

## Human Resources for Health Supplementary Readings

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Supplementary Reading 1  
*Chu "Surgical Task Shifting in Sub-Saharan Africa"*

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## Essay

## Surgical Task Shifting in Sub-Saharan Africa

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## Introduction

The poor availability of surgical services in developing countries is a long neglected problem that has recently gained attention [1,2]. Violence, injury, and obstetric emergencies are among leading causes of mortality and morbidity that can be mitigated through surgical intervention. Surgically treatable problems are estimated to account for up to 11% of the world's disability-adjusted life years [1]. In addition to this massive disease burden there are problems that are seriously debilitating (cataract) or stigmatizing (fistula).

Surgical interventions are often viewed as expensive and complex, but many common problems amenable to surgery in resource-limited settings are cost-effective and do not require specialized staff and equipment. The World Health Organization (WHO) has prioritized a list of cost-effective surgical interventions for developing countries including emergency care of trauma, obstetrical complications, and acute abdomens as well as elective care of hernias, clubfoot, cataracts, hydroceles, and otitis media [3].

One of the main barriers to surgical care—defined as the safe provision of pre-operative, operative, and post-operative surgical and anesthesia services—in resource-limited settings is the shortage of trained health workers. Africa accounts for 24% of the global disease burden but only 3% of the global health workforce [4]. The reasons for this are well documented and include inadequate salaries and poor working conditions leading to staff attrition, unwillingness of international donors to support financing for human resources [5], an insufficiency of medical schools [6], and the brain drain of health staff to resource-rich countries [4,7,8]. The human resource crisis is most acute at the level of specialists, including surgeons and anesthesiologists [9,10]. In East Africa, there are 0.25 fully trained surgeons per 100,000 persons compared to 5.69 per

The Essay section contains opinion pieces on topics of broad interest to a general medical audience.

## Summary Points

- Surgically treatable problems account for a significant proportion of disease burden in resource-limited settings, but are neglected due to lack of skilled professionals, adequate infrastructure and equipment, and the perception that surgical services are complex and expensive.
- In the absence of trained surgeons, surgical tasks are often performed by non-specialist physicians and non-physician clinicians. While evaluations have proven the effectiveness of such task shifting, this is often done de facto, with little supervisory or training framework in place.
- As efforts increase to scale up surgical care in the developing world, a number of important lessons from task shifting in the field of HIV/AIDS care could serve to support task shifting in surgery.
- These include clearly defining the limits of task shifting, ensuring adequate training and supervision, providing adequate recognition and remuneration, developing simplified tools and guidelines, ensuring engagement with regulatory bodies, and mobilizing community health workers.

100,000 in the United States [11,12]. The actual minimum number of surgeons required is unknown.

**Citation:** Chu K, Rosseel P, Gielis P, Ford N (2009) Surgical Task Shifting in Sub-Saharan Africa. *PLoS Med* 6(5): e1000078. doi:10.1371/journal.pmed.1000078

**Published:** May 19, 2009

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**Funding:** No funding was received for this work.

**Competing Interests:** The authors have declared that no competing interests exist.

**Abbreviations:** CHW, community health worker; MoH, Ministry of Health; NPC, non-physician clinician.

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**Provenance:** Not commissioned; externally peer reviewed

Given the unlikelihood of even a modest increase in the number of surgeons and anesthesiologists working in Africa in the near future, a number of approaches are being piloted to overcome the skills shortage. These include surgical camps and specialist outreach programs (often supported by international experts) and the mobilization of non-physician clinicians (NPCs) to perform surgical and anesthetic tasks [13]. This latter approach, which involves the shifting of tasks from surgeons and anesthesiologists to non-specialists, has the greatest potential to provide coverage of basic surgical care, especially in rural areas. Task shifting involves the delegation of certain medical responsibilities to less specialized health care workers. In sub-Saharan Africa, task shifting has recently been promoted and formalized to help address the HIV/AIDS epidemic [14]. This paper discusses some of the experiences of surgical task shifting to date, and outlines lessons from task shifting in the delivery of HIV/AIDS care.

## Task Shifting in Surgery

The concept of a surgeon as a university-trained physician is a relatively modern one—prior to 1745 surgeons were still part of the Company of Barbers—but today surgery has become a highly specialized profession. Currently, much of the global surgical workforce is comprised of non-specialist physicians whose only formal surgical training is during medical school. In Uganda, a study of five general hospitals reported that over 5,000 surgical procedures were performed annually by non-specialist physicians [13]. In many coun-

tries, where doctors are scarce, certain surgical tasks are delegated to NPCs: almost half of all countries in sub-Saharan Africa use NPCs to perform minor surgical procedures [15]. In Tanzania and Mozambique, 84% and 92% (respectively) of cesarean sections, obstetric hysterectomies, and laparotomies for ectopic pregnancy are performed by NPCs [16,17]. In Malawi, 90% of cesarean sections at district hospital level are performed by surgical clinical officers with low morbidity and mortality [18]. International organizations have supported task shifting in a number of resource-limited settings (Box 1).

There is resistance to delegating surgical procedures to lower cadres for a number of reasons. Surgery is considered a highly specialized field that requires long years of training: in the US, surgeons complete a five-year surgical residency before operating independently. Indications for surgery are not always straightforward, patient management decisions can be complex, and learning the technical skills required to perform major surgery requires committed trainers. All this leads to a concern that such complex skills and knowledge cannot be adequately transferred in a shortened training course.

While the epidemiology of surgical disease in the developing world is relative-

ly unknown, simple procedures can be life-saving. The most common procedures performed at district hospitals are dilation and curettage and cesarean sections, while the most common general surgical procedures are suturing of wounds and manipulation of fractures [19]. These can be safely managed by non-surgeons. Highly complicated procedures that require the expertise of fully trained surgical specialists are referred to tertiary hospitals.

Evaluations of task shifting in surgery have concluded that NPC cadres are safe and effective. In Mozambique, *técnicos de cirurgia* have supported surgical care in district hospitals since 1989, performing 92% of emergency obstetrical care and 65% of major general surgery [20]. Moreover, because their training can be less expensive and shorter, NPCs are highly cost-effective [4,15,21]; by one estimate, operations performed by NPCs cost less than a tenth of those performed by doctors [20].

NPCs are often from the local area, understand local customs and the language, and are more likely to remain in their home country because their training is not internationally recognized: 88% of the *técnicos de cirurgia* trained in Mozambique were still working at district hospitals seven years after their training, while none

of the junior doctors who started at the same time remained. In Malawi, 112 orthopedic clinical officers have been trained since 1984 and all have remained in the country [21].

## Lessons from Task Shifting in HIV Care

While these examples are encouraging, task shifting in surgery is for the most part ad hoc. As attention is increasing around the need to address human resource shortages for surgery, the potential for task shifting will likely be encouraged [22,23]. Task shifting has gained significant attention in the field of HIV/AIDS care, where a growing evidence base is informing policy and practice [14]. Some core principles are emerging that could support its application to surgery.

### 1. Defining the Limits

To promote task shifting in HIV care, WHO developed guidelines that outline over 150 essential tasks for the management of HIV patients, which can be shifted to NPCs and lay workers. The WHO's Clinical Procedures Unit has established a list of surgical tasks that can be safely and effectively performed at the district hospital level [24]. This work needs to be expanded to define a framework for task shifting that would outline which procedures can be safely performed by different health cadres (Table 1). With studies describing mortality rates as high as 5%–10% in developing countries [25–27], defining the limits of task shifting is essential to ensure quality of care. This requires innovative testing of new approaches together with rigorous evaluation to build the evidence base for policy. International nongovernmental organizations and academic institutes can support governments in the elaboration and implementation of a priority operational research agenda, establish pilot programs, and evaluate outcomes.

### 2. Providing Training, Supervision, and Referral Systems

To ensure adequate quality, reduce burnout, and encourage recognition of responsibilities, the provision of training, supervision, monitoring, and evaluation are all critical. In HIV care, nurses and other NPCs are responsible for direct patient care, while doctors are taking on a supervisory role, often working as part of a mobile team overseeing multiple clinics and providing training and mentorship of complex cases [28]. Similarly, increasing capacity for basic surgical care by NPCs implies the increased need to provide

#### Box 1. Examples of International Organizations Supporting Surgical Task Shifting

**Médecins Sans Frontières** has provided a range of MoH-approved training programs, including teaching non-specialist physicians basic surgical skills in Chad (six-month course), and nurse anesthetists in Haiti (15-month course). In conflict settings where formal training was not possible (Angola and Somalia), ad hoc trainings have been provided to nurses so that they could carry out life-saving interventions such as cesarean sections and intestinal resections when no physician was available.

**The International Committee of the Red Cross (ICRC)** supports a MoH-approved surgical training program for non-specialist physicians and nurses in anesthesia in Eritrea. From 1991–1995, ICRC trained non-specialist physicians in Cambodia who were providing most of the surgical care after the Pol Pot regime. ICRC has also supported informal training of physicians and nurses in basic surgery in the Democratic Republic of the Congo and Somalia.

