



SCIENTIFIC REVIEW

Surgical Task-Sharing to Non-specialist Physicians in Low-Resource Settings Globally: A Systematic Review of the Literature

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Abstract

Background As the global community increasingly recognizes the large and unmet burden of surgical disease, a new emphasis is being placed on strengthening the health system at the first-level hospital. The shortage of surgical care providers at this district and rural level can be met by surgical task-shifting/sharing to non-physician clinicians (NPCs) and non-specialist physicians (NSPs). While the role of NPCs in low–middle-income countries (LMICs), in particular in sub-Saharan Africa (SSA), has been well documented in the literature, there has been little focus on NSPs. In addition to providing essential surgical services, this physician cadre also practices generalist medicine, an advantage at the first-level hospital. The present study seeks to explore where, across all country income groups, NSPs are providing surgical services and what additional surgical training, if any, is available in each identified country.

Methods A systematic review of the literature was performed, following PRISMA guidelines. Medline, EMBASE, EBM Reviews, and CINAHL were searched. Including hand-searching for further references, 53 publications met inclusion/exclusion criteria and were identified for data extraction purposes. Gray literature was also explored within the time limits for this study.

Results Surgical task-shifting/sharing to NSPs occurs across all country income groups; some provide surgical obstetrics, while others also provide a broader scope of surgical services. Within LMIC countries, the majority are in SSA. In SSA, 16 of 54 countries were included in the reviewed articles, only 4 of which (Ethiopia, Niger, Nigeria, and Sierra Leone) have a formal surgical program beyond the regular medical officer/general practitioner training. Canada and Australia have established programs for both surgical obstetrics and the broader scope, while the USA has several programs for surgical obstetrics and is developing a new, broad-scope program.

Conclusion This study has demonstrated that NSPs are providing surgical services across all income groups, with varying degrees of additional training specific to the surgical needs of their district/rural location. To “close the gap” in needed surgical services at the first-level hospital, more task-sharing needs to occur to both NSPs (the focus of this study) and NPCs. Collaboration between practitioners and training programs, given the shared challenges and practice environments, would help support task-sharing at the first-level hospital and improve access to the 5 billion underserved people.

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Introduction

Up to 32% of the global burden of disease is surgical in nature; this is higher than earlier estimates [1]. While 5 billion people on our planet have minimal access to surgical services, 2 billion have no access [2, 3]. These statistics put in context the statement by Farmer and Kim that “surgery may be thought of as the neglected stepchild of global public health” [4]. With the efforts of the World Health Organization (WHO), the *Lancet* Commission on Global Surgery, and the *Disease Control Priorities* (3rd edition), attention is being drawn to this unmet surgical need, which disproportionately affects rural and under-served populations.

Surgery cannot be performed as an isolated, vertical program; rather, it “should be viewed as an indispensable component of a properly functioning health system” [5]. This fact integrates well with the recent proposals by the World Health Assembly to refocus on primary health system development, and specifically Resolution 68.15 in “strengthening emergency and essential surgical care and anaesthesia as a component of universal health coverage” [6]. These proposals came into being to address the Sustainable Development Goals (replacing the Millennium Development Goals in 2015) and recall the 40-year-old intentions of the Alma-Ata Declaration [7].

Within regionalized healthcare, the first-level hospital is the “core site for surgical and anaesthetic care delivery” [1]; it should be able to provide 80–90% of emergency and essential surgical services (see Box 1). The Bellagio Essential Surgery Group published four recommendations in 2009, the first of which was to strengthen surgical services at district hospitals [8]. Given its proximity to rural and under-served catchment populations, the first-level hospital has therefore become a focus for health system strengthening and provision of the essential surgery package [8–10]. In low–middle-income countries (LMICs), this facility is usually the district hospital; in high-income countries (HICs), it is usually referred to as a rural or community hospital [2, 9]. Surgical services have also been considered the cornerstone to maintain rural hospital-based care [11].

One of the challenges to deliver quality surgical care is the shortage of human resources globally, and specifically the shortage of surgical and anesthetic care providers. While models, such as by Holmer et al. [12], have been developed to propose the number of specialist surgeons required to “close the gap,” in practice specialist surgeons tend to migrate to urban and tertiary care settings [13]. This is often appropriate to maximize the clinical use of their specialized training, but reduces surgical services at earlier levels of the health system. In the face of this shortage and

urban distribution of specialist surgeons, and in an effort to increase surgical access in under-served areas, the concept of task-shifting/sharing to other cadres has been introduced [1, 2, 14–16]. This refers to “the rational redistribution of tasks among health workforce teams...—from highly qualified workers to health workers with shorter training and fewer qualifications” [1].

Surgical tasks can be shifted/shared to two broad categories of healthcare professionals: non-physician clinicians (NPCs) or non-specialist physicians (NSPs) [16]. The model of task-shifting with NPCs has been well implemented and validated in LICs, in particular in Tanzania, Malawi, and Mozambique [17–20]. The literature has focused largely on NPCs; some reviews have specifically excluded NSPs [16]. Surgical task-shifting/sharing to physicians has not been well studied as a solution to global human resource shortages, despite being a model used across low- and high-income settings. For the purposes of this paper, the term *task-sharing* will be used.

Within the global surgical literature, task-sharing is proposed as a temporary solution to the shortage of specialist surgeons [1, 2, 14–17]. At the rural and district level, however, the volume can be too low to support specialist physicians (in both LMIC and HIC settings), who then become under-utilized [11, 13]. Fly-in models of care with rotating specialists have been attempted [21], but these are not sustainable for continuous coverage of emergency surgical services. Because the task-shared generalist can also provide other medical services, this type of physician is a valuable resource at the first-level hospital [22]. The advantages to having a *generalist* physician as the surgical care provider have not been well explored in the literature, in particular in LMICs; a more detailed description of rural generalist medicine and its importance can be found in the *Cairns Consensus Statement* [22].

Through a systematic review of the global surgical literature, this study aims to survey which countries, in both LMIC and HIC settings, have generalist physicians providing surgical services at the under-served, first-level hospital. Where possible, the training model will also be described. Patterns within and between LMIC and HIC settings, as well as opportunities for shared learning given the many shared challenges, will also be explored.

