Novel application of existing tools to define the training needs of surgical teams in low resource settings

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Abstract

Background

Global surgery has developed rapidly from being the "neglected stepchild of global health" to now being a burgeoning academic field with internationally accepted metrics for benchmarking performance and to measure progress alongside an evolving ethical structure to address the social injustices in healthcare. However, in order to ensure that training initiatives are appropriate to the context they are delivered in, the burden of surgical disease, the surgical workforce and the learning needs of the workforce must be identified. Low resource settings are the most frequently affected by humanitarian disasters and increasingly provide the majority of the workforce to humanitarian medical organisations (HMOs). Despite this, the term 'humanitarian surgery' is yet to be defined

Methods

The Synthesis Without Meta Analysis (SWIM) methodology was used to conduct a systematic review to define the burden of surgical disease in low- and middle-income countries (LMICs) using Disability Adjusted Life Years (DALYs). The SWIM methodology was again used to conduct a second systematic review investigating the surgical workforce gap in LMICs using the density of surgical, obstetric and anaesthesia providers per 100,000 population (SAO density).

Using the Hennessy-Hicks Training Needs Analysis (TNA) questionnaire as a basis, a bespoke questionnaire was designed and delivered as an online survey across two study locations in Africa; Somaliland and South Africa in collaboration with partner organisations. This mixed-methods survey collected quantitative and qualitative data and allowed respondents to identify key areas of learning needs and offer suggestions as to how novel technologies could be used to address these needs. A secondary aim was to validate this novel TNA questionnaire to encourage its use in similar contexts in future.

Finally, an international, collaborative study was designed using Delphi methodology to reach consensus on the term 'humanitarian surgery'.

Results

Systematic review 1 revealed a vast, and growing burden of surgical disease and highlighted an ongoing trend of increased disease burden from non-

communicable diseases. Systematic review 2 demonstrated the global shortage of the surgical workforce and highlighted the inequitable distribution of the existing workforce. Both studies highlighted the additional inequity of academic interest, as South East Asia was the focus of 9% and 12% of studies respectively, despite representing nearly 25% of the global population. This 3-dimensional lack of equity creates structural imbalances within global health and must be addressed by the international community

The TNA received responses were received from 69 Surgical Providers (SPs) and 41 Anaesthesia Providers (APs) in Somaliland. Responses highlighted ongoing concerns with access to reliable oxygen monitoring in the operating theatre environment and that a majority of SPs used the WHO Surgical Safety Checklist infrequently. The performance of emergency cricothyroidotomy was reported as an area of concern by APs. Mixed training and organisational improvements were desired in every skill, highlighting the importance of wider surgical system strengthening rather than focussing on improving training alone. In Somaliland there was desire to see a greater use of technology in improving communication with patients and colleagues and to improve patient outcome data recording. There was minimal appetite for more advanced use of technology such as tele-proctoring.

Responses were received from 59 General Surgeons in South Africa. Overall, the surgeons surveyed felt their training programme prepared them well for clinical practice. Access to technology for use of and training in minimally invasive surgery (MIS) was a key recurring theme amongst respondents. The qualitative analysis also demonstrated that non-technical skills training was an important theme. This highlights that any training intervention or training programme must ensure the wider development beyond the development of technical skills.

During the Delphi study to define humanitarian surgery, 107 responses were received from 34 separate countries, generating 25 initial statements. Ten statements met the pre-defined criteria for agreement and consensus and were included in the final definition.

Conclusions

The burden of surgical disease and the extent of the global surgical workforce crisis have been highlighted in addition to the unequal allocation of academic research creating a 3-dimensional lack of equity. The novel application of the HH

TNA has been demonstrated to be useful and practical across different cultural, political and geographic boundaries and it can collect meaningful data. This data can be used in combination with other complimentary data sources such as the Global Burden of Disease (GBD) study and workforce surveys such as the WHO Situational Analysis Tool (SAT) to give a holistic view of the healthcare needs of the local population as well as the density, and training needs, of the local surgical workforce. Further modifications in the application of the HH TNA could also generate long-term data, for example by conducting before and after surveys to measure the impact of any training intervention.

Finally, achieving international consensus on the definition of humanitarian surgery facilitates comparison of activity against international standards and enables meaningful data collection and ensures that those who are most likely to be affected by sudden onset disasters, and are most likely to provide the workforce to respond, have their voices represented in defining and standardising this sphere of global health.

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Glossary

Anaesthetist - a specialist physician with formal post-graduate qualification in anaesthesia.

Anaesthetic provider - any health worker providing anaesthesia

Bellwether procedures – Any procedure involving laparotomy, cesarean section, or treatment of an open long bone fracture

DCP – Disease control priorities

EMT – Emergency medical teams

ESP - Essential surgical procedures

GBD – Global burden of disease study

Global North – North America, Europe, Israel, Japan, South Korea, Australia and New Zealand.