**Serving in Mission (SIM) International** trains nurses in a two-year apprenticeship model to perform operations at Kalukembe District Hospital in Angola (<http://www.ceml.net/>). This program, which has been running for over 20 years, has not yet been recognized by the MoH, but these nurses have been a critical resource in delivering surgical care in this poor rural district where there are no physicians.

**The Global Health Access Program** (<http://www.ghap.org/>), working along the Thai/Burmese border in Myanmar, trains non-physician “backpack medics” in skills such as basic resuscitation, surgical stabilization, fracture management, and wound care.

The **Christian Blind Mission** trains NPCs to perform cataract surgery across Africa.

**Table 1.** Examples of surgical tasks that could be performed by different health workers.

Health Cadre	Level of Care	Procedures Performed
Surgeon+anesthesiologist	Tertiary hospital	Neurosurgery; Thoracic surgery; Vascular surgery; Complex orthopedic surgery; Endocrine surgery; Reconstructive surgery; Critical care
General doctor/non-physician clinician with surgical skills+nurse anesthetist	District hospital	Incision and drainage of abscess; Wound debridement; Acute burn care; Skin graft; Circumcision; Hernia repair; Dilatation and curettage; Manual placenta extraction; Cesarean section; Exploratory laparotomy for ectopic pregnancy or ovarian torsion; Hysterectomy; Appendectomy; Bowel resection; Stoma creation; Cholecystectomy; Splenectomy; Repair of perforated gastroduodenal ulcer; Limb amputation; Thoracostomy; Closed fracture reduction; Skeletal traction
Community health worker	Primary health center	Pre-hospital transport of trauma victims; Basic wound care management; Referral of surgical disease

doi:10.1371/journal.pmed.1000078.t001

specialists to train and supervise lower cadres and to manage complex cases and complications. Currently, some countries such as Zimbabwe rely on itinerant expatriate surgeons who rotate through district hospitals to assist non-specialist physicians with complex cases and to provide continuing surgical training. This should be formalized in order to provide sustainable support in a systematic manner.

### 3. Ensuring Adequate Recognition and Remuneration

Giving lower cadres more responsibilities is unlikely to be sustainable unless adequate recognition and remuneration is provided. In Mozambique, training of *técnicos de cirurgia* was recognized by government and doctors who welcomed them as colleagues; Malawi, Zambia, and Tanzania also have well established cadres of surgical NPCs that are recognized formally and supported by the Ministries of Health (MoHs) [19]. As has been argued for HIV care, task shifting in surgery should be seen primarily as a way to increase access to care, not to save money, as financial incentives are still required to ensure retention of lower cadres [29].

### 4. Developing Adapted Guidelines

Task shifting in HIV care has been supported by the development of standardized protocols, including simplified clinical guidelines and simplified recording, reporting, and monitoring and evaluation systems. Basic guidelines for surgery are provided by the WHO's Emergency and Essential Surgical Care project, with basic surgical training supported through the Integrated Management of Emergency and Essential Surgical Care toolkit, including a manual for surgical care at the

district hospital [30]. Guidelines and protocols for simplification need to be developed for different cadres of health workers if task shifting is to be scaled up. *Primary Surgery* by Maurice King is an invaluable guide for non-surgeons performing surgery in the resource-poor district hospital setting. Similarly, manuals providing practical management of obstetrical emergencies for non-obstetricians working in developing countries exist. These texts should be made broadly available [31,32].

### 5. Simplification

In HIV care, standardized drug regimens and lab investigations did much to support the simplification of HIV care such that it could be taken on by lower health cadres [33]. Similar approaches are needed for surgery. Minimum standards have been established for safe, effective anesthesia techniques relying on a minimal arsenal of drugs, disposables, and basic equipment, and these should be promoted [34,35]. Simplified data recording and monitoring and evaluation systems are also needed to provide outcome data to identify areas where further training and supervision is needed.

### 6. Engaging with Regulatory Frameworks and Professional Bodies

Formal recognition by physician professional societies is essential, and the reluctance of professional bodies to support task shifting has been recognized as a barrier to task shifting in HIV care [36]. In Haiti, although the MoH recognized nurse anesthetists as an official cadre, some anesthesiologists still viewed them as assistants and were reluctant to allow them to function independently. Specialists such as surgeons and anesthesiologists should

also take leadership roles in the training and accreditation of these lower cadres and help define their responsibilities and limits. In some conflict settings, the MoH ceases to function and there is no regulatory body to provide official recognition of training or new cadres.

### 7. Exploring the Potential for Community Support

Community health workers (CHWs) have recently been engaged to support HIV/AIDS care, where considerable work has been done to define frameworks for engagement [37]. In surgery, CHWs have been successfully trained in the past to recognize diseases requiring surgical intervention, such as hernias and hydroceles. The full potential of CHWs in the provision of surgical care needs to be explored. With proper training and supervision, a minimum package could be administered that might include wound management, basic life support and trauma care, and referral for acute surgical needs such as cesarean section for obstructed labor.

### Ethics of Task Shifting

Shifting clinical responsibilities from higher to lower cadres raises ethical concerns about lowering standards of care. However, while medical ethics clearly insist that doctors provide the best standard of care they can for their patients, public health ethics require health professionals to also consider how to help patients who cannot access care. Health professionals have a duty to ensure that benefits and burdens be fairly balanced, being mindful not just of the fortunate few who get to see a surgeon, but of the invisible majority who never will [38]. In

HIV care it was recognized from the outset that if the Western model of care— infectious disease specialists in tertiary hospitals with a multitude of diagnostic and therapeutic options—were to be replicated, then only a fraction of the millions of people in need of treatment in the developing world would benefit, while most of the rest would die. Simplification of protocols and task shifting of key clinical tasks was embraced as a means of ensuring broad benefit and avoiding the creation of “islands of excellence in a sea of under-provision” [39]. Similarly, capacitating lower health cadres to undertake specific surgical tasks aims to maximize benefits while minimizing harm in settings where the unmet need of surgical care is great.

The development of a clear, evidence-based framework defining the limits would establish boundaries for what is already happening by default across rural Africa, where surgeons are absent but patients need care.

## Conclusions

The dire shortage of surgeons and anesthesiologists working in Africa means that non-specialist physicians and NPCs provide the majority of surgical services in district hospitals. Efforts should focus on training, supervision, and recognition for these de facto surgeons and anesthesiologists. At the same time, opportunities for further task shifting need to be explored,

given the reality that doctors also are in short supply, particularly in rural areas. As CHWs are showing, even people who have not received any formal training in health care can with a minimum of training make an important contribution.

## Acknowledgments

We would like to thank Marco Baldan, Chris Giannou, Seydouba Guilavogui, Slava Sviridov, and Miguel Trelles for valuable discussions.

## Author Contributions

ICMJE criteria for authorship read and met: KC PR PG NF. Wrote the first draft of the paper: KC. Contributed to the writing of the paper: KC PR PG NF.

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Supplementary Reading 2

*Federspiel “Global surgical, obstetric, and anesthetic task shifting: a systematic literature review”*

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SURGERY



## Global surgical, obstetric, and anesthetic task shifting: A systematic literature review

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### ARTICLE INFO

#### Article history:

Accepted 3 April 2018

Available online xxx

### ABSTRACT

**Background:** Five billion people lack access to safe, affordable, and timely surgical care; this is in part driven by severe shortages in the global surgical workforce. Task shifting is commonly implemented to expand the surgical workforce. A more complete understanding of the global distribution and use of surgical, obstetric, and anesthetic task shifting is lacking in the literature. We aimed to document the use of task shifting worldwide with a systematic review of the literature.

**Methods:** We performed a systematic review of 10 health literature databases. We included journal articles published between January 1, 1995, and February 17, 2017, documenting the provision of surgical or anesthetic care by associate clinicians (any non-physician clinician). We extracted data for health cadres performing task shifting, types of tasks performed, training programs, and levels of supervision, and compared these across regions and income groups.

**Results:** We identified 55 relevant studies, with data for 52 countries for surgery and 147 countries for anesthesia. Surgical task shifting was documented in 19 of 52 countries and anesthetic task shifting in 119 of 147. Task shifting was documented across all World Bank income groups. No associate clinicians were found to perform surgical procedures unsupervised in high-income countries (0 of 3 countries with data). Independent anesthesia care by associate clinicians was noted in 3 of 19 countries with data. In low-income countries, associate clinicians performed surgical procedures independently in 2 of 3 countries and independent anesthesia care in 17 of 17 countries with data.

**Conclusion:** Task shifting is used to augment the global surgical, obstetric, and anesthetic workforce across all geographic regions and income groups. Associate clinicians are ubiquitous among the global surgical workforce and should be considered in plans to scale up the surgical workforce. Further research is required to assess outcomes, especially in low-income and middle-income countries where documented supervision is less robust.