Methods

To conduct this systematic review, the PRISMA guidelines were followed. MedLine (October 2, 2018), EMBASE (October 2, 2018), EBM Review (October 3, 2018), and CINAHL (October 7, 2018) were searched using the keywords provided in Table 1; the search terms were intentionally broad to be as sensitive as possible. A total of 3788

Box 1 The essential surgery package**Box 1: The Essential Surgery Package**

Various groups have proposed lists of what should be included in the emergency and essential surgical procedures delivered at the first-level hospital (WHO's Situational Analysis Tool (based on the WHO Primary Surgical Package), the World Bank's Disease Control Priorities (3rd edition) package, the International Collaboration for Essential Surgery's 15 Essential Surgeries, etc). To facilitate the assessment of a facility's ability to deliver this package, 3 procedures have been identified as "Bellwether procedures": cesarean section, laparotomy, and treatment of open fractures. If these 3 procedures are performed, it is likely that most of the package is as well. The table (below) of an essential surgical package is taken from the Disease Control Priorities (3rd edition); such lists are developed to reflect the surgical needs in LMICs. Other surgical procedures may also be performed.

Type of Procedure	Surgical Intervention
Obstetric, gynecologic, and family planning	<ul style="list-style-type: none"> • Cesarean delivery • Vacuum extraction/forceps delivery • Ectopic pregnancy • Manual vacuum aspiration and dilation and curettage • Tubal ligation • Vasectomy • Hysterectomy for uterine rupture or intractable postpartum hemorrhage • Colposcopy
General surgical	<ul style="list-style-type: none"> • Repair of perforations (ie: perforated peptic ulcer, typhoid ileal perforation) • Appendectomy • Bowel obstruction • Colostomy • Gallbladder disease, including emergency surgery • Hernia, including incarceration • Hydrocelectomy • Relief of urinary obstruction (catheterization or suprapubic cystostomy)
Injury	<ul style="list-style-type: none"> • Resuscitation with advanced life support measures, including surgical airway • Tube thoracotomy • Trauma laparotomy • Fracture reduction • Irrigation and debridement of open fractures • Placement of external fixator; use of traction • Escharotomy/fasciotomy • Trauma-related amputations • Skin grafting • Burr hole
Nontrauma orthopedic	<ul style="list-style-type: none"> • Drainage of septic arthritis • Debridement of osteomyelitis

The surgical interventions in *italics* indicate ones which may be performed at the first-level hospital in HIC settings; there is significant overlap. The literature reviewed in this study included additional procedures which are performed in rural hospitals in HICs:

- Laparoscopy (diagnostic, appendectomy, salpingectomy)
- Tonsillectomy and adenoidectomy
- Carpal tunnel release
- Trigger finger release
- Varicose vein surgery
- Endometrial ablation
- Hysteroscopy
- Cystoscopy
- Gastroscopy
- Colonoscopy

publications resulted from the initial search strategy and were imported into Mendeley for reference management. Following duplicate removal, title and abstract review was conducted (see Fig. 1 for the PRISMA diagram).

Articles were included if published after 1998 and if discussing non-specialist physicians performing surgery, even if the only mention was in a table. The search strategy did not restrict by language, but only one article was not in English and it was excluded. Most excluded articles pertained to surgical specialties and/or had no relevance to rural/district settings.

The 126 articles for full-text review were assessed by 2 authors and consensus obtained; references were hand-searched, and a further 8 articles were identified. In total, 53 articles were identified for study and data extraction (see Table 2 for the list of articles). Extracted data included country, terms used for NSPs (medical officer, general practitioner, etc.), scope of skills in surgical practice, training program details, and practice environment details.

Table 1 Depending on the database, terms were searched as keywords or matched to subject headings

Search category	Search term
Task-sharing/NSPs	Task-sharing Physician* Generalist* Generalism General practitioner* GP surgeon Enhanced surgical skills Medical officer*
Setting	Rural Developing countries Low resource District hospital
Surgery	Surg*

Search terms within each category were combined using the "or" function, and then, all 3 categories combined using the "and" function

* Search performed as a truncated term

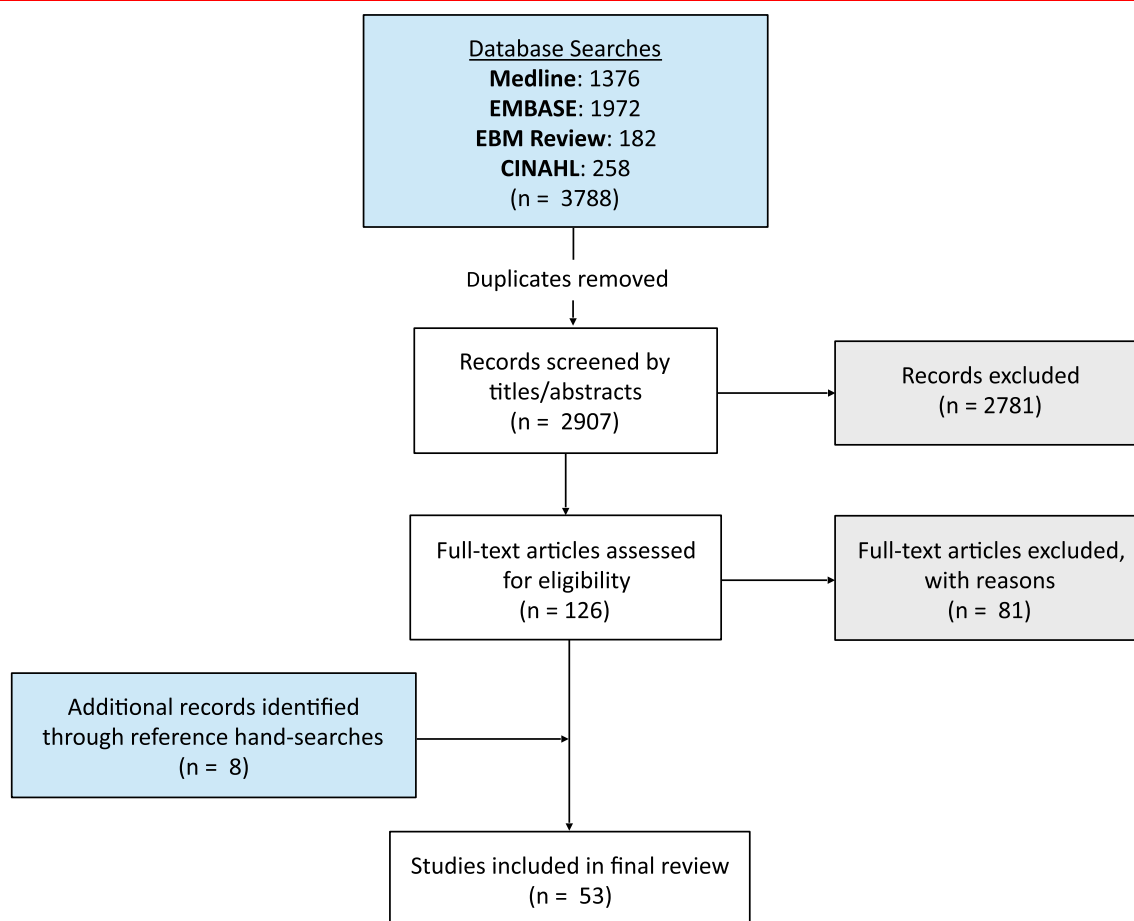


Fig. 1 PRISMA study flow diagram

To the extent possible within the time limitations of this study, supporting gray literature was also explored.

Results

Table 3 summarizes the findings from the 53 reviewed articles. A total of 26 countries, across all income groups, were identified as having non-specialist physicians (NSPs) performing surgery at the district or rural hospital (Fig. 2). There are two general categories of NSPs: those who provide *surgical obstetric services* (i.e., cesarean section, emergency hysterectomy, laparotomy for ectopic pregnancy, dilation and curettage), and those who provide surgical obstetric services AND additional surgical services drawing from general surgery, orthopedics, otorhinolaryngology, and others (see Box 1; this second category will hereafter be referred to as *broad-scope services*). Most physicians have completed medical school and then either an internship/housemanship (usually 2 years) or a family medicine residency (2 or 3 years). In addition, some

countries provide additional formal training in surgery for the non-specialist physician; a detailed comparison of training programs was beyond the scope of the current study.

Low-income countries

Sub-Saharan Africa (SSA) dominates the literature, with occasional references to Latin America and South and Central Asia. NSPs providing surgical services at the district level may be called medical officers (MOs), general practitioners (GPs), or family physicians (FPs). These physicians most often do not receive formal training in surgery beyond those skills acquired during their internship/housemanship. Five countries were identified which have developed a specific surgical training program for generalist physicians.

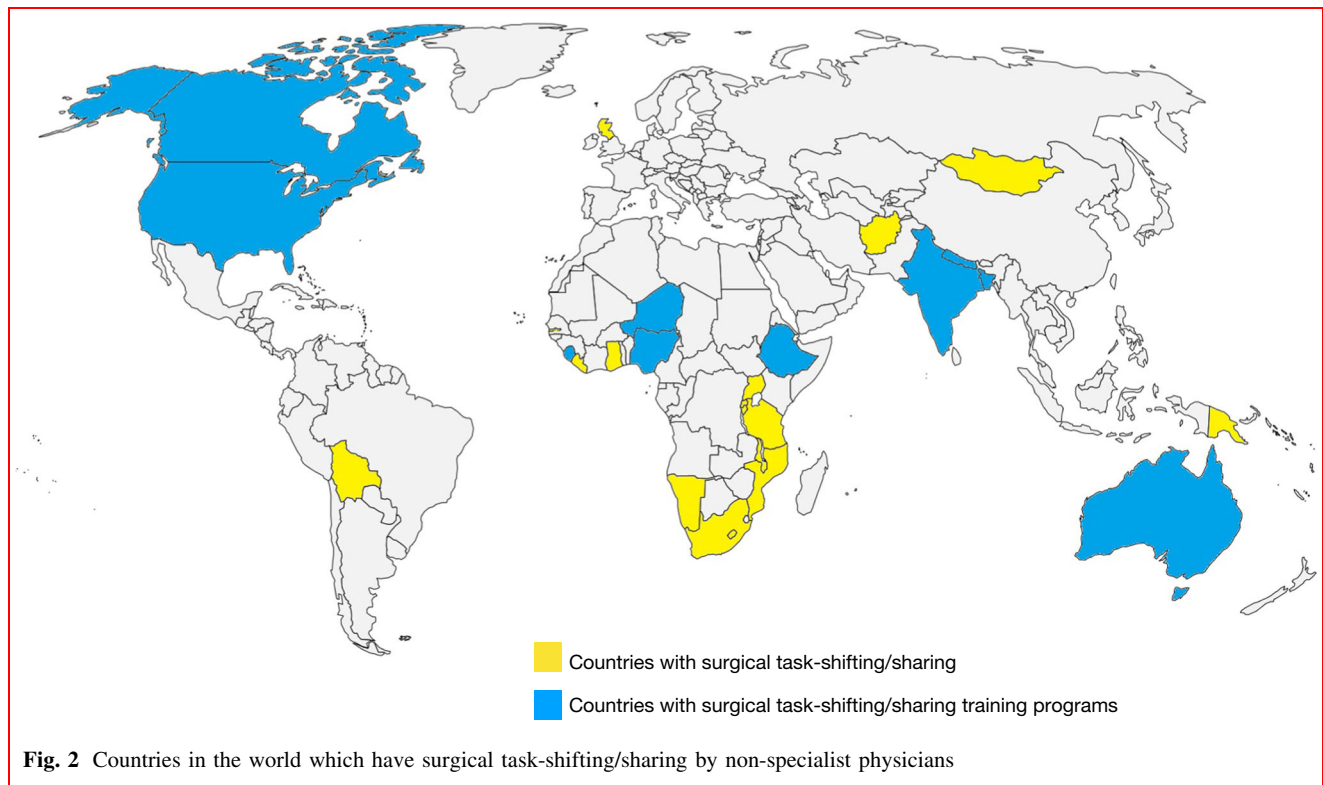


Fig. 2 Countries in the world which have surgical task-shifting/sharing by non-specialist physicians

Ethiopia

Following the end of the civil war in 1991, it was recognized that training general practitioners in surgery would improve surgical access. With assistance from Médecins Sans Frontières, a 12-month program was initiated in 1995 in Woldya to train GPs in the broad-scope services. In 2012, a 3-month program based on the WHO's Comprehensive and Emergency Obstetrical Care (CEmOC) program was developed by the Federal Ministry of Health to address Millennium Development Goal 5. Since 2013, a formal residency program in family medicine was established at the Addis Ababa University, in partnership with the Medical Education Partnership Initiative (Doohan 2014). While Doohan et al. do not specify what the surgical component of training would include, they do assert the value in training family physicians in surgical care for district hospital and rural settings.

Niger

The Government of Niger recognized that training district hospital GPs in surgical skills would improve surgical access, but also help with maintaining those services by training physicians already established in those communities. Initially, a 3-month program was developed in 1994,

but graduates found the training was too short and few maintained surgical skills in their practice; based on lessons learned, a 12-month program was established in 2005 and provides training for the broad-scope services. Graduates of this program receive the certificate "Capacity of District Surgery."

Sierra Leone

Non-specialist physicians provide broad-scope services at district hospitals in Sierra Leone. While no mention is made of the surgical training for most NSPs, as of 2011 "junior doctors" may enter a 3-year training program to become surgical care providers.

Nigeria

Most MOs/GPs at the district hospital do not have formal training. However, the Nigerian Government has recently developed two training paths, of 12–18-month duration, culminating in a Diploma in Obstetrics (D.Obst). Candidates may be either MOs with 3-year work experience (first path), or general practitioner/family medicine (GP/FM) residents who have completed the first 2 years of residency (second path). This second path is compared to the Canadian, Australian, and American models.

Nepal

A program was initiated in 2006 to recruit family physicians with surgical obstetric skills to rural areas of Nepal. This program involved recruiting physicians to a 3-year postgraduate program in family medicine; the article does not describe how the surgical obstetric training was provided within that program.

Other

The following countries have either medical officers or general practitioners performing surgical care at the district hospital level; these providers receive either no additional training, or the literature reviewed did not comment on what training does occur: Uganda, Rwanda, Mozambique, the Gambia, Namibia, Liberia, Lesotho, Ghana, Malawi, Afghanistan, Mongolia, Bangladesh, Bolivia, and Papua New Guinea. In Mozambique and Ghana, for example, medical officers are often required to work for a couple of years at a district hospital upon completion of their housemanship; after completion of this “return of service,” most move to larger centers, leaving surgical care to clinical officers or other recent MO graduates [23, 24].

Middle-income countries

The only MICs referenced in the 53 studies reviewed were India and South Africa. The one study involving India described medical officers receiving training in CEmOC during a 16-week program.

Six studies described South Africa. These physicians are usually general practitioners, but may also be referred to as family physicians; those who provide surgical services are called *GP surgeons* and provide the broad-scope surgical services. There is no formal training program for district hospital practice, although Porter et al. recognize the need for one to be developed. Surgical skills are acquired through exposure during hospital-based clinical rotations and internships; some physicians, upon completing their GP training, may remain within a clinical service for 6–12 months and thereby obtain an additional “diploma” in that field (while a diploma can be earned in obstetrics, including cesarean delivery, a diploma in surgery has not been an option) [25]. Historically, South African physicians with “enhanced skills” have been recruited to rural areas abroad (such as by the Canadian government during

the late 1970s and 1980s) [25], contributing to the “brain drain” out of South Africa.

High-income countries

In HIC settings, Canada, Australia, and the USA are best represented in the literature, with no evidence of generalist physicians providing surgical care in most of Europe, New Zealand, or Japan.

Canada

In Canada, this cadre is formed by GPs or FPs. These terms are often used interchangeably. Surgical providers have been referred to as *GP surgeons*, although more recently this term has changed to *family physicians with enhanced surgical skills (FP-ESSs)*. This group of physicians practices exclusively in rural Canada, in communities ranging from 2500 to 17,000 population. Some mixed models exist, where specialist surgeons and FP-ESS practice in the same community (often 15,000–25,000 population). Given the often remote geography of rural Canada, and the inability of rural communities to support specialist surgeons due to low volumes, FP-ESSs are an ideal solution to provide surgical care in these settings. Historically, these physicians have been either international medical graduates (often recruited from South Africa or the UK) or Canadian medical graduates who pursued additional supervised surgical training, with no formal certification. Most FP-ESS physicians in Canada provide surgical obstetric services, while the rest provide the broad scope of surgical services. The former group, soon to be designated *FP-OSS* (obstetrical surgical services), receive formal training through a 3–6-month residency program offered through one of four departments of family medicine in the country. The latter group, FP-ESS, currently receive training through a 12-month residency program offered through the University of Saskatchewan since 2007. At the time of this writing, a new program is being piloted through the University of Alberta.

USA

FPs (also sometimes referred to as GPs) in rural areas of the USA may receive training to perform surgical obstetric services. Examples are documented from various states, including Kansas, Washington, Oregon, Texas,

Massachusetts, Idaho, and New England. The sources did not provide information regarding community size, but all were considered rural in the American context. Three forms of training exist: on-the-job training, a fellowship, or as part of the family medicine residency in particular cases. Length of training can vary from 3 months to 2 years, depending on the form of training and experience of the physician. Recently, a 12-month program was initiated in Iowa based on the Canadian ESS program in Saskatchewan [26].

Australia

The Australian generalist physician with surgical skills is called a *GP surgeon* and may provide either surgical obstetrics or the broad-scope services. As in Canada, many practicing GP surgeons in Australia have been either international medical graduates or Australian medical graduates with additional supervised but informal surgical training. Some have also received a formal designation in GP surgery. None of the studies indicated community size, but all providers practiced in a rural hospital. In 1997, the Australian College of Rural and Remote Medicine (ACRRM) was formed to respond to the needs of rural Australians. This college provides training in “rural generalist medicine,” as more recently defined in the Cairns Consensus Statement (see discussion in the Introduction), to include an enhanced skill such as surgery. In addition to the usual 3 years of family medicine training in Australia, a 2-year fellowship is required to obtain certification in surgery as a rural generalist.

Scotland

One study referenced general practitioners providing cesarean sections in Scotland. A review of the gray literature, however, did not confirm this comment, but rather suggest that all rural surgery is performed by specialist surgeons.

Discussion

Compared with non-physician clinicians, surgical task-sharing with non-specialist physicians has not been as well studied or represented in the literature. This review identified 53 papers which, to greater or lesser extents, included non-specialist physicians providing surgical services. The

greatest amount of literature was from Canada and Australia, with publications focused exclusively on this subject; many sub-Saharan countries were represented, but publications varied from a focus on surgical services in general (with passing mention of medical officers performing surgery at district hospitals) to a focus on training programs directed at enhancing the surgical skills of NSPs.

With a few exceptions, there was a remarkable absence of evidence of task-sharing outside of Canada, the USA, Australia, and sub-Saharan Africa. It is likely that task-shifting/sharing does occur in other countries, but the search strategy in this review did not capture those publications, and a more extensive review of the gray literature would be required to identify them.

The overall lack of surgical providers worldwide, together with the usually urban distribution of specialists, provides a strong rationale for surgical task-sharing [1, 2, 14–16]. Henry et al. [17] go so far as to state that “the use of these practitioners...is the only feasible route to deal with the huge lack of primary surgical care in LMICs, as well as elsewhere.” While surgical task-sharing with NPCs is common in many LMICs, it does not appear to occur in HICs. (Anesthetic task-sharing was not addressed in this study.) Sharing with NSPs, however, occurs in both LMICs and HICs. In all country income groups, these physicians may provide either surgical obstetrics alone, or a broader scope package of essential surgeries.

In LMIC settings, where the main justification for these cadres has been the lack of human resources, the scope of practice of task-sharing by NPCs and NSPs has significant overlap. The working relationship between these providers is an area in need of further exploration. In HIC settings, where human resources are (more than) adequate, surgical task-sharing is more a consequence of population size and geography [9]. Where populations are too small to support a specialist surgeon, or when a rural community is considered too distant from a secondary or tertiary care hospital, GP surgeons or FP-ESS physicians have been the solution. There are also regional differences within a given country; for example, FP-ESS physicians are common in western and northern Canada, but do not exist in eastern Canada.

There are significant contextual differences between FP-ESS practice in HIC when compared to LMIC, with the former seeing the gradual evolution of training expectations of rural generalist proceduralists. (For example, the College of Family Physicians of Canada has just approved a Certificate of Added Competence for Family Physicians

providing procedural care.) Although increasing expectations of both quality care through formalized training and continuous medical education and the bureaucracy around credentialing and privileging has the potential to create gaps in care, this has not been a significant issue in HIC to date. In contrast, however, as the skill level of FPES in district hospitals in LMIC continues to increase, it is conceivable that the demand placed on their practices due to increased confidence in their services could overwhelm these providers. This contextual difference speaks to the larger systems resource disparities between HIC and LMIC.

Specific surgical training beyond the basic medical officer/general practitioner/family physician program is not universal. In much of SSA, graduating medical officers provide surgical services at the district hospital. Four countries in this region—Ethiopia, Niger, Sierra Leone, and Nigeria—have recognized the need and developed educational programs targeting NSPs. A few other programs have been developed in LMICs, focusing on surgical obstetrics (in-line with the WHO’s CEmOC program), for example in Nepal and India. In HIC settings, Canada, Australia, and the USA require additional training to provide surgical services as a generalist in rural areas.

Despite the broader scope of surgical skills practiced in sub-Saharan Africa, there is significant overlap in the surgical services provided by NSPs across all country income groups. All NSPs start from a similar baseline of generalist training. The challenges of rural/district surgical practice, including isolation, lack of regional support, and challenges accessing continued professional development, are universal. For these reasons, we expect there to be much shared learning by comparing models of both education and service-delivery and in this way, jurisdictions without established training programs can look to those where they exist to model educational infrastructure. The ESS program in Canada has helped inspire another one in the USA; task-sharing with NPCs has been a model in eastern Africa since 1984, and those successes could be translated into improved educational models for task-sharing with NSPs; networks of care which involve connecting urban specialist surgeons to rural FP-ESS physicians in British Columbia, Canada, are being developed and could provide a model for other jurisdictions [27, 28]. The promotion of such “network” or “hub-and-spoke” models which “bridge the urban–rural divide” [27] in rural Canada and Australia supports the Lancet Commission’s rationale to promote task-sharing over task-shifting as models of care.

Surgical services at the first-level hospital are essential to meet the surgical needs of rural, under-served, and

often indigenous populations from outlying communities, as well as the population cohort of the communities themselves. While the global surgical community has accepted the role of non-specialist physicians providing surgical services at the first-level hospital, the value of those NSPs also providing *rural generalist medicine* has not been well explored. This is despite the growing recognition of the importance of access to emergency and essential procedural care a part of the spectrum of primary healthcare. In rural jurisdictions without local access to specialist care, this responsibility has defaulted to primary care providers, challenging the very designation of “primary” versus “secondary” care. In terms of strengthening primary health systems, this could be an area for further research.

Conclusion

To provide emergency and essential surgical services to the 5 billion people who lack access, health systems, which include surgical services at the first-level hospital, need to be improved. Given the lack of surgical care providers and the years of training required to become a specialist surgeon, task-sharing is more realistic cadre of surgical providers to fill the gap. Networked models of care involving specialist support of rural hospital-based providers are being successfully developed in Canada and Australia, consistent with the *Lancet* Commission definition and promotion of task-sharing. In the case of non-specialist physicians, the focus of this review, the generalist nature of these physicians provides an additional advantage at the district and rural level where a broad scope of clinical skills is essential.

While task-sharing with non-specialist physicians occurs in both LMIC and HIC settings, nothing has been published in the literature to compare experiences in education and meeting challenges in practice. Lessons learned since the 1980s in training non-physician clinicians in eastern Africa would likely benefit their task-shared non-specialist physician colleagues. These areas deserve future collaboration and research, thereby mutually supporting surgical care providers across the globe.

Appendix

See Tables 2 and 3.

Table 2 Studies included in the literature review (53 for data extraction)

Reference #	Author(s)	Year	Title	Journal	Volume	Issue	Pages
2	M.H. Bruening	1998	The provision of general surgical services in rural South Australia: A new model for rural surgery	Australian and New Zealand Journal of Surgery	68	11	764–768
3	Reid, S J Chabikuli, N Jaques, P H et al.	1999	The procedural skills of rural hospital doctors	South African Medical Journal	89	7	769–774
4	N. Sohler L. Frejaques	1999	Design and implementation of a training programme for general practitioners in emergency surgery and obstetrics in precarious situations in Ethiopia	Annals of the Royal College of Surgeons of England	81	6	367–375
5	Dunbabin, J	2002	Procedural Medicine in Rural and Remote NSW: The General Practice Workforce	NSW Rural Doctors Network			
6	Green, Anthony Kiroff, George	2003	Maintaining surgical standards beyond the city in Australia	ANZ Journal of Surgery	73	4	172
7	S. Iglesias J. Tepper E. Ellehoj et al.	2006	Rural Surgical Services in two Canadian Provinces	Canadian Journal of Rural Medicine	11	3	207–217
8	J. Kornelsen S. Grzybowski	2006	Is Rural Maternity Care Sustainable Without General Practitioner Surgeons?	CJRM	11	3	218–220
9	Pereira, C Cumbi, A Malalane, R et al.	2007	Meeting the need for emergency obstetric care in Mozambique: work performance and histories of medical doctors and assistant medical officers trained for surgery	BJOG	114	12	1530–1533
10	Symmons, David Curry, Chris	2007	Rural Hospital Generalist and Emergency Medicine in Papua New Guinea	Emergency Medicine Australasia	19	2	151–154
11	Humber, Nancy Freckler, Temma N. Humber et al.	2008	Rural Surgery in British Columbia: Is There Anybody Out There?	Canadian Journal of Surgery	51	3	179–184

Table 2 continued

Reference #	Author(s)	Year	Title	Journal	Volume	Issue	Pages
12	D. Ozgediz M. Galukande J. Mabweijano et al.	2008	The neglect of the global surgical workforce: experience and evidence from Uganda	World Journal of Surgery	32	6	1208–1215
13	Ellis, Chris	2008	Training general practitioners for very remote areas	Medical Teacher	30	8	809–811
14	N. Humber Humber, Nancy Frecker, Temma	2008	Delivery models of rural surgical services in British Columbia (1996–2005): are general practitioner-surgeons still part of the picture?	Canadian Journal of Surgery	51	3	173–178
15	C. Chang Pecci L. Leeman	2008	Family medicine obstetrics fellowship graduates: training and post-fellowship experience	Family Medicine	40	5	326–332
16	Lynn, Cherrie Maine, Deborah Mcloskey, Lois et al.	2009	Where there is no obstetrician—increasing capacity for emergency obstetric care in rural India: an evaluation of a pilot program to train general doctors	International Journal of Gynecology and Obstetrics	107		277–282
17	Dresang, Lee Koch, Paul	2009	The Need for Rural Family Physicians Who Can Perform Cesareans	American Journal of Clinical Medicine	6	2	39–41
18	R. Sani B. Nameoua A. Yahaya et al.	2009	The impact of launching surgery at the district level in Niger	World Journal of Surgery	33	10	2063–2068
19	M.E. Kruk A. Wladis N. Mbembati et al.	2010	Human resource and funding constraints for essential surgery in district hospitals in Africa: A retrospective cross-sectional survey	PLOS Medicine	7	3	1–11
20	Monjok, E Essien, E J Smesny, A et al.	2010	A training need for rural primary care in Nigeria	Journal of Obstetrics and Gynecology	30	8	833–835
21	S. Contini A. Taqdeer M. Cherian et al.	2010	Emergency and Essential Surgical Services in Afghanistan: Still a Missing Challenge	World Journal of Surgery	34		473–479

Table 2 continued

Reference #	Author(s)	Year	Title	Journal	Volume	Issue	Pages
22	S. Choo H. Perry A. Hesse et al.	2010	Assessment of emergency and essential surgical providers at the district hospital in Ghana	Journal of Surgical Research	158	2	376
23	Robinson, M Slaney, G M Jones, G I et al.	2010	GP Proceduralists: 'the hidden heart' of rural and regional health in Australia	Rural and Remote Health	10	3	1–13
24	Iddriss, Adam Shivute, Nestor Bickler, Stephen et al.	2011	Emergency, anaesthetic and essential surgical capacity in the Gambia	Bull World Health Organ	89		565–572
25	Spiegel, David A Choo, Shelly Cherian, Meena	2011	Quantifying Surgical and Anesthetic Availability at Primary Health Facilities in Mongolia	World Journal of Surgery	35		272–279
26	M.R., Notrica F.M., Evans L.M., Knowlton et al.	2011	Rwandan surgical and anesthesia infrastructure: a survey of district hospitals	World Journal of Surgery	35		1770–1780
27	S. Choo H. Perry A.A.J. Hesse et al.	2011	Surgical training and experience of medical officers in Ghana's district hospitals	Academic Medicine: Journal of the Association of American Medical Colleges	86	4	529–533
28	Kornelsen, Jude Iglesias, Stuart Humber, Nancy et al.	2012	GP Surgeons' Experiences of Training in British Columbia and Alberta: A Case Study of Enhanced Skills for Rural Primary Care providers	Canadian Medical Education Journal	3	1	e33–41
29	L.M. Knowlton S. Chackungal B. Dahn et al.	2013	Liberian surgical and anesthesia infrastructure: a survey of county hospitals	World Journal of Surgery	37	4	721–729

Table 2 continued

Reference #	Author(s)	Year	Title	Journal	Volume	Issue	Pages
30	Markin, Abraham Barbero, Roxana Leow, Jeffrey J et al.	2013	A quantitative analysis of surgical capacity in Santa Cruz, Bolivia	The Journal of Surgical Research	185	1	190–197
31	Abbot, Ben Laurence, Caroline O Elliott, Taryn et al.	2014	GP surgeons: what are they? An audit of GP surgeons in South Australia	Rural and Remote Health	14	3	1–7
32	Ridgway, Priscilla	2014	Learning from our Ethiopian colleagues: operative obstetrics for the generalist	Canadian Journal of Rural Medicine	24	4	335–343
33	N.C., Doohan M., Derbew Doohan, Noemi C	2014	Solutions for the global surgical crisis: the role of family medicine in surgery, obstetrics, and anesthesia	Family Medicine	46	9	679–684
34	Bevis-Challinor, Kenneth	2014	Improved surgical output in district hospitals relies more on softer ingredients than on formal postgraduate training time	South African Medical Journal	104	9	593–594
35	Q.N. Kalu A.I. Eshiet E.I. Ukpabio et al.	2014	A rapid need assessment survey of anaesthesia and surgical services in district public hospitals in cross River State, Nigeria	British Journal of Medical Practitioners	7	4	6–12
36	Mash, B	2014	Well-trained generalists can help improve surgical capacity at district hospitals	South African Medical Journal	104	5	323
37	J.A. Henry E. Frenkel E. Borgstein et al.	2015	Surgical and anaesthetic capacity of hospitals in Malawi: key insights	Health Policy and Planning	30	8	985–994
38	J.A. Henry E. Frenkel E. Borgstein	2015	Intern to independent doctor: Basic surgical skills required for South African practice and interns' reports on their competence	South African Family Practice	57	4	261–266
39	S. Iglesias J. Kornelsen R. Woollard et al.	2015	Joint position paper on rural surgery and operative delivery	Canadian Journal of Rural Medicine	20	4	129–138

Table 2 continued

Reference #	Author(s)	Year	Title	Journal	Volume	Issue	Pages
40	Sani, Rachid Sanoussi, Samuila	2015	Rural Surgery in Niger: A Multicentric Study in 21 District Hospitals	Indian Journal of Surgery	77	December	822–826
41	Didier, James Lassey Nwanna-Nzewunwa, Obieze C Ajiko, Mary-Margaret Kirya, Fred et al.	2016	Barriers and facilitators of surgical care in rural Uganda: a mixed methods study	The Journal of Surgical Research	1		242–250
42	Zimmerman, Mark Shah, Sharada Shakya, Rabina et al.	2016	A staff support programme for rural hospitals in Nepal	Bulletin of the WHO	94	1	65–70
43	Muhirwa, Ernest Habiyaakare, Caste Hedt-Gauthier, Bethany L et al.	2016	Non-Obstetric Surgical Care at Three Rural District Hospitals in Rwanda: More Human Capacity and Surgical Equipment May Increase Operative Care	World Journal of Surgery	40		2109–2116
44	J. Kornelsen K. McCartney McCartney, Kevin et al.	2016	Centralized or decentralized perinatal surgical care for rural women: a realist review of the evidence on safety	BMC Health Services Research	16	1	381
45	Bolkan, Håkon A Hagander, Lars von Schreeb, Johan et al.	2016	The Surgical Workforce and Surgical Provider Productivity in Sierra Leone: A Countrywide Inventory	World Journal of Surgery	40		1344–1351
46	Loveday, Jonathan Sachdev, Sonal P Cherian, Meena N et al.	2017	Survey of Emergency and Essential Surgical, Obstetric and Anaesthetic Services Available in Bangladeshi Government Health Facilities	World Journal of Surgery	41		1743–1751
47	De Plecker, E. Zachariah, R. Kumar, A. M. V. et al.	2017	Emergency obstetric care in a rural district of Burundi: What are the surgical needs?	PLOS ONE	12	2	1–13
48	Dell, A J Kahn, D	2017	Surgical Resources in South Africa: An International Comparison and Deficit Calculation	World Journal of Surgery	42		541–548

Table 2 continued

Reference #	Author(s)	Year	Title	Journal	Volume	Issue	Pages
49	Bolkan, H. A. van Duinen, A. Waalwijk, B. et	2017	Safety, productivity and predicted contribution of a surgical task-sharing programme in Sierra Leone	British Journal of Surgery	104	10	1315–1326
50	Eden, Ainee R Peterson, Lars E	2018	Challenges Faced by Family Physicians Providing Advanced Maternity Care	Maternal and Child Health Journal	22	6	932–940
51	Porter, D C Bezuidenhout, J Du Toit, R S	2018	Surgical skills deficiencies and needs of rural general practitioners in South Africa	South African Medical Journal	108	3	210–216
52	Prasad, Shailendra Hung, Peiyin Henning-Smith, Carrie, et al.	2018	Rural Hospital Employment of Physicians and Use of Cesareans and Nonindicated Labor Induction	Journal of Rural Health	34		s13–20
53	Albutt, Katherine Punchak, Maria Kayima, Peter et al.	2018	Access to Safe, Timely, and Affordable Surgical Care in Uganda: A Stratified Randomized Evaluation of Nationwide Public Sector Surgical Capacity and Core Surgical Indicators	World Journal of Surgery	42		2303–2313

Table 3 Data extraction table (data are grouped by country; citation number refers to the corresponding publication from Appendix 1)

Citation	Geography		Education and scope of practice			Practice environment		
	Country	Region/city	MD training	Surgical skills scope	Surgical training	Facility	Catchment	Network/support
21	Afghanistan		GP	n/a	n/a	n/a	n/a	n/a
2	Australia	South Australia	GP	n/a	n/a	n/a	n/a	n/a
5	Australia	NSW	GP	Cesareans, “surgery”	Formal and informal, 38% had formal surgical postgrad	n/a	n/a	n/a
6	Australia	n/a	GP	n/a	n/a	n/a	n/a	n/a
23	Australia		GP	n/a	n/a	n/a	n/a	n/a
31	Australia	South Australia	GP	Cesareans, ectopics, minor ortho, TL, hydrocelectomy, tonsillectomy, herniorrhaphy, appendectomy, varicose vein surgery	local (informal), form (2-year ACRRM)	Rural	n/a	Informal (working with mentors, visiting specialists), courses, workshops
44	Australia	Various (Perth, Cairns, NSW, Queensland)	GP	Cesareans	n/a	Rural hospitals	n/a	n/a
46	Bangladesh		General doctor	Cesarean, laparotomy	n/a	Sub-district and DH	2,57,000	n/a
30	Bolivia		Non-surgeon physician	n/a	n/a	Rural	n/a	n/a
47	Burundi		GP	Cesareans, hysterectomy, ectopics, D&C	on-site by ex-pat OB/GYNs	Rural DH	n/a	n/a
7	Canada	BC, ON	Family physician	Appendectomy, carpal tunnel, cholecystectomy, herniorrhaphy	n/a	Rural B	2500–15,000	n/a
8	Canada	BC, AB	GP	Cesareans, appendectomies, ectopic pregnancy	n/a	n/a	n/a	n/a
11	Canada	BC	GP	Appendectomy, D&C, cesareans, herniorrhaphy, laparoscopy, etc.	n/a	Rural hospital	1700–17,000	n/a
14	Canada		GP	Appendectomies, cesareans	n/a	Rural hospitals	1738–17,940	n/a
28	Canada	BC, AB	Family physician	Cesareans, laparoscopy, appendectomy, herniorrhaphy, D&Cs, T&A, TLs, etc.	Formal and informal	Rural hospitals	5000–15,000	N/a
39	Canada	Western provinces	Family physician	n/a	12-month program, 3–6-month program; historically IMGs or ad hoc mentorship	Rural hospitals	n/a	Networks of care
44	Canada	BC, AB, YK, NT, SK, ON	GP	cesareans	n/a	rural hospitals	5–15,000	

Table 3 continued

Citation	Geography Country	Region/city	Education and scope of practice MD training	Surgical skills scope	Surgical training	Practice environment Facility	Catchment	Network/support
4	Ethiopia	Woldya	GP	Full scope (see Fig. 1a)	12-month, teaching hospital based	n/a	n/a	n/a
32	Ethiopia		GP	Cesareans (CEmOC)	3-month, new integration of surgical OB into family med residency	n/a	n/a	n/a
33	Ethiopia		Family physician	Cesareans	Included in FM residency?	n/a	n/a	n/a
22	Ghana		MO	Appendectomies, cesareans, laparotomy, herniorrhaphies	Informal (housemanship only)	n/a	n/a	n/a
27	Ghana		MO	Cesareans, D&Cs, appendectomies, laparotomy, herniorrhaphy	Informal (various forms)	DH	N/a	N/a
16	India		MO	cesareans (CEmOC)	16 weeks	Community health center	n/a	n/a
33	Lesotho		Family physician	Cesareans (and other)	Included in FM residency?	n/a	n/a	n/a
29	Liberia		GP	N/a	Informal	County hospital	N/a	N/a
37	Malawi		Medical doctor	n/a	n/a	DH	n/a	n/a
25	Mongolia		General doctor	Appendectomies, herniorrhaphy, laparotomy, cesarean section, D&C, hydrocelectomy, etc.	n/a	Primary level hospital (soum, intersoum)	<4500	n/a
9	Mozambique		MO	Cesareans, hysterectomy, ectopic pregnancy	Informal, “minimal”	DH		
19	Mozambique	Choke	GP	n/a	n/a	n/a	n/a	n/a
13	Namibia		GP	Cesareans, T&A, etc.	n/a	n/a	n/a	n/a
42	Nepal	Rural areas	Family physician	Cesareans (and other non-specified)	3-year program (including FMR)	DH	n/a	n/a
18	Niger		GP	Appendectomies, laparotomies, herniorrhaphy, cesareans, D&C, hysterectomy, ortho	12-month program ending in certificate “Capacity of District Surgery,” CDS	DH	168,000–620,000	Support from training specialists
40	Niger		GP	cesareans, ectopics, appendectomies, herniorrhaphy, hysterectomy, laparotomy	12-month program, certificate CDS	DH	n/a	n/a
20	Nigeria		MO/GP	Cesareans, laparotomy, ectopic pregnancy	12–18-month (D.Obst)			

Table 3 continued

Citation	Geography Country	Region/city	Education and scope of practice MD training	Surgical skills scope	Surgical training	Practice environment Facility	Catchment	Network/support
35	Nigeria	Cross River State	MO	Cesareans, appendectomies, laparotomy, herniorrhaphy	Mostly no, ARSPON doing some outreach support	DH	n/a	n/a
10	Papua New Guinea	Western Highlands Province	MS (medical superintendent)	Open ortho, D&C, obstetrics, gyne, ENT, gen surg, urology, TL	n/a	DH	40,000	n/a
26	Rwanda		GP	N/a	N/a	DH	249,000–434,000	N/a
43	Rwanda	Butaru, Rwinkavu, Kirehe	GP	Herniorrhaphy, laparotomy, hydrocelectomy, mastectomy, amputation	n/a	DH (rural)	n/a	n/a
44	Scotland		GP	cesareans	n/a	Rural hospitals	n/a	n/a
45	Sierra Leone		Non-specialist physicians	Cesareans, herniorrhaphy, orthopedic procedures, appendectomy, laparotomy, D&C, ectopics	n/a	DH	n/a	n/a
49	Sierra Leone		Junior MD	Cesareans, laparotomy, herniorrhaphy, appendectomy, D&C, hysterectomy	3-year program	Government DH	n/a	n/a
3	South Africa	KZN and NP	GP	Cesareans, ectopic, TL, D&C, hernia, skin graft, laparotomy, circumcision, etc.	n/a	n/a	n/a	n/a
34	South Africa	KwaZulu-Natal	GP	Appendectomy, cesareans	n/a	n/a	n/a	n/a
36	South Africa		Family physician	Cesareans, “common obstetric, surgical and orthopedic procedures”	FM residency itself	DH	n/a	n/a
38	South Africa		GP	Cesareans, appendectomies, herniorrhaphy, T&A, hydrocelectomy, minor ortho	Internship, supervision by senior physicians	DH, rural community hospitals	n/a	n/a
48	South Africa		NSP	Herniorrhaphy, laparotomy, amputation	n/a	n/a	n/a	n/a
51	South Africa	Various districts	GP	Various	Informal	Mostly rural hospitals	n/a	Need recognized
19	Tanzania	Bagamoyo, Kasulu	GP	n/a	n/a	n/a	n/a	n/a
24	The Gambia		GP	n/a	n/a	n/a	n/a	n/a
12	Uganda		MO	Cesareans, TLs, salpingectomy, hysterectomy, D&C, hernia repair, laparotomy, general surgery		DH	125,000–500,000	n/a
19	Uganda	4 sites	GP	n/a	n/a	n/a	n/a	n/a

Table 3 continued

Citation	Geography Country	Region/city	Education and scope of practice MD training	Surgical skills scope	Surgical training	Practice environment Facility	Catchment	Network/support
41	Uganda	Teso subregion	MO	n/a	n/a	n/a	n/a	n/a
53	Uganda		MO	n/a	n/a	DH	101,400–825,300	n/a
15	USA		Family physician	Cesareans, PPTL, D&C	Fellowship, 3 months to 2 years	Rural hospitals (and other)	n/a	n/a
17	USA	MN, CO, WA	Family physician	Cesareans	Family med residency (some programs), fellowship, on-the-job	Rural hospitals	n/a	n/a
33	USA	KS, WA, CA, PO, TX, MA, ID	Family physician	Cesareans	Included in FM residency?	n/a	n/a	n/a
44	USA	NE, WA, OR	GP	Cesareans	n/a	Rural hospitals	n/a	n/a
50	USA		Family physicians	Cesareans	FMR training, postgrad fellowship	Rural hospitals	n/a	n/a
52	USA		Family physicians	Cesareans	n/a	Rural hospitals	n/a	n/a

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