1)	<0.001
Benign disease	3341 (94.2)	9222 (76.5)	
Trauma	78 (2.2)	599 (5.0)	
Obstetric	17 (0.5)	55 (0.5)	
(Missing)	15	34	
Operation			
Appendicectomy	727 (20.4)	2047 (16.9)	<0.001
Colorectal	166 (4.7)	1701 (14.1)	
Gynaecology	1044 (29.3)	2201 (18.2)	
HPB	244 (6.9)	535 (4.4)	
Other	737 (20.7)	2881 (23.8)	
Small bowel	300 (8.4)	1134 (9.4)	
Upper GI	186 (5.2)	895 (7.4)	
Urology	142 (4.0)	662 (5.5)	
(Missing)	16 (0.4)	39 (0.3)	
Contamination			
Clean-contaminated*	2003 (56.5)	6537 (54.2)	<0.001
Contaminated	704 (19.8)	2852 (23.7)	
Dirty	841 (23.7)	2670 (22.1)	
(Missing)	14	36	
Prophylactic antibiotics			
No	102 (2.9)	324 (2.7)	0.584
Yes	3446 (97.1)	11 738 (97.3)	
(Missing)	14	33	
Hair removal at site of wound			
No hair at site of wound	2059 (58.1)	5020 (41.6)	<0.001
In theatre, electric	154 (4.3)	433 (3.6)	
In theatre, razor/blade	282 (8.0)	1214 (10.1)	
Before theatre arrival	514 (14.5)	4330 (35.9)	
Not done	537 (15.1)	1064 (8.8)	
(Missing)	16	34	
WHO Surgical safety checklist			
No	20 (0.6)	809 (6.7)	<0.001
Yes	3528 (99.4)	11 253 (93.3)	
(Missing)	14	33	
Intraoperative pulse oximetry			
No	19 (0.5)	78 (0.6)	0.536
Yes	3529 (99.5)	11 985 (99.4)	
(Missing)	14	32	
Glove and instrument change*			
No	2238 (62.8)	8128 (67.2)	<0.001
Yes	1324 (37.2)	3967 (32.8)	

Continued

Table 3 Continued

	First referral centre	Referral centre	P value
GI surgery			
Non-GI tract	1452 (43.0)	5538 (49.1)	<0.001
GI tract	1923 (57.0)	5744 (50.9)	
(Missing)	187	813	

*This data collection point was only available for CHEETAH. The clean-contaminated group includes the clean group.
GI, gastrointestinal.

Improving safety and quality of surgery in the LMICs is associated with improved outcomes for patients such as 30-day SSIs and postoperative mortality. The latter is recognised to be the third most common cause of death globally.[21] Several major trials testing interventions have tested interventions in patients undergoing surgery in LMICs. Despite this, the implementation of evidence into practice is slow. One such intervention is the surgical safety checklist which was significantly higher in first referral centres compared with referral centres (99.4% vs 93.3%). Therefore, shifting focus onto identifying key factors for successful implementation to support wider scale-up both in referral and non-referral centres may serve to maximise the impact of research programmes and enable cross-institutional learning to the benefit a wider patient population. For instance, key priority areas for scale-up would be around improving the workforce population and increasing healthcare financing in these countries to support these systems.

While upscaling surgical capacity in LMICs is of growing importance,[22–24] the knowledge on the interface between referral systems and different hospital types is limited and has been under-researched.[1 25] Understanding these pathways is important to deliver efficient care pathways and equitable surgical care for patients towards achieving universal health coverage. A recent scoping review including 14 articles identified several issues in these pathways.[26] First, shortages of essentials such as infrastructure, equipment and personnel extend into referral centres. Therefore, improving national and international funding for interventions to improve functionality and reliability of referral pathways into surgical services in LMICs is important. Second, there is a lack of national protocols for the triage of common urgent surgical conditions to facilitate more timely transfer of patients to appropriate levels of care.[27 28] In LMICs, paper-based referral forms are often the only piece of documentation following patients through the healthcare system. Clinician training and compliance in the completion of structured referral forms may reduce unnecessary referrals,[29] as well as improving the quality of referrals. A strong focus on interventions to improving these pathways will serve to strengthen surgical health systems in LMICs.

The major strength of the study includes a large cohort of patients from two major randomised surgical

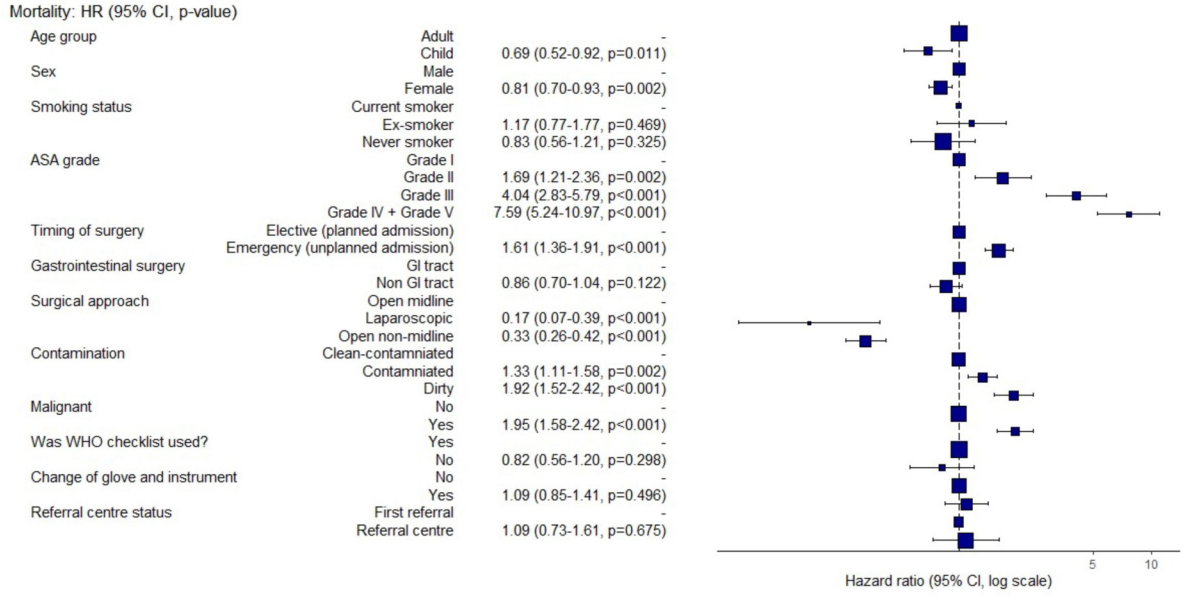

Figure 3 GI, gastrointestinal.
ASA: American Society of Anesthesiology

trials testing interventions to reduce SSIs in six LMICs. This study also has important limitations to address. First, there are no clear definitions or criteria that constitute a first referral centre. Therefore, the type of hospital was self-defined as principal investigators from both the FALCON and CHEETAH trials. This may likely be biased as this was the perceived hospital type, and it remains unclear on the factors that led to their judgement. Therefore, casemix of procedures performed in first referral may be under-represented. Nevertheless, this paper is the first step towards generating further research into understanding of the surgical activity and the surgical health systems around these hospitals. Future research should seek better ways to define first referral centres which may include a future Delphi consensus meeting around key metrics such as distance from nearby referral centres, surgical volume, availability of specialists and capacity of access and transport mechanisms. Second, data on population-level estimates were not collected for the number of workforces in each country to draw direct comparisons with the Global Surgery 2030 Commission. Third, in-depth structures and processes that govern these hospitals and implementation of best practice beyond the operating theatres were not collected. Despite this, early signals from the use of the WHO checklist highlight the need for further evaluation of implementation processes globally. Finally, despite adjustment in the statistical model, there may still be some residual confounding bias which may not be captured in this study. For instance, differences in pathways within countries and hospitals, as well as the lack of representation from a broader range of LMICs, remain challenges.

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