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### Introduction

Five billion people lack access to safe, affordable surgical care when needed.<sup>1</sup> This is driven, in part, by severe shortages in the global surgical workforce.<sup>2</sup> Task shifting (TS), defined by the WHO in 2008 as “the rational redistribution of tasks among health work-

force teams ... from highly qualified health workers to health workers with shorter training and fewer qualifications,” is a commonly implemented yet often contentious strategy to expand the workforce. Criticisms include that the practice is frequently unregulated and is an often unassessed intervention.<sup>3–9</sup> Still, many advocate for its use to scale up the surgical workforce to decrease the gap between patients and access to care. An estimated 1,272,586 new surgical workforce providers are needed to achieve a global surgical workforce density of 20 surgeons, anesthesiologists, and obstetricians per 100,000 people by 2030, costing US\$71–146 billion; in-

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<https://doi.org/10.1016/j.surg.2018.04.024>

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creased “task sharing” has been proposed as a way of decreasing cost and training times to reach this goal.<sup>10</sup>

Before the debate on surgical TS can be advanced, some fundamental questions need clarifying, which includes understanding the current scope of TS globally. While separate regional studies of the use of surgical and anesthetic TS and a global survey of the use of nurse anesthetists have been performed,<sup>3,4,11,12</sup> an updated global view of the use of TS in the surgical and anesthetic disciplines is currently lacking in the literature. Understanding how and where TS is employed to bend the cost curve of health care expenditure while simultaneously expanding access to care is a first step in an informed discussion regarding policies on the needs in the global surgical workforce across all income settings.

In this review, we describe the current use of surgical and anesthetic TS as it is reported in the literature throughout the world. This review includes a description of the tasks shifted, the health workers involved in TS, and the role of supervision in TS. This review will serve as a more complete and updated expansion of our preliminary findings presented as an abstract in 2015.<sup>13</sup>

## Methods

### Definitions

#### –Task shifting

For the purposes of this review, we used the WHO definition of TS (“the rational redistribution of tasks among health workforce teams ... from highly qualified health workers to health workers with shorter training and fewer qualifications”) with the added modification that we also included situations in which surgical and anesthetic tasks were performed by associate clinicians (ACs) before and/or more frequently than by physicians, even though said tasks had not been redistributed from physicians to other cadres.

#### –Associate clinician

The WHO defined an AC in 2012 as “a professional clinician with basic competencies to diagnose and manage common medical, maternal, child health, and surgical conditions. They may also perform minor surgery.”<sup>14</sup> The WHO separated a subset titled “advanced level associate clinician” as “a professional clinician with advanced competencies to diagnose and manage the most common medical, maternal, child health, and surgical conditions, including obstetric and gynecological surgery (eg Caesarian sections).” For the purpose of simplicity, we did not differentiate between these two cadres in this study and included nurses and midwives in our definition of ACs. Additionally, we included the terms “non-physician clinician” and “mid-level provider” for completeness within our search, because they represent the cadre of ACs under consideration, but these names have become outmoded language by the WHO due to their potentially negative connotation.<sup>14</sup> (See Table 1, which defines the abbreviations used for the group of ACs in this study.)

Our scope did not include TS to general practitioners (GPs) or non-specialist physicians, though we recognize in many parts of the world that these groups are relied on to carry out procedures they may or may not be formally trained to perform. Rather, we focused on TS to cadres with training that did not include medical school.

### Literature search

We followed the PRISMA guidelines for a systematic review without a meta-analysis.<sup>15</sup> Data collected for this review came from searches of PubMed on August 17, 2014, and an additional 9 databases on August 29, 2014: Embase, The Cochrane Library, CINAHL, WHOLIS, and 5 regional databases (AIM, LILACS,

**Table 1**

Associate clinician abbreviations.

Associate Clinician Title	Abbreviation
Anesthesia Assistant	AA
Anesthetic Care Practitioner	ACP
Anesthesia Technician	AT
Anesthetic Technical Officer	ATO
Anesthetic Medical Assistant	AMA
Assistant Medical Officer	AMO
Clinical Officer	CO
Community Health Officer	CHO
Health Officer	HO
Medical Assistant	MA
Medical Licentiate Practitioner	MLP
Nurse Midwife	NM
Nurse Practitioner	NP
Nurse Anesthetist	NA
Orthopedic Officer	OO
Physician Assistant	PA
Surgical Care Practitioner	SCP
Surgical Technician	ST
Técnico de Cirugía	TC

IMEMR, IMSEAR, and WPRIM). In addition, the website of the WHO Global Health Workforce Alliance was searched manually.<sup>16</sup> Our initial search string consisted of 4 components: 9 database-specific subject-heading terms for health care personnel, 63 variations of 19 AC terms, 14 variations of 7 general terms for surgery, obstetrics, and anesthesia, and database-specific subject-heading terms for geographic locations.

This search strategy was repeated before final write-up of the article for all listed databases on February 19, 2017, with 4 variations of obstetric terms added to identify any newly published relevant literature as well as additional obstetric literature not identified with the initial search.

The full search strings used on PubMed are provided in Appendix 1. Potentially relevant articles that were not identified by our search strategy but were cited in reviewed articles were retrieved and included in review. See Fig. 1 for a flowchart of the search and review.

### Inclusion criteria

Articles published from January 1, 1995, to February 19, 2017, with title or abstract mentioning surgical or anesthetic care provision by ACs or non-physician clinicians.

### Exclusion criteria

For the purposes of this study, we excluded articles focused on physician (non-surgical or anesthetic) TS, ophthalmology or odontology, TS of diagnostic or outpatient procedures, and non-English language or opinion piece articles.

### Review process

The review was performed by 3 independent reviewers. A primary screening of titles and abstracts was conducted with discrepancies resolved by reevaluation and consensus among all 3 reviewers. In cases where conflicting literature was identified, the most recent source was chosen. To ensure the data were not affected by literature from individual countries with large bodies of literature, we introduced a 10 article limit per country. In the end, this limit applied only for the United States (US) and the United Kingdom (UK); >200 relevant articles in total). Ten articles from each of these countries published over the past 10 years were selected randomly for full-text review, removing more than 200 additional articles.

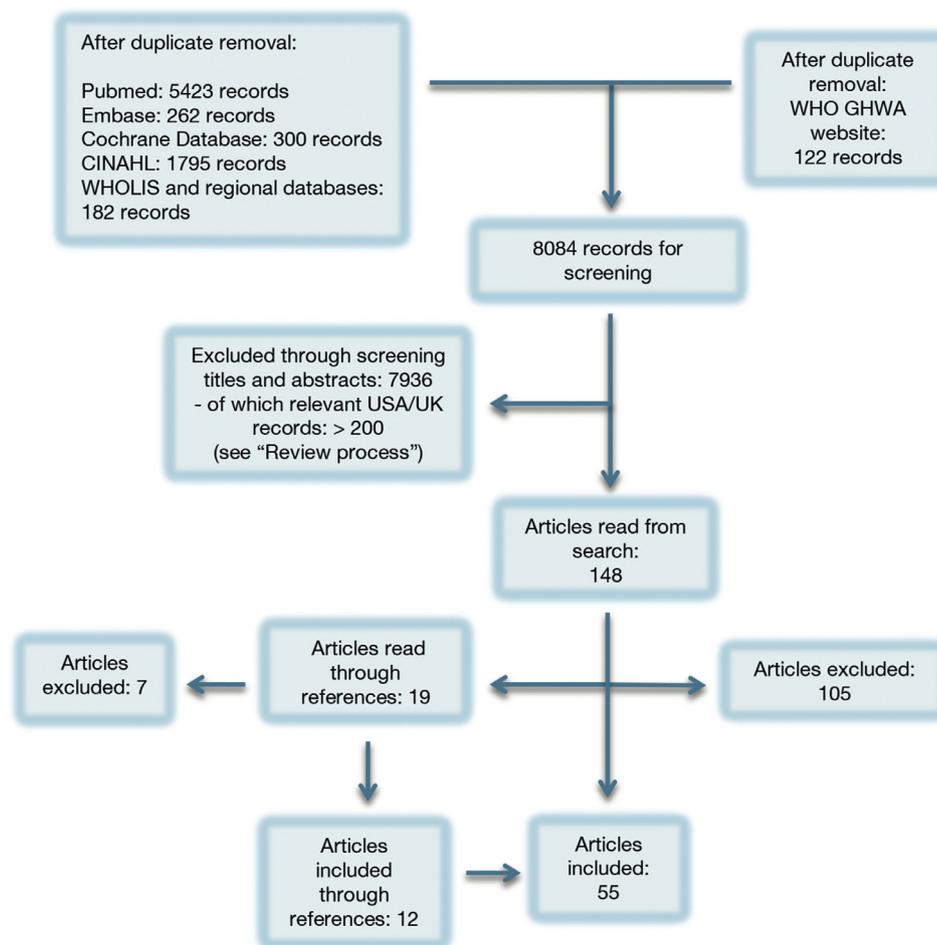


Fig. 1. Study flow diagram.

### Data extraction

The following data were extracted from each article: the occurrence of either surgical or anesthetic TS in the country, the specific fields and complexity of tasks shifted, the presence of a relevant training program for ACs, and the level of supervision provided to ACs. We differentiated the supervision of ACs by surgeons and anesthesiologists into the following 3 levels:

**Direct supervision:** a relevant, certified specialist physician is present in the same room overseeing procedures.

**Indirect supervision:** a relevant, certified specialist physician is immediately available though not physically present during all parts of procedures.

**Independent practice:** the AC is allowed to perform procedures independently without any supervision.

Statements indicating a substantial majority of care in a country being provided by ACs were interpreted as independent AC practice; for example “There are more than 50 nurse anesthetists [and] 5 physician anesthetists ... for 1.3 million people,” or “97% of all anesthetics are carried out by nurses.”<sup>3</sup>

We also searched for and extracted data for countries that specifically prohibit the use of TS either by law or cultural statement.

### Results

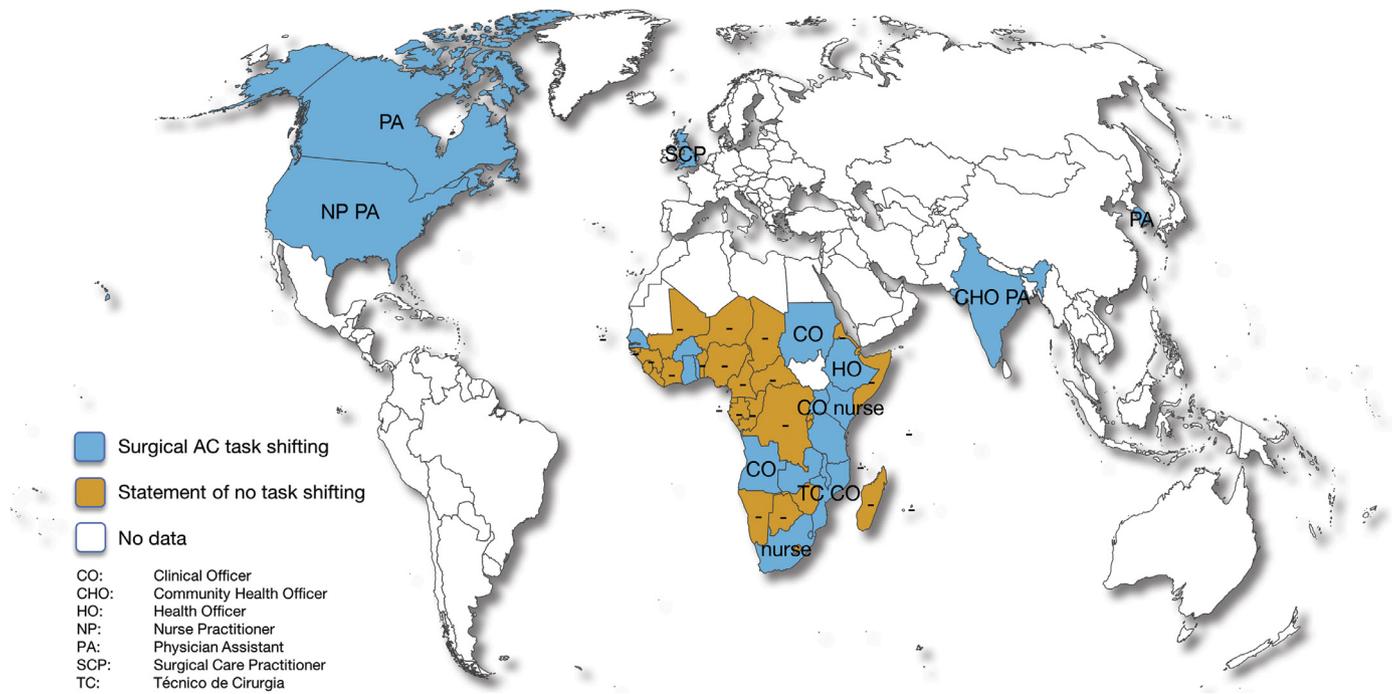
Our search strategy resulted in 8,084 distinct articles, of which 43 met our inclusion criteria, and 12 additional articles were in-

cluded through references (Fig. 1 shows study flow diagram and online appendix shows full list of included review references). Data on surgical and anesthetic TS were obtained from 52 and 147 countries, respectively. The practice of surgical TS was reported in 19 of 52 countries (37%) with available data and the practice of anesthetic TS in 119 out of 147 countries (81%) with available data (Figs. 2 and 3).

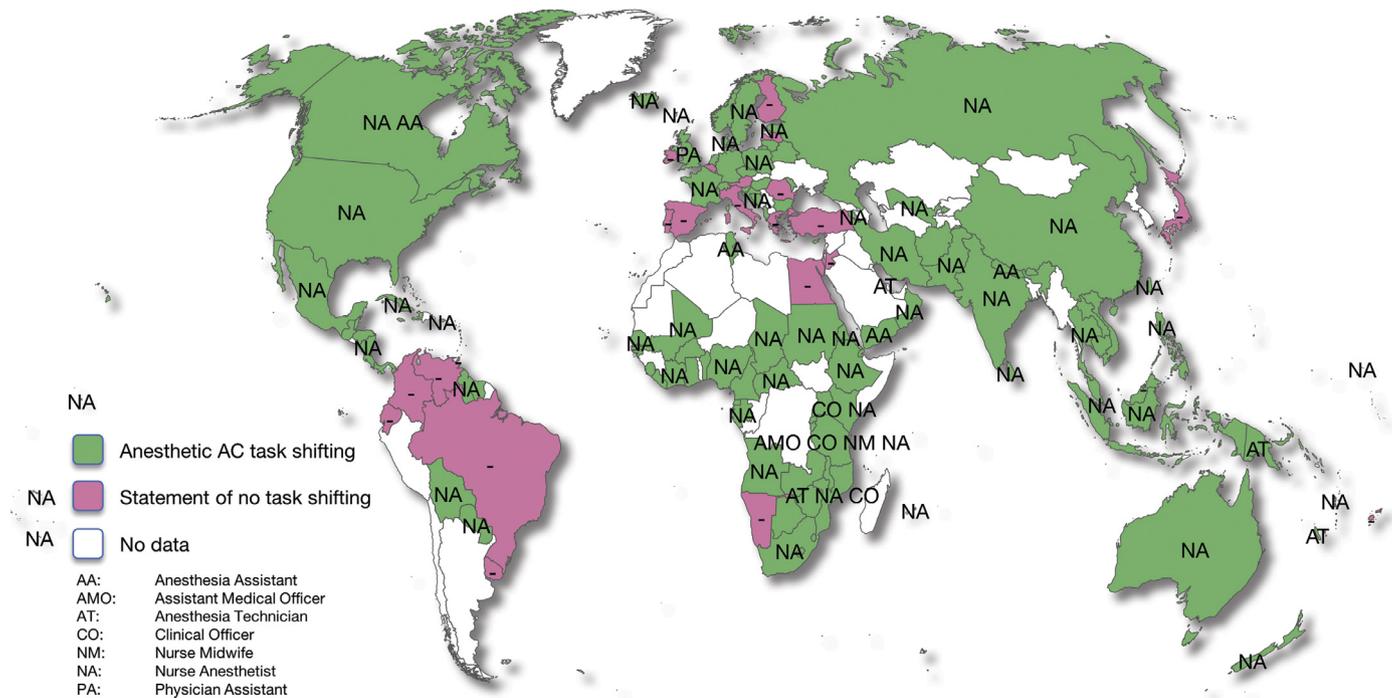
TS in both surgery and anesthesia was documented across all World Bank income groups (Table 2). With the exception of lower income countries (LICs), however, scarce data were available for surgical TS. Substantially more information was identified for anesthetic TS. The majority of relevant data came from sub-Saharan Africa, where TS was documented in 14 of 46 countries (30%) for surgery and in 36 of 37 countries (97%) for anesthesia; however, examples were found across all WHO geographic regions. Performance of tasks was shifted to a number of different named cadres, mainly clinical officers and nurse anesthetists (Appendixes 3 and 4), who were all included as ACs for the purposes of this study.

### Occurrence of task shifting separated by country income groups

In LICs, surgical TS was documented in 7 of 25 countries (28%) and anesthetic TS in 23 of 23 countries (100%) with available data (Table 2). In lower middle-income countries (LMICs), surgical TS was documented in 6 of 16 countries (38%) and anesthetic TS in 32 of 33 countries (97%) with available data. In upper middle-income countries, surgical TS was documented in 2 of 5 countries (40%) and anesthetic TS in 26 of 34 countries (76%) with available data. In high-income countries (HICs), surgical TS was documented in 4



**Fig. 2. Results for Surgical Task Shifting.** Not all cadres displayed on map, please see Appendix 3 for full details. Note that this is a static picture of dynamic health systems, and it is solely based on what we were able to identify in the published literature. Countries were labeled with "Statement of no task shifting" only when reports explicitly stated that no surgical task shifting was taking place. Where the literature was discrepant, the newest article was used to code the country as utilizing AC task shifting or not.



**Fig. 3. Results for Anesthetic Task Shifting.** Not all cadres displayed on map, please see Appendix 4 for full details. Note that this is a static picture of dynamic health systems, and it is solely based on what we were able to identify in the published literature. A statement of no use of nurse anesthetists was used as a statement of no task shifting occurring in anesthesia within the country. Where the literature was discrepant, the newest article was used to code the country as utilizing AC task shifting or not.

of 6 countries (67%) and anesthetic TS in 36 of 54 countries (67%) with available data.

*Tasks shifted*

Across all income categories, TS of surgical procedures was observed in general surgery, orthopedic surgery, obstetric surgery,

neurosurgery, plastic surgery, otolaryngology (ENT) surgery, and pediatric surgery. Of note, however, a broader range of surgical procedures performed by ACs was observed in LICs compared to HICs.

In the 2 HICs engaging in surgical TS, tasks were specific and well defined. These included performing minor surgical proce-

**Table 2**

Number of countries with reported task shifting out of total countries with data separated by World Bank regions and income groups.

World Bank	Surgery	Anesthesia
<b>World Bank region</b>		
Europe and Central Asia	1/1 (100%)	31/42 (74%)
Middle East and North Africa	0/1 (0%)	7/11 (64%)
South Asia	1/1 (100%)	6/6 (100%)
East Asia and Pacific	1/1 (100%)	19/23 (83%)
North America	2/2 (100%)	2/2 (100%)
Latin America and Caribbeans	No data	16/24 (67%)
Sub-Saharan Africa	14/46 (30%)	36/37 (97%)
<b>World Bank income group</b>		
High income countries	4/6 (67%)	36/54 (67%)
Upper middle income countries	2/5 (40%)	26/34 (76%)
Lower middle income countries	6/16 (38%)	32/33 (97%)
Low income countries	7/25 (28%)	23/23 (100%)

**Table 3**

Number of countries with reported independent associate clinician task shifting practice out of total countries with data on supervision, separated by World Bank regions and income groups.

World Bank	Surgery	Anesthesia
<b>World Bank region</b>		
Europe and Central Asia	0/1 (0%)	0/18 (0%)
Middle East and North Africa	No data	0/1 (0%)
South Asia	No data	1/2 (50%)
East Asia and Pacific	0/1 (0%)	6/11 (55%)
North America	0/1 (0%)	1/2 (50%)
Latin America and Caribbeans	No data	6/9 (67%)
Sub-Saharan Africa	3/4 (75%)	23/24 (96%)
<b>World Bank income group</b>		
High income countries	0/3 (0%)	3/19 (16%)
Upper middle income countries	0/1 (0%)	7/15 (47%)
Lower middle income countries	No data	10/16 (63%)
Low income countries	2/3 (67%)	17/17 (100%)

dures<sup>17</sup> or assisting in major surgery<sup>8</sup> compared to the independent practice found more commonly in LICs.<sup>4,18–20</sup> Further details of this are provided in [Appendix 3](#).

#### Availability of training programs for ACs

Training levels varied between different cadres and countries. For surgery, we found evidence of AC training programs in 16 countries. The duration of the training program ranged from on-the-job training to 5 years in LICs. For anesthesia, we identified AC anesthesia training programs in 49 countries. The duration of the training programs ranged from on-the-job training to 5 years. Generally, we noted less variability with longer average training programs in middle income countries (MICs) and HICs. Further details of this are provided in [Appendixes 3 and 4](#).

#### Level of supervision

Independent practice of a wide range of surgical procedures among ACs was found to be highly prevalent in LICs but was rarely observed among HICs ([Table 3](#)). In HICs, surgical ACs were reportedly always supervised, either directly or indirectly. In contrast, we found that in LICs, ACs were allowed to perform surgery (major obstetric, general, orthopedic, plastic, ENT, and neurosurgical procedures) without supervision in 2 of 3 (66%) countries.<sup>4,18–20</sup>

For anesthesia, 3 of 19 HICs (16%) with available data compared to 17 of 17 LICs (100%) with available data allowed independent AC-provided anesthesia care.

## Discussion

In this review, we demonstrated that TS for surgery, obstetrics, and anesthesia occurs throughout the world across all regions and income levels. TS was most heavily used in sub-Saharan Africa the United States, and the United Kingdom. While the economic constraints on health systems in sub-Saharan Africa are substantially greater than in the US and the UK, all these regions regardless of budget may use ACs as surgical and anesthetic providers to fill a human resource gap that would otherwise be difficult to fill, particularly in rural areas. The US has approximately 47 nurse practitioners and 36 physician assistants per 100,000 people,<sup>21,22</sup> emphasizing that the widespread use of ACs is not limited to poor countries.

TS was found to be more prevalent in anesthesia than in surgery in the literature reviewed. This observation may be due to the observed widespread use of nurse anesthetists (111 countries); however, the lesser volume of data for surgery compared to anesthesia (52 and 147 countries, respectively) likely contributes to the disproportionate representation as well. For surgery, a gap in the data exists regarding the use of TS in middle- and high-income countries, especially in Europe and Asia. This gap could represent an absence of the practice—or simply an absence of reporting. More research is needed in this area to understand different models of TS and their subsequent results.

Training programs for TS were available in nearly all settings where data were available. Of note, the duration of training varied greatly in LICs. More data are needed to better understand which forms of training are most effective at producing surgical providers with good patient outcomes.

Though the aim of this study was not to evaluate outcomes of care provided by ACs, we did notice an apparent scarcity of quality evaluations of surgical patient outcomes through our review process. Outcome studies have been performed for TS in orthopedic surgery in Malawi,<sup>23</sup> general surgery in Tanzania<sup>24</sup> and Mozambique,<sup>25</sup> and male circumcisions<sup>26</sup> and Caesarian sections<sup>25,27–33</sup> across various sub-Saharan African countries. None of the studies identified were randomized trials. The studies mentioned have shown positive results with similar patient outcomes between ACs and physicians, however, this topic remains controversial and to our knowledge inadequately evaluated. Further research is needed to fully establish the safety of AC-performed surgery, including an examination of the safety of different types of procedures performed, at different levels of training, and under different levels of supervision. The results of such research should always be weighed against the alternative, which in some settings might be the total absence of care.

Our study has limitations. What we have presented is likely an underrepresentation of surgical and anesthetic TS, because we only investigated what was published in the English literature and excluded GPs and non-specialist physicians, focusing instead on ACs. Notably, reporting bias is likely to have favored the more novel and successful TS initiatives, which potentially may have caused our results to underestimate the absolute number of countries that utilize TS.

Our interpretation of the WHO definition of TS for this review was done to avoid the fallacy of assuming that AC-provided tasks are always delegated or substituted from a physician. In many underserved regions of the world, surgical and anesthetic care historically has been and is still provided predominantly by ACs,<sup>3,4,7</sup> which necessitated this amendment to the definition to capture as much AC-provided care as possible. We referred to this as TS to align with the general terminology of the field, even though said tasks may never have been performed by physicians in the given setting. We did not distinguish among task delegation, task substitution, or task sharing, because this was all included under our

definition of TS. The supervision data provided (Table 3 and on-line Appendix) capture some of the level of detail left out by using this definition—but not necessarily all—and add an important dimension to understanding the nature of AC-provided surgical and anesthetic care globally.

The included maps indicate which countries utilize TS based on the literature reviewed and clearly illustrate the widespread use of TS globally. Because the maps illustrate a static picture of a dynamic situation and are based solely on the published literature identified, they should be interpreted with care. In spite of the simplistic nature of the maps, they provide an overview of where the literature was most scarce, which proved to be for surgical TS in South America, Asia, Europe, and North Africa. More research on the status of surgical TS in these areas is needed to help inform decision-making in these regions.

## Conclusion

TS is used to augment the global surgical, obstetric, and anesthetic workforce across all geographic regions and income groups. Independent practice among ACs in anesthesia was found to be highly prevalent in LMICs but was rarely reported among HICs. Data on supervision of AC-provided surgery were also scarce. Further research is required to evaluate the effect of supervision on patient outcomes, especially for health systems where supervision is less robust. Future research might also include a systematic comparison of patient outcomes and costs between ACs and specialist physicians to investigate the cost-effectiveness, quality, and safety profiles of surgical and anesthetic ACs. Research efforts should highlight all aspects of TS, with the ultimate goal of increasing expeditious access to safe and quality surgical and anesthesia care to those in need. ACs are ubiquitous in the global surgical workforce and should be part of any considerations for scaling up the surgical workforce in countries with workforce shortages, provided ACs align with country-specific needs and priorities.

## Supplementary materials

Supplementary material associated with this article can be found, in the online version, at doi:[10.1016/j.surg.2018.04.024](https://doi.org/10.1016/j.surg.2018.04.024).

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Supplementary Reading 3

*Beard “Surgical Task-Shifting in a Low-Resource Setting: Outcomes After Major Surgery Performed by Nonphysician Clinicians in Tanzania”*

**Page 15-21**

# Surgical Task-Shifting in a Low-Resource Setting: Outcomes After Major Surgery Performed by Nonphysician Clinicians in Tanzania

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## Abstract

**Background** Little is known about the breadth and quality of nonobstetric surgical care delivered by nonphysician clinicians (NPCs) in low-resource settings. We aimed to document the scope of NPC surgical practice and characterize outcomes after major surgery performed by nonphysicians in Tanzania.

**Methods** A retrospective records review of major surgical procedures (MSPs) performed in 2012 was conducted at seven hospitals in Pwani Region, Tanzania. Patient and procedure characteristics and level of surgical care provider were documented for each procedure. Rates of postoperative morbidity and mortality after nonobstetric MSPs performed by NPCs and physicians were compared using multivariate logistic regression.

**Results** There were 6.5 surgical care providers per 100,000 population performing a mean rate of 461 procedures per 100,000 population during the study period. Of these cases, 1,698 (34.7 %) were nonobstetric MSPs. NPCs performed 55.8 % of nonobstetric MSPs followed by surgical specialists (28.7 %) and medical officers (15.5 %). The most common nonobstetric MSPs performed by NPCs were elective groin hernia repair, prostatectomy, exploratory laparotomy, and hydrocelectomy. Postoperative mortality was 1.7 % and 1.5 % in cases done by NPCs and

physicians respectively. There was no significant difference in outcomes after procedures performed by NPCs compared with physicians.

**Conclusions** Surgical output is low and the workforce is limited in Tanzania. NPCs performed the majority of major surgical procedures during the study period. Outcomes after nonobstetric major surgical procedures done by NPCs and physicians were similar. Task-shifting of surgical care to nonphysicians may be a safe and sustainable way to address the global surgical workforce crisis.

## Introduction

A severe shortage of skilled healthcare providers exists in low-resource settings. The global workforce crisis is especially pronounced in the fields of surgery and anesthesia. While there are 6.7 general surgeons per 100,000 population in the United States, there are just 0.14 general and specialist surgeons for every 100,000 Tanzanians [1, 2].

At the time of Tanzania's independence in 1961, there were only 12 Tanzanian physicians working in the country [3]. In response to this incredible health workforce shortage, the first president of Tanzania, Julius Nyerere, initiated a policy of task-shifting, training and licensing nonphysician clinicians (NPCs) to deliver medical and surgical care throughout the country [3]. Currently, nonphysician clinicians are allowed to perform major obstetric surgery in five sub-Saharan African countries; however, debate continues regarding the safety of task-shifting complex surgical duties to nonphysicians [4].

The use of nonphysician clinicians to address the workforce crisis in low-resource settings has several demonstrated advantages over the traditional model of

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doctor-delivered care. NPC training is shorter and less expensive than physician education, and NPCs are more likely to serve in rural areas, where practitioners are most needed [5]. The World Health Organization (WHO) has advocated task-shifting in HIV care through the “Treat, Train, Retain” plan, formalizing guidelines for the implementation of task-shifting globally in 2008. However, recommendations regarding surgical task-shifting policy are notably missing from WHO guidelines [6].

Today, NPCs are responsible for much of the surgical care in Tanzania’s district hospitals, although little is known about the extent of their surgical activity and their scope of surgical practice [7]. While there is evidence that NPCs can safely perform cesarean sections in Tanzania, the quality of nonobstetric surgical care they deliver has not been studied [4, 8]. The WHO has called for investigation into the extent of current task-shifting activities in low-resource settings. In addition, monitoring of the quality of services provided by NPCs under the auspices of task-shifting is a key component of WHO task-shifting guidelines [6]. To address these gaps in knowledge and inform policy, we aimed to document the scope of surgical practice of nonphysicians and to characterize outcomes after nonobstetric major surgical procedures performed by NPCs in one political region in Tanzania.

## Materials and methods

### Study sites

This study was conducted in the Pwani Region, located on the Eastern coast of Tanzania. Despite its proximity to Dar es Salaam, Pwani is one of the poorest regions in the country. According to estimates by the Tanzanian government, Pwani ranked 14th out of 21 regions in per-capita income in 2003 [9].

To allow for population estimates of surgical capacity, all seven district, regional, and mission hospitals in the six districts of the Pwani Region were included in the study. The study sites were Bagamoyo District Hospital, Kisarawe District Hospital, Mafia District Hospital, Mchukwi Mission Hospital (Rufiji district), Mkuranga District Hospital, Tumbi Special Hospital (Kibaha district), and Utete District Hospital (Rufiji district).

### Study design and data collection

First, basic hospital, workforce, and surgical capacity data were documented through hospital administrator interviews using an abridged version of the World Health Organization Tool for Situational Analysis to Assess Emergency and Essential Surgical Care [10]. Then, a retrospective records

review of all major surgical procedures (MSPs) performed in 2012 at the Pwani hospitals was conducted. A major surgical procedure was defined according to previous work by Weiser and colleagues as “any intervention occurring in a hospital operating theatre involving the incision, excision, manipulation, or suturing of tissue, usually requiring regional or general anesthesia or sedation” [11].

MSPs were identified in hospital operating theatre log books. Information was collected on patient age and gender, indication for and type of procedure, level of care provider performing the procedure, and type of anesthesia given for each MSP. Charts of patients undergoing non-obstetric MSPs were reviewed and post-operative outcomes data was recorded using a standardized form. The outcomes documented included readmission, reoperation, blood transfusion, wound infection, urinary retention, death, and others. Although considered an obstetric procedure by some, laparotomy for ruptured ectopic pregnancy was included in our outcomes analysis as performance of this procedure by NPCs has not been studied. Procedure and outcomes data were supplemented with information from hospital death records, death certificate receipts, ward admission, and discharge books. Information on mortality was collected as an in-hospital outcome, whereas occurrences of morbidity were collected up to 30 days postoperatively.

In our description of surgical cases performed, we included 31 procedures done as reoperations. We excluded these procedures in the outcomes analysis, including just one set of outcomes data per patient. We were able to accurately characterize in-hospital mortality for all patients undergoing nonobstetric MSPs during the study period ( $n = 1,667$ ). However, given poor record keeping at some of the sites, we were unable to obtain data on occurrences of postoperative morbidity in 16.4 % of cases. Therefore, 83.6 % of nonobstetric MSPs ( $n = 1,392$ ) were included in the final outcomes analysis.

### Level of care provider definitions

At the study sites, we found four levels of care providers performing surgeries: clinical officers (COs), assistant medical officers (AMOs), medical officers (MOs), and surgical specialists. For simplicity, we have included the surgical activity and outcomes data for both COs and AMOs under the broad category of nonphysician clinicians our results.

In Tanzania, COs are secondary school graduates who have completed 3 years of training and are qualified to practice medicine and perform minor surgeries [4]. Although they are not licensed to perform MSPs in Tanzania, COs were doing major surgery at one of the study sites. After several years of clinical service, high

performing COs are chosen to attend AMO school for 2 years [4]. AMO education includes training in common major obstetric and general surgical procedures, and AMOs are licensed to practice medicine and surgery in Tanzania [12].

MOs are physicians who have completed medical school and a year of internship but have not received specialty training in surgery. Specialists are physicians with formal residency training in a surgical specialty.

#### Statistical analysis

Patient and procedure characteristics for cases performed by NPCs and physicians were compared using a Student's *t* test and Chi squared test. Differences in outcomes after nonobstetric MSPs performed by NPCs and physicians were evaluated using a Chi squared test and Fisher's exact test when appropriate.

Multivariate logistic regression was used to compare postoperative outcomes between NPCs and physicians. The model was adjusted for morbidity and mortality risk factors, including age and gender, procedure complexity and urgency, hospital type, and anesthesia type. Patient and procedure factors that differed between the two provider groups also were adjusted for. Procedure complexity was graded on a scale of one (least complex) to three (most complex) according to a previously described methodology [13]. Hospitals were grouped into three categories for the "hospital type" variable: district (Bagamoyo, Kisarawe, Mafia, Mkuranga, and Utete), mission (Mchukwi), and regional (Tumbi). A *p* value of <0.05 was considered statistically significant. Data were analyzed using Stata version 12.1 (Statacorp LP College Station, TX, USA).

#### Ethical considerations

Ethical approval for this study was obtained from the Muhimbili University of Health and Allied Sciences Directorate of Research and Publications Committee. The Tanzania Commission for Science and Technology also approved the study, issuing a research permit to the principal investigator (JHB). The University of California San Francisco Committee on Human Research certified the study as exempt from full committee review. Informed consent was not obtained as no identifiable patient information was ultimately recorded.

## Results

The Pwani Region has a population of approximately 1 million people served by seven public and private hospitals (Table 1). In 2012, there were 6.5 surgical care providers

per 100,000 population in the region. Most of these providers were nonphysician clinicians. There were only five surgical specialists operating in Pwani: one general surgeon, one general and pediatric surgeon, two obstetrician/gynecologists, and one expatriate orthopedic surgeon. We found no specialists working at the district level hospitals. There were no medical doctors delivering anesthesia care at the sites and no trained anesthesia provider on the island of Mafia, the most remote districts in Pwani.

During the study period, a total of 4,894 major surgical procedures were performed. The average annual surgical output was 461 procedures per 100,000 population. Of the major surgical cases, 34.7 % (1,698/4,894) were nonobstetric MSPs. NPCs performed 55.8 % (948/1,698) of all nonobstetric MSPs followed by surgical specialists (28.7 %, 587/1,698) and medical officers (15.5 %, 263/1,698).

Table 2 summarizes patient and procedure information by level of care provider for the 1,698 nonobstetric MSPs performed during the study period. Patients undergoing nonobstetric MSPs performed by NPCs were older and more likely to be men than patients operated on by physicians (*p* < 0.0001 for both). Physicians more commonly operated on children and performed cases as emergencies (*p* < 0.0001 for both). While most patients received spinal anesthesia, cases done by NPCs were more likely to be performed under general anesthesia (*p* < 0.0001). There was no difference in the average complexity of procedures performed by both provider groups.

As demonstrated in Fig. 1, nonphysician clinicians performed the majority of nonobstetric MSPs at the district level hospitals (87.1 %, 535/614) and at the mission hospital (67.2 %, 352/624). Specialists were the predominant operators at the regional hospital, where they performed 75.2 % (421/560) of cases. Medical officers had varying degrees of surgical responsibility at the different hospitals; they were most active at the mission hospital, where they performed 24.8 % (130/524) of the cases.

The most common operations done by NPCs in Pwani are illustrated in Fig. 2. Elective hernia repair was the most common procedure followed by prostatectomy, exploratory laparotomy, hydrocelectomy, and emergency hernia repair. NPCs performed the majority of these common cases: 81.8 % (225/275) of elective hernia repairs, 69.5 % (157/226) of prostatectomies, 53.2 % (106/199) of exploratory laparotomies, 77.2 % (105/136) of hydrocelectomies, and 81.2 % (77/94) of emergency hernia repairs. All of the prostatectomies were done at Mchukwi mission hospital, which is an unofficial specialist center for this procedure in the region. Ruptured ectopic pregnancy was the indication for the majority of exploratory laparotomies (83.0 %). Only 13 trauma laparotomies were done during the study period.

**Table 1** Hospital characteristics, human resources, and surgical cases in Pwani Region, 2012

District	Population	Beds	Surgical care providers			Surgical care providers (per 100,000 population)	Anesthesia providers	Number of MSPs	Number of nonobstetric MSPs (% of total MSPs)
			NPCs	MOs	Specialists				
Bagamoyo	248,328	125	11	0	0	4.4	1	832	216 (26)
Kibaha	255,826	158	4	6	4	5.5	4	1,715	560 (32.7)
Kisarawe	101,638	150	8	5	0	12.8	2	305	122 (40)
Mafia	42,870	74	3	2	0	11.7	0	171	31 (18.1)
Mkuranga	193,170	112	7	4	0	5.69	4	637	115 (18)
Rufiji	218,980					6.84			
Utete		72	9	2	0		4	399	130 (32.6)
Mchukwi		100	2	1	1		2	835	524 (62.8)
Total	1,060,812	791	44	20	5	6.5	17	4,894	1,698 (34.7)

Source Ref. [9]

NPC nonphysician clinician, MO medical officer, MSP major surgical procedure

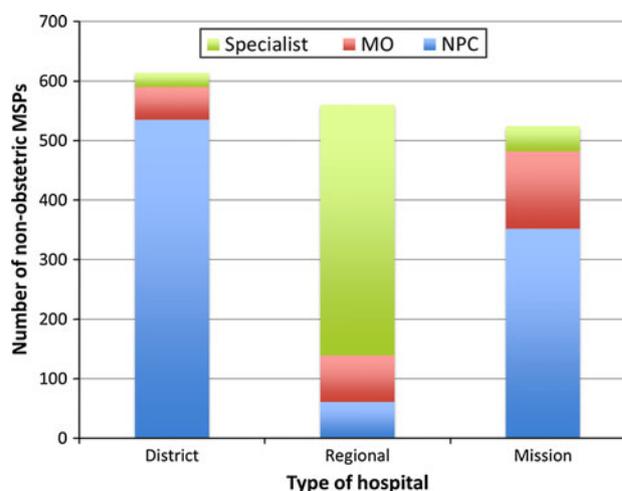
**Table 2** Patient and procedure characteristics by level of care provider for nonobstetric MSPs

	NPC (n = 944)	Physician (n = 750)	p value
Mean age (range)	48 (1–100)	40 (0–100)	<0.0001
Pediatric <16 years (%)	48 (5.1)	71 (9.5)	<0.0001
Gender			
Male (%)	617 (65.4)	336 (44.8)	<0.0001
Emergent cases (%)	278 (29.4)	286 (38.1)	<0.0001
Mean procedure complexity score (SD)	1.55 (0.52)	1.57 (0.51)	0.55
Type of anesthesia			
Spinal (%)	548 (58.1)	532 (70.1)	<0.0001
General (%)	259 (27.4)	140 (18.7)	<0.0001
Local (%)	43 (4.6)	21 (2.8)	0.062

MSP major surgical procedure, NPC nonphysician clinician, Physician medical officer or surgical specialist, SD standard deviation

Results of the outcomes analysis for all nonobstetric MSPs are presented in Table 3. The most common adverse events along with a composite variable, including all occurrences of morbidity, are included in the table. In-hospital mortality rate was 1.7 % and 1.5 % after cases done by NPCs and physicians respectively. There was an increased risk of wound infection in the patients operated on by NPCs in univariate analysis ( $p = 0.019$ ). However, this difference was not statistically significant in our multivariate logistic regression model. There was no difference in the occurrence of other adverse events, including death, between the two groups in either univariate or multivariate analysis.

The subgroup analysis of outcomes after the five most common procedures performed by nonphysicians revealed

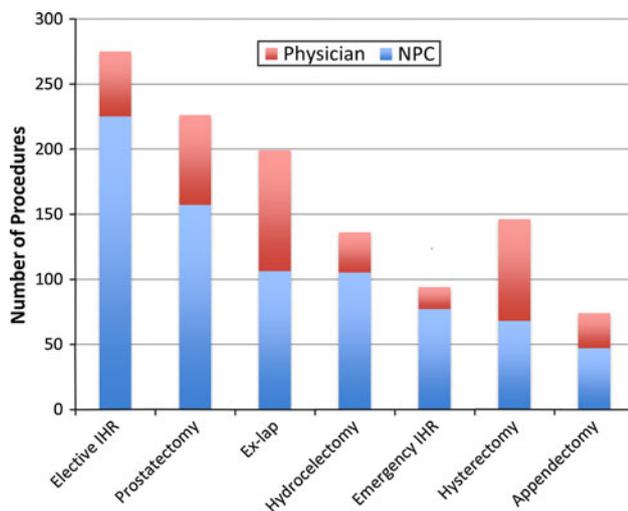


**Fig. 1** Non-obstetric major surgical procedures by level of provider. MSP major surgical procedure, District Hospitals Bagamoyo, Kisarawe, Mafia, Mkuranga, Utete. Regional Hospital Tumbi Regional Hospital, Mission Hospital Mchukwi

no difference in rates of morbidity and mortality after procedures done by NPCs compared with physicians (Table 4). The procedure with the highest incidence of mortality was exploratory laparotomy at 7.1 % in NPC cases and 6.8 % in physician cases. Approximately one-third of patients undergoing prostatectomy and exploratory laparotomy experienced some type of morbidity in both provider groups.

## Discussion

To our knowledge, this is the first study in Tanzania to document the surgical output in an entire region. Our



**Fig. 2** Common non-obstetric MSPs performed by NPCs. *MSP* major surgical procedure, *NPC* nonphysician clinician, *Physician* medical officer or surgical specialist, *IHR* inguinal hernia repair, *Ex-lap* exploratory laparotomy for acute abdomen or abdominal trauma

**Table 3** Adverse events after nonobstetric MSPs performed by NPCs and physicians

Adverse event	NPCs (%)	Physicians (%)	Adjusted OR (95 % CI) <sup>a</sup>
Wound infection	75 (9.9)	41 (6.4)	0.81 (0.5, 1.31)
Anemia requiring blood transfusion	43 (5.7)	43 (6.8)	0.98 (0.53,1.79)
Reoperation	27 (3.6)	16 (2.5)	1.15 (0.51, 2.6)
Readmission	22 (2.9)	21 (3.3)	0.56 (0.24, 1.33)
All morbidity <sup>b</sup>	111 (17.4)	144 (19)	0.89 (0.62, 1.3)
Death <sup>c</sup>	16 (1.7)	11 (1.5)	0.73 (0.25, 2.1)

*MSP* major surgical procedure, *NPC* nonphysician clinician, *OR* odds ratio, *CI* confidence interval

<sup>a</sup> Multivariate logistic regression model adjusted for patient age and gender, procedure complexity and urgency, hospital type, anesthesia type. Physician group served as referent

<sup>b</sup> For morbidity events,  $n = 1,392$

<sup>c</sup> For death,  $n = 1,667$

results indicate that the volume of surgery in the Pwani region is very low. We found an annual output of major surgery in the region of 461 cases per 100,000 population during the study period compared with an average of 11,110 MSPs performed each year in wealthy countries [11]. Our estimate of surgical output in Tanzania is somewhat lower than recent surgical volume calculations in neighboring Uganda (652 operations per 100,000 population per year) [14]. Based on our findings, we conclude that many patients are missing the opportunity for life-saving surgery in Tanzania.

The surgical workforce in Pwani is limited. Including nonphysicians, we found just 6.5 surgical care providers

**Table 4** Morbidity and mortality after common non-obstetric MSPs performed by NPCs and physicians

Procedure	Adverse event <sup>a</sup>	NPCs (%)	Physicians (%)	<i>p</i> value
Elective IHR	Morbidity	23 (13.4)	5 (12.5)	0.883
	Death	2 (0.9)	1 (2.0)	0.454
Prostatectomy	Morbidity	45 (31.2)	19 (29.2)	0.769
	Death	2 (1.3)	1 (1.4)	1.000
Exploratory Laparotomy	Morbidity	28 (35.4)	26 (34.7)	0.92
	Death	7 (7.1)	6 (6.8)	0.931
Hydrocelectomy	Morbidity	17 (22.4)	5 (21.7)	0.949
	Death	0 (0)	0 (0)	none
Emergency IHR	Morbidity	6 (9.5)	2 (13.3)	0.614
	Death	3 (3.9)	0 (0)	1.000

*MSP* major surgical procedure, *NPC* nonphysician clinician, *IHR* inguinal hernia repair

<sup>a</sup> For morbidity events,  $n = 1,392$ . For death,  $n = 1,667$ . See “Materials and methods” for further information

per 100,000 population in the region during the study period. According to estimates by the American College of Surgeons, practitioners performing similar procedures in the US amount to 30.6 providers per 100,000 population [2]. While the surgical workforce is certainly lacking in Tanzania, our figures suggest that the crisis may not be as bleak as previously thought. Including NPCs in our calculation of available surgical care providers resulted in a 46-fold increase in our workforce capacity estimations compared to previous calculations of surgeon supply in Tanzania [1].

Most of the major surgical procedures performed during the study period in Pwani were cesarean sections, a finding consistent with previous literature [15]. However, the number of nonobstetric MSPs done was not insignificant. Our results provide evidence that nonphysicians play an important role in the delivery of both obstetric and non-obstetric surgical care in Tanzania.

Our study represents the first comprehensive description of common nonobstetric MSPs performed by NPCs at different types of hospitals in a low-resource setting. We found that NPCs were most active in the district and mission hospitals in Pwani, whereas surgical specialists more commonly operated at the regional referral center. In addition, NPCs tended to perform relatively simple, essential surgical procedures including hernia repair and hydrocelectomy, although they also commonly did more specialized or complex procedures like prostatectomy and exploratory laparotomy. Interestingly, the complexity of cases performed by NPCs and physicians was similar.

Outcomes after nonobstetric MSPs were quite good in Pwani during the study period, with an in-hospital post-operative mortality rate of less than 2 % overall. Death

after emergency inguinal hernia repair occurred in 3.1 % of patients, which is notably lower than reported mortality rate of 21 % of this procedure in Nigeria [16]. These findings suggest that NPCs and physicians are generally operating within a safe scope of practice in Pwani, likely referring difficult cases to a higher level of care. Though we did note a significant number of patients transferred from Pwani to the national hospital in Dar es Salaam for emergency surgical care during data collection, we were unable to capture any data on these patients due to our study design. Further investigation is needed to characterize the outcomes of transferred patients to get a more complete picture of surgical outcomes in Pwani.

In our review of the literature, we found just one article that examined outcomes after nonobstetric major surgery performed by NPCs in a low-income country [17]. In this study, Wilhelm and colleagues compared perioperative outcomes for three procedures (ventriculo-peritoneal shunt placement, prostatectomy, and repair of strangulated hernia) retrospectively over a 5-year period at a major referral and teaching hospital in Malawi. The authors found no difference in outcomes after procedures performed by NPCs and surgeons.

The results of our study are more generalizable to other low-income contexts than the previous work by Wilhelm and colleagues, because we included all public and private hospitals in one political region of Tanzania [17]. This methodology allowed for a more complete view of the surgical activity of NPCs and in turn a more robust comparison of postoperative outcomes after procedures performed by non-physicians. More research is needed to characterize the most effective training modalities for NPCs in surgery and to define the safest scope of surgical practice for nonphysicians to optimize patient outcomes.

An adequate and well-trained workforce is not the only piece in the puzzle. During our review of patient charts and hospital records, we found that infrastructure and supplies at the Pwani hospitals were severely lacking. Patients often were discharged from the hospital or transferred to another facility, because there was no operating room equipment or supplies, including a working anesthesia machine, sterile gowns, and medications. Any training program of NPCs must be accompanied by hospital infrastructure development to ensure patient access to safe surgery in this setting.

The findings of our study have important implications for the discussion of surgical workforce needs in Tanzania, sub-Saharan Africa, and beyond. While nonphysician clinicians are currently filling the gap in surgical provider supply in Tanzania, this fact does not discount the role of surgical specialists in LMICs. Trained surgeons will always be needed to perform highly complex procedures, make informed clinical decisions, and educate and

supervise surgical care providers in-training, including physicians and NPCs. Ideally, surgical specialists would oversee and mentor NPCs in their surgical practice, although this model is not feasible with Tanzania's current surgeon supply situation.

The precise workforce mix of physicians, NPCs, nurses, and other support staff required to optimize health care system efficiency is unstudied and likely varies by context. Further research in this area is needed to identify long-term solutions for the surgical workforce crisis in low-resource settings. We forecast that NPCs will continue to play an important role in the delivery of surgical care in Tanzania for years to come. In fact, NPCs are closely involved in the delivery of surgical care in high-income countries, providing anesthesia and abortion care safely in the United States without physician oversight [18, 19]. We hope our study will serve to further inform the debate regarding appropriate NPC scope of practice both in both low and high-resource settings.

Our study has limitations related to its retrospective design. Although we were able to collect data on in-hospital mortality for all patients undergoing MSPs, we were missing other outcomes data on approximately 16 % of patients. We found relatively poor record keeping at most of the sites, which may have resulted in an underreporting of patient complications, such as wound infection and readmission. In some cases, a separate patient chart was opened for each readmission event, resulting in missing data on adverse events when only the primary chart was available for review. In addition, some patients may have sought care for postoperative complications at another health facility or not at all, which would have resulted in further underestimation of morbidity. Finally, limited follow-up prevented us from investigating important outcomes related to the quality of surgical care, such as inguinal hernia recurrence.

Because we accounted for variations in hospital record keeping by adjusting for hospital type in our multivariate model, we believe that the missing data and potential underreporting of morbidity does not bias the results of our outcomes analysis. Nevertheless, our retrospective design strongly limits the accuracy of our reported incidence of adverse events. There is no doubt that we have underestimated the rate of postoperative morbidity after procedures done by both NPCs and physicians in Pwani Region, Tanzania. In addition, we have reported in-hospital mortality data only and thus remain unable to draw conclusions about more long-term postoperative outcomes after procedures done by NPCs. Further investigation is needed, likely with a prospective study design, to define more accurately rates of morbidity and mortality after operations done by NPCs and physicians.

## Conclusions

We have shown that nonphysician clinicians play a key role in the delivery of major surgery in Tanzania. Our data suggest, at least preliminarily, that NPCs can safely perform common and in some cases complex surgery with good outcomes in rural Africa. The training of nonphysicians to perform essential surgery may be a safe and sustainable solution to the global workforce crisis in surgery.

Steps should be taken to develop global policy regarding surgical task-shifting. Under the guidance of the World Health Organization, other low-resource countries could follow Tanzania's lead and consider initiating or strengthening existing task-shifting programs to meet surgical need. Local Ministries of Health should work to define the surgical duties of NPCs more clearly to ensure they continue to operate within a safe scope of practice in Tanzania. An official training and credentialing system for NPCs in general surgery, similar to advanced programs for assistant medical officers in radiology and anesthesia already in place in Tanzania, would be one option to ensure a consistent level of competency among these important practitioners of surgical care. Monitoring and reporting of the quality of surgical care delivered by NPCs should be the cornerstone of any surgical task-shifting program.

**Acknowledgments** We received funding for this project from the UCSF Department of Surgery.

**Conflict of interest** JHB, LBO, LA, AM, CAM, and RAD have no conflicts of interest to disclose.

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