Global South – Africa, Latin America and the Caribbean, Asia (excluding Israel, Japan and South Korea) and Oceana (excluding Australia and New Zealand).

GPSP - General physician surgical provider: a physician providing surgical care but without a formal post-graduate surgical qualification.

GPAP - General physician anaesthesia provider: a physician providing anaesthesia but without a formal post-graduate surgical qualification.

GRADE – Grading od Reccomendations, Assessment, Development and Evaluation framework.

GSPU – Global Surgery Policy Unit, a collaboration between the Royal College of Surgeons of England and the London School of Economic and Political Science

HIC - High income country

HMO – Humanitarian Medical Organisation

JBI – Joanna Briggs Institute

LCoGS – Lancet Commission on Global Surgery

LSE – London School of Economics and Political Science

MDG – Millennium Development Goals

NGO – Nongovernmental organisation

NPAP - Non-physician anaesthesia provider: a non-physician health worker providing anaesthesia.

NPSP - Non-physician surgery provider: a non-physician health worker providing surgery.

NSOAP – Nationals surgical, obstetric and anaesthetic plan

OBGYN - Obstetrician/Gynaecologist: a specialist physician with formal post-graduate obstetric and/or gynaecological qualification.

POMR – Post-operative mortality rate, expressed as a percentage

RCS Eng – Royal College of Surgeons of England

SAO density – Density of specialist surgical, anaesthetic and obstetric physicians per 100,000 of the population

SAO provider - any healthcare worker providing surgical, anaesthetic, or obstetric care.

SDG – Sustainable development goals, from 2015 onwards

SDI – Sociodemographic index

Surgical care - provision of perioperative and operative and non-operative management of surgical conditions

Surgical provider - any health worker providing surgery

Surgeon: a specialist physician with formal post-graduate surgical qualification.

Task-shifting – delivery of surgical or anaesthetic procedures by individuals with shorter training and fewer qualifications than specialist physicians

Task-sharing – the delivery of surgical or anaesthetic procedures by inidivudals with shorter training and fewer qualifications than specialist physicians in addition to the delivery of the same procedures by specialist physcians

UCES – Universal coverage of essential surgical procedures

UHC – Universal health coverage

UN - United Nations

LMIC – Low- and middle-income country

WHA – World Health Assembly

WHO – World Health Organization

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This thesis is also dedicated to the memory of Dr Ahmed Almaqadma, a devoted, professional and caring surgeon, fully committed to the care of his patients, who was a member of the Royal College of Surgeons of England's Humanitarian Surgery Initiative and tragically killed in Gaza in March 2024.

Most importantly, to my parents and my partner Jasmine – thank you for your unwavering support and belief.

"With rare exceptions, all of your most important achievements on this planet will come from working with others—or, in a word, partnership."

Dr Paul Farmer

Chapter 1 - Introduction

"Surgery is an indivisible, indispensable part of health care and of progress towards universal health coverage"(1)

1.0 Global Health

Global health has been described as one of the defining issues of the 21st century.(2) However, despite widespread interest in the field for many decades, it was not until 2009 that Koplan and colleagues offered a now widely accepted definition of the term: "an area for study, research, and practice that places a priority on improving health and achieving health equity for all people worldwide". Multiple other authors have also offered definitions to describe this complex interaction between public health, policy, research and advocacy.(3)

In 2005 the United Nations published the 'Millennium Development Goals' (MDGs) as part of a focussed effort to reduce poverty and improve health amongst the worlds' poorest by 2015.(4) These time bound goals set out to mobilise the world to achieve the following:

1. Eradicate extreme poverty and hunger
2. Achieve universal primary education
3. Promote gender equality and empower women
4. Reduce child mortality
5. Improve maternal health
6. Combat HIV/AIDS, malaria and other diseases
7. Ensure environmental sustainability
8. Global partnership for development

These MDGs highlight the inextricable relationship between health, education and economic development, however, only 'reducing child mortality' and 'improving maternal health' can be argued to be directly relevant to surgical care. The MDGs were very successful in combatting communicable diseases, but were criticised for taking a ‘vertical approach’ targeting specific infectious diseases rather than a more ‘horizontal’ and intersectoral approach to improving health systems.(5) In 2015 these MDGs were replaced with the ‘Sustainable Development Goals’ (SDGs) – see Figure 1, which produced a set of focussed targets to be achieved by 2030.(6) These 17 high level goals were broken down into specific indicators, with SDG 3 representing ‘Good health and well-being’.

Figure 1-1*. The Sustainable Development Goals*

The specific indicators from SDG 3 ‘Good health and well-being’ are displayed in Table 1 below. Targets 3.1 ‘reduce maternal mortality’, 3.2 ‘end all preventable deaths under 5 years’, 3.4 ‘reduce mortality from non-communicable disease’ and 3.6 ‘reduce road injuries and death’ are all directly applicable to global surgical care.

Table 1-1. Targets within SGD 3 'Good health & well-being'.

No.	Target	Detail
3.1	Reduce maternal mortality.	By 2030, reduce the global maternal mortality ratio to < 70/100,000 live births.
3.2	End all preventable deaths < 5 years.	By 2030, end preventable deaths of newborns and children <5, with all countries aiming to reduce neonatal mortality to 12/100,000 live births, and <5 mortality to <25/100,000 live births.
3.3	Fight communicable diseases.	By 2030 end epidemics of AIDS, tuberculosis,, malaria, and others.
3.4	Reduce mortality from non-communicable diseases and promote mental health.	By 2030, reduce by 1/3 premature mortality from non-communicable diseases through prevention and treatment and promote mental health and well-being.
3.5	Prevent and treat substance abuse.	Strengthen the prevention and treatment of substance abuse, including narcotic drug abuse and harmful use of alcohol.
3.6	Reduce road injuries and deaths.	By 2020, halve the number of global deaths and injuries from road traffic accidents.
3.7	Universal access to sexual and reproductive care, and family planning and education.	By 2030, ensure universal access to sexual and reproductive health-care services, including for family planning, information and education, and the integration of reproductive health into national strategies and programmes.
3.8	Achieve universal health coverage	Achieve universal health coverage, including financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.
3.9	Reduce illness and death from hazardous pollution	By 2030, substantially reduce the number of deaths and illnesses from hazardous chemicals and air, water and soil pollution and contamination.

1.1 Global Surgery

Global surgery is a more recent field within global health, and was described in 2008 as “the neglected stepchild of global public health” by Farmer & Kim.(7) The authors reported that over 500,000 women die each year in childbirth from peri-partum complications, many of which are treatable by surgical care.(7) Lack of workforce was one clear problem, however more complicated was the inequitable access to surgical care highlighted, as in many low income countries surgical services are often found exclusively in urban settings and only available to those who can pay.(7) The authors also highlighted that international health organisations had been focussed on successfully targeting communicable disease, at the expense of strengthening surgical systems. A lack of surgeons involved in global health was also identified as an issue, alongside the inherently complex task of improving surgical systems when compared to the more straightforward interventions of vaccinations and mosquito nets.(7) The success of the MDGs in combatting individual infectious diseases highlighted the importance of specific, attainable and timebound goals, however surgical systems were neglected by the global health community.

To bring more focus on surgical care within global health, Dare and colleagues offered a common definition in 2014; “global surgery is an area of study, research, practice, and advocacy that seeks to improve health outcomes and achieve health equity for all people who require surgical care, with a special emphasis on underserved populations and populations in crisis. It uses collaborative, cross-sectoral, and transnational approaches and is a synthesis of population-based strategies with individual surgical care.”(8) Importantly, this definition includes those from chronically underserved populations and those in acute crises – an area that will be further explored as part of this study.

Agreeing on a common definition enabled target setting, prioritisation, communication of targets and resource allocation.(9) Additionally, this definition provided focus to the academic and political communities to act as a catalyst to action.

1.2 Lancet Commission on Global Surgery

Farmer & Kim’s intervention helped spur the development of global surgery as a specialist field of its own right and led to the Lancet Commission on Global Surgery (LCoGS), an international project that began in 2013 and was published in 2015 to coincide with the release of the SDGs.(10) The LCoGS had 5 key messages:

1. Five billion people do not have access to safe, affordable surgical and anaesthetic care when needed. This is worse in low- and middle-income countries (LMICs), where 90% of the population cannot access basic surgical care.

2. An extra 143 million surgical procedures are needed in LMICs every year. Only 6% of surgical procedures worldwide take place in the poorest countries, despite accounting for one third of the world's population. Low operative volumes are associated with high case-fatality rates and the need is greatest in sub-Saharan Africa and Asia.

3. Thirty-three million individuals face catastrophic expenditure to pay for surgical and anaesthetic care. An additional 48 million individuals face catastrophic expenditure due to the non-medical costs of accessing surgical care. This burden falls most heavily on those in LMICs, and within every country affects the poorest individuals most commonly.

4. Investing in surgical services in LMICs is affordable, saves lives and promotes economic growth. It is estimated that if all LMICs were to scale up to the level of the best performing LMICs, two-thirds of countries would be able to reach the 5000 surgical procedures per 100,000 population minimum suggested standard by 2030. Failing to do this is estimated to cost $12.3 trillion in lost economic productivity by 2030.

5. Surgery is an "indivisible, indispensable part of health care".(1) Surgical services are a prerequisite to achieve global health goals in areas such as cancer, injury, cardiovascular disease, infection, and reproductive, maternal, neonatal and child health.

The 5 key messages of the LCoGS lead to a renewed focus on surgery within global health and additionally added 6 core indicators for monitoring of universal access to safe and affordable surgical anaesthetic care – see Table 2. These 6 indicators enabled all countries to effectively monitor their performance and compare this against an internationally agreed standard to monitor progress. This provided the theoretical framework to develop National Surgical, Obstetric and Anaesthetic Plans (NSOAPs) – core policy documents that each country could develop to give a roadmap to strengthen their surgical healthcare system.(5) One of these metrics, the density of specialist surgical workforce (SAO density) will be explored further in chapter 3.

Importantly, the World Health Organization (WHO) adopted the LCoGS postoperative mortality rate (POMR) metric as one of the 100 key health indicators to be monitored and reported by all member states, and the World Bank adopted the LCoGS core indicators into its World Bank Development Indicators data set.(11,12) The World Health Assembly (WHA) also passed a resolution unanimously emphasising the essential role of surgery and anaesthesia in universal health coverage (UHC).(13) These indicators were further updated in 2021 to improve clarity and explicitly define each indicator to improve comparability – also in Table 2.(14)

In the same year, The World Bank published the 3rd edition of the Disease Control Priorities (DCP3) – a publication that seeks to inform resource allocation at the international and national level by providing a comprehensive review of the effectiveness, cost, and cost-effectiveness of the highest priority health interventions. This 3rd edition was the first to contain a volume focussed entirely on surgery.(15) Importantly DCP3 identified 44 surgical procedures that addressed substantial need, are cost effective and are feasible to implement in LMICs – the 'essential surgical procedures'.(15)

A key message from the DCP3 was that provision of these essential surgical procedures world avert an estimated 1.5 million deaths per year and that these procedures rank among the most cost-effective of all health interventions. The WHO 1st level hospital was considered highly cost effective as these facilities can provide access to 28 out of the 44 essential surgical procedures, and therefore recommended as the priority for investment over larger and typically more urban 2nd or 3rd level facilities. Furthermore, task sharing (the process of non-physician clinicians taking on surgical or anaesthetic procedures) was shown to be a safe and effective way to expand the surgical and anaesthetic workforce. The cost of universal coverage of essential surgery (UCES) at the 1st level hospital was estimated to be over $3 billion additional spend annually, however would likely yield a benefit: cost ratio of greater than 10:1.(15)

Table 1-2. Lancet Commission on global Surgery core indicators with definition, minimum targets and 2021 updates to the definitions.

Indicator	Definition	Target	2021 Revision
Access to timely essential surgery	Proportion of population that can access, within 2 hours, a facility that can perform the Bellwether procedures*	Minimum of 80% per country by 2030	Proportion of a country's population with geographic access (within 2 hours) to a facility capable of providing surgical and anaesthesia care for the Bellwether procedures*
Specialist surgical workforce density	Number of specialist surgical, anaesthetic and obstetric physicians per 100,000 population.	100% of countries with >20 surgical, anaesthetic and obstetric physicians per 100,000 by 2030.	Number of each of surgery, obstetric, or anaesthesia providers who are actively practicing, per 100,000 population
Surgical volume	Procedures performed in an operating theatre (OT), per 100,000 population per year.	80% of countries by 2020 and 100% of countries by 2030 tracking volume; minimum of 5000 procedures/100,000 by 2030.	Number of surgical procedures done in an operating theatre using any form of anaesthesia, per 100,000 population per year
Perioperative mortality	All-cause death rate before discharge in patients who have undergone a procedure in an OT, divided by the total number of procedures, presented as a percentage.	80% of countries by 2020 and 100% of countries by 2030 tracking perioperative mortality.	Deaths from all causes, before discharge (up to 30 days), in all patients who have received any anaesthesia for a procedure done in an operating theatre, divided by the total number of procedures, per year, expressed as a percentage.
Protection against impoverishing expenditure	Proportion of households protected against impoverishment from direct out-of-pocket payments for surgical and anaesthesia care.	100% protection against impoverishment from out-of-pocket payments for surgical and anaesthesia care by 2030.	Removed.
Protection against catastrophic expenditure	Proportion of households protected against catastrophic expenditure from direct out-of-pocket payments for surgical and anaesthetic care.	100% protection against catastrophic expenditure from out-of-pocket payments for surgical and anaesthesia care by 2030.	Percentage of the population at risk of catastrophic expenditure if they were to require a surgical procedure

*Bellwether procedures; caesarean delivery, laparotomy, surgical management of open long bone fractures.

1.3 Ethical global surgery

The rise in popularity of global surgery, particularly since the publication of the LCoGS in 2015, has seen a corresponding rise in the academic and political interest in the field. Academic institutions offering global surgery courses, degrees and research opportunities have proliferated. Concerns have also been raised about the questionable ethical practices of some actors within the field and, there are lingering connections of global health and 'tropical medicine' to the European colonies of the 19th and 20th centuries. The establishment of prestigious academic institutions, almost exclusively based in the 'Global North' are still powerful actors in global health today.(16) This has led to movements to 'de-colonise' global health and, by extension, global surgery.(16)

Additional concerns have been raised on 'parachute' and 'parasite' researchers in global health research. These are described as researchers "who drop into a country, makes use of the local infrastructure, personnel, and patients, and then go home and write an academic paper for a prestigious journal."(17) These concerns were highlighted by an satirical editorial in the BMJ Global Health by Desmond Jumbam; 'how (not) to write about global health', describing a number of recurring mistakes made by global health researchers form the Global North when conducting research in low- or middle-income countries (LMICs).(18) Despite improved attempts for more equitable collaborations, a recent systematic review highlighted the issue of authors from LMICs being 'stuck in the middle' of authorship groups and rarely in the more prestigious first or last author position.(19)

1.4 Humanitarian medicine

The ethical concerns above can be even more acute in humanitarian settings, with reports of 'neo-colonialism' or 'surgical safaris' leading to Welling and colleagues to describing the 'seven sins of humanitarian medicine'.(20) Ensuring quality of surgical care in these environments is challenging, especially as humanitarian programmes are often set up within days of a sudden onset disaster (SOD) or due to conflict.(21) Measuring and benchmarking the quality of care is made even more difficult by the paucity of reported data, the various terms used to describe these programmes, and conflating these terms with charitable surgical missions.(22,23) There have been over 45 different terms to describe short-term charitable surgical missions in published global surgical literature – adding to the difficulty in standard setting and benchmarking quality.(24–27)

The international response to the earthquake in Haiti in 2010 highlighted the problem when well-intentioned care is delivered poorly. The official WHO report into the response described over 400 separate non-governmental organisations (NGOs) in operation in Haiti and described a number of these NGOs as “ill-prepared, in some cases incompetent.”(28) Van Hoving and colleagues described seeing an influx of “disaster tourists” and concluded that “the medical fraternity should hang it’s head in shame’”.(29)

Due to the chaotic response seen, the WHO launched the Emergency Medical Teams (EMT) initiative, in an effort to professionalise the humanitarian response sector. The WHO now maintains a register of EMTs stratified according to their capabilities, once they have proven that they meet the WHO’s prescribed minimum technical standards.(30–32)

Although the humanitarian principles have been well defined, there is no agreed definition of ‘humanitarian surgery’.(33) This prevents evaluation of many humanitarian activities due to the varying terminology used to describe and report them. This issue will be addressed in Chapter 7 of this thesis, where an international Delphi process will be used to achieve consensus on the term.

1.5 Global health & the military

The involvement of military organisations in global health and humanitarian medicine is contentious. This is in part due to the concerns from humanitarian medical organisations (HMOs) that military organisations do not, and cannot, meet the key humanitarian principles; the military links to ‘colonial tropical medicine’; and to their core role in conflict.(33) However as Michaud and colleagues reported, many countries are showing an increasing willingness to use militaries in support of global health efforts and concluded that “the key question is not whether militaries should be involved in global health but rather how to ensure military engagement is appropriate, constructive, effective, and co-ordinated with other actors.“(34)

The co-ordinated civilian-military response to the battle for Mosul in 2018 offers an intriguing case study of how greater civilian-military collaboration can be achieved in austere circumstances. Using military principles of ‘echelons of care’, a number of NGOs and private contractor trauma teams were co-ordinated by the UN to form a tiered and interlinked trauma system to provide trauma care to civilians caught in the conflict.(35)

The broad skill sets required of clinicians in the military and in HMOs are similar, with a greater emphasis on obstetric skills in the civilian humanitarian setting.(36–38) Indeed, some authors have suggested greater collaboration between these groups in training deploying surgeons with the skills required.(39) In situations such as sudden onset disasters and infectious disease epidemics, the potential for military contribution is clear, however there are other examples where longer term collaboration has developed nursing care, trauma and intensive care systems.(40–43) Given the likelihood of national military organisations working alongside, or at least in close proximity to HMOs in conflict or sudden onset disasters there is a clear rationale for the organisations to learn to work with each other.(44)

1.6 Training in low resource settings

Training in global surgery can take on a number of forms and be aimed at very different groups.(45) Using the taxonomy suggested by O'Flynn and colleagues these can be broadly slit into 4 separate categories:

1. **High income country (HIC) academic education**. Primarily marketed towards surgeons and trainees in HICs, these educational offerings focus on the key concepts behind global surgery and some offer research opportunities within the field.

2. **Trainee mobility**. This category describes opportunities for trainees to work and train in another country and usually reflects a trainee from a HIC visiting a LMIC, but there are examples LMIC to HIC exchanges and of bi-directional exchanges.

3. **Qualified high-income country (HIC) surgeons**. Many institutions in HICs support their staff to deliver training in LMICs, either as part of a formal training programme, or for specific short courses.

4. **Low- and middle-income country (LMIC) training**. Additionally, many HIC surgeons will visit LMICs to conduct in person training or to receive

training themselves to enable them to work in low resource settings or with HMOs.

Shrime and colleagues also offered a helpful taxonomy to categorise the many charitable platforms that provide surgical care in LMICs.(24) Assessing each on the published evidence for their effectiveness, cost-effectiveness, sustainability and training impact, the authors proposed the following categories:

1. **Temporary, short-term platforms**. Common throughout the world for several decades, this practice describes sending surgical teams into LMIC hospitals or clinics for short periods. There are widespread concerns about the quality, cost-effectiveness, and sustainability of this practice.(24)

2. **Temporary, self-contained platforms**. This practice is much rarer since it relies on significant infrastructure, but institutions such as Mercy ships and the US Navy Pacific Partnership deployments fall into this category.(46,47) The published data from these platforms suggests equivalence with HIC outcomes but there is no available data on cost-effectiveness or the sustainability of these programs.(24)

3. **Surgical speciality hospitals**. Usually run by large NGOs, these programmes establish a physical facility dedicated to the treatment of a small number of conditions, such as the Addis Ababa Fistula Hospital. Available data suggests these platforms have equivalent outcomes to HIC institutions and are cost effective, sustainable as well as providing consistent training for LMIC surgeons.(24)

Shrime and colleagues' assessment of each type of platform above, highlights that whilst the majority of charitable platforms are temporary and short term, published data suggests these are not the preferred method of delivering care and this type of programme should only be used where no other type of programme is possible, and the care cannot be delivered by local teams.

1.6 The role of technology

Increased use of technology in training and the delivery of surgical care has long been advocated as a key enabler to successfully achieving universal health coverage (UHC). Notable examples include the Lifebox portable pulse oximeter, gas insufflation-less laparoscopic surgery (GILLS) in India and the use of unmanned aerial vehicles to deliver blood products in Rwanda.(48–50) Additionally the war in Ukraine has seen the novel application of existing technologies to provide low cost telemedicine even during large scale conflict.(51)

However, dissemination of these technological advances is not uniform, as it often led by industry or individual academic institutions rather than taking a system level approach focussing on the local healthcare needs. Additionally, technology developed for use in HICs in not always useful or appropriate in other contexts, and more frugal innovations designed by those in resource challenged environments can improve healthcare without the large cost often associated with technological advances.(52)

1.7 Conclusion

Global surgery has developed rapidly from being the “neglected step-child of global health” through key interventions such as the Lancet Commission on Global Surgery to now being a burgeoning academic field with internationally accepted metrics to benchmark performance and measure progress alongside an evolving ethical structure to address the social injustices in healthcare.

This research study will seek to answer the question; ‘what are the training needs of surgical teams in low resource settings?’ It will address this through identifying the current burden of surgical disease in LMICs, identifying the density of the specialist surgical workforce in LMICs and through conducting a training needs analysis (TNA) of surgical teams in two low- and middle-income countries in Africa. The research will be conducted in line with ethical best practices and seeks to add voices of the surgical teams in low- and middle-income countries to the debate on how to harness technology to improve training and surgical care. This will reinforce the message from Farmer & Kim in 2008; “We need our surgical colleagues to speak fluently about rebuilding infrastructure, training personnel, and delivering high-quality care to the very poorest.”(7)

Chapter 2 - The burden of surgical disease in low- and middle-income countries

"Each year, at least 77·2 million disability-adjusted life-years (DALYs) could be averted by basic, life-saving surgical care.(53)*"*

2.1 Introduction

The previous chapter has given an overview of the vast disparity in health and surgical care in low- and middle-income countries (LMICs). The majority of surgically treatable diseases and injuries often occur in the person's most economically productive years, therefore surgical treatment may not only save and improve the life of the individual but may restore them to active participation in society.(54) The net benefit to treating surgical pathology has been estimated at 2% of Gross Domestic Product (GDP).(55) These economic arguments add weight to the clear moral and ethical arguments for improving access to surgical care for those without it. In his opening address to the launch of the Lancet Commission on Global Surgery (LCoGS) Dr Kim, the president of the World Bank highlighted that investing in surgical services in LMICs is affordable, saves lives and promotes economic growth.(10,56) This is especially important in countries where high proportion of their populations are children or young adults.

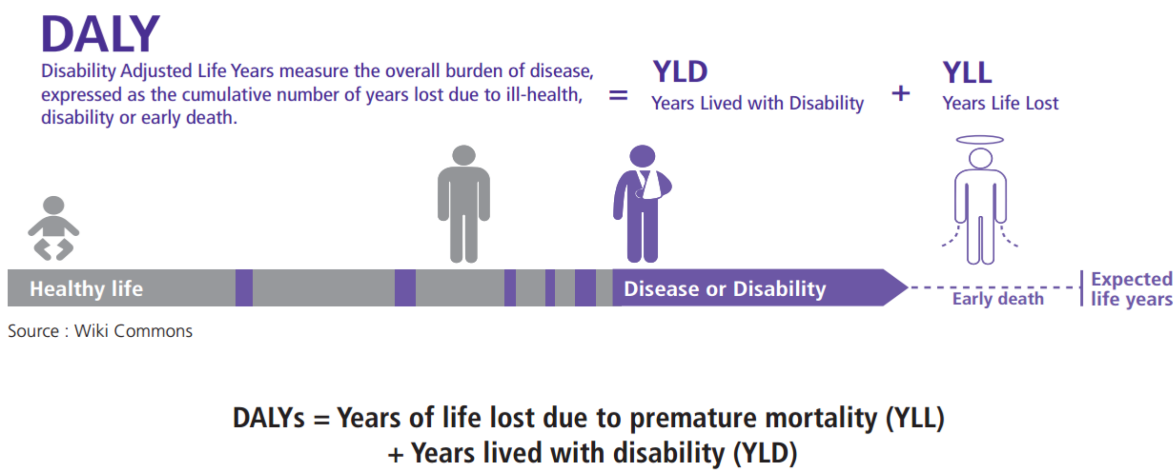
However, surgical care is limited by finite consumable resources, a suitably trained workforce as well as robust healthcare systems to ensure transfer of patients, assessment, direct care and discharge. It is for these reasons that improving the delivery of surgical care and patient access to surgical care is more complicated and challenging than the traditional health interventions outlined above. Safe and effective surgical care has the potential to transform the lives of both individual patients and their communities. A further economic analysis by Chao and colleagues compared the cost of common surgical procedures against the traditional tools of global health such as vaccinations in US dollar per disability adjusted life year. This study concluded that many common surgical procedures are as cost effective or in some cases more cost effective than the more traditional global health interventions such as vaccinations and malaria bed nets.(57)

2.1.2 Disability Adjusted Life Years (DALYs)

The most widely used method of measuring the burden of disease is by calculating Disability Adjusted Life years (DALYs). This method, proposed by the World Health Organisation (WHO) as part of the original Global Burden of Disease (GBD) study, describes the impact of disease on the life expectancy but also the years of life affected by disability.(58,59) This is calculated by adding two composite measures: years of life lost (YYL) and years lost due to disability (YLD) – see Figure 1 for an illustration of the concept.

YYL is calculated by multiplying the number of deaths by a standard life expectancy at age of death. YLD is calculated by multiplying the incidence of the disease by the average duration of the condition with a weighted value assigned to the type of disability known as the disability weight. The disability weight is a figure from 0 (perfect health) to 1 (death) generated through consultations with clinicians, experts and patient communities.(60)

Figure 2-1. *Illustration explaining the concept of DALYs.*



DALYs can be presented as an absolute number, or as a rate relative to the population, e.g. DALYs per 1000 population. Additionally, DALYs may be presented relative to the number of cases, allowing diseases to be compared at patient level.(61)

2.1.3 Aim

The aim of this systematic review and synthesis without meta-analysis on the burden of surgical disease in low- and middle-income countries using the Disability Adjusted Life Year (DALY metric) and conduct a geographic analysis of this data.

2.2 Methods

This systematic review and synthesis without meta-analysis will summarise the available evidence for the burden of surgical disease in low- and middle-income countries. To the authors knowledge, it is the first attempt to do so with an attempted synthesis without meta-analysis (SWiM). The SWiM methodology was chosen as a formal meta-analysis will not be possible given the heterogeneity of the data sources used to generate estimates within this field. The SWiM methodology provides a robust framework for synthesis and analysis of data that is not amenable for meta-analysis and is considered more rigorous than a narrative review – see 2.2.4 below.(62) The protocol for this literature review was registered with PROSPERO (ID: CRD42023404062) and the inclusion and exclusion criteria can be found in Table 1 below.

Table 2-1 *Inclusion and exclusion criteria.*

	Include	**Exclude**
Type of article	Primary quantitative, qualitative or mixed method study	Case reports (unless on national level), academic letter, correspondence or conference proceeding
	Literature or systematic review	Abstracts
	Report or guideline from national or international health organisation	
	Study reporting GBD metrics: a. Years of Life Lost (YYL). b. Years lived with disability (YLD). c. Disability Adjusted Life Years (DALY).	Economic evaluation: a. Cost-benefit b. Cost-effectiveness c. Cost-utility d. Cost minimisation
Type of condition or care setting	Surgical, anaesthetic, obstetric care, emergency or elective. As defined by the Disease Control Priorities: Essential Surgery.[11]	Non-urgent care, primary care, elective care as the main focus of assessment Medical conditions and infectious diseases
	Trauma care	Mental health
		Non-accidental injury in children
		Disaster management
Subject of study	Assessment of economic impact of ill health and care	Animal studies
	Whole health system assessment	Modelling studies
	Assessment of health system access	
Setting according to World Bank status 2018	Includes low- or lower middle- or upper middle-income country	High-income country only

2.2.1 Search strategy

A search strategy was devised to comprehensively search the following electronic databases: MEDLINE (Ovid), Global Health (Ovid), Embase (Ovid), CINAHL (EBSCO), ECONLIT (EBSCO), Cochrane (Wiley), and Global Index Medicus (WHO). The search terms used for MEDLINE can be found in Appendix 2B and were chosen as a combination of the search terms used in a similar published systematic review, and 2 validated search term filters: the Cochrane cost of illness search terms and the LMIC filter (for MEDLINE) developed by the University of Sheffield's School of Health and Relates Research (ScHARR).(24,63,64)

Although there is no agreed 'gold standard' for performing a rigorous search of grey literature, a four stage strategy used in previous similar studies was adopted.(65) These complementary approaches are searching of grey literature databases, a customised Google search, targeted websites and consultation with experts.(65) The search terms used in the grey literature review were: "Burden" OR "DALY" OR "Disability adjusted life year" OR "burden" AND "disease" OR "injury" AND "surgical" AND "low income" OR "low-middle income" OR "LMIC". The search was performed both with and without limiting the domains to .org .edu .gov .ac.uk and .int and the first 50 results were screened for each search. This number follows similar systematic reviews in the field and is a pragmatic balance between completeness and feasibility.(66) Articles were initially collated in EndNote (EndNote © 20.6 X8, Clarivate, Philadelphia, USA / London, UK) for de-duplication of results. Abstracts and titles were screened collaboratively using the Rayyan QCRI online open-source web application.

2.2.2 Selection of studies

Duplicate studies were removed using EndNote following an established and peer-reviewed method.(67) The Rayyan application was used to screen titles and abstracts and aid collaboration between the 4 researchers. Each study was independently reviewed by two blinded researchers. Study titles and abstracts were reviewed, and any disagreements were settled with discussion between the researchers. If required, the senior researcher was used to advise on any remaining disagreement. Inter-rater reliability was assessed using Cohen's kappa.(68) An initial pilot was performed with the first 10 articles independently assessed by each group of two researchers. Any disagreements and the reasons for them were clarified at this stage. A full text review stage was then performed, again with each study being independently assessed by two blinded researchers. All reasons for exclusion were recorded to ensure methodological rigour.

2.2.3 Data extraction

Data was extracted by a single researcher to ensure reproducibility. Data was extracted as either raw DALYs or as DALY rates per 100,000 of population and was collected using a Google Form (Google®. Accessed 25/7/23). Further analysis was conducted in Microsoft Excel (Microsoft® Excel, Microsoft®, Version 16.80).

2.2.4 Synthesis without Meta-Analysis (SWiM)

As a meta-analysis was not possible, due to heterogenous data and multiple analyses of the same databases with unclear sample sizes over different time points, a synthesis without meta-analysis was conducted. The synthesis without meta-analysis (SWiM) Guideline has been used and the reporting items can be seen in Table 2 below.(62) Where two or more metrics were collected for the comparable conditions in the same country or region, these have been displayed in graphical form. Bar charts were chosen over Box-and-whisker plots as bar charts allow comparison of trends between multiple studies over time.

***Table 2-2**. Synthesis without meta-analysis (SWiM) guideline reporting items.*

Methods	
1 - Grouping studies for synthesis	1. Individual country 2. Geographic/regional location of country e.g. 'North Africa' 3. World Bank Income status 4. Condition specific 5. Groups of condition/surgical speciality e.g. 'obstetric procedures'
2 - Standardised metrics	1. Disability Adjusted Life Years (DALY), expressed either as an absolute number (preferred) or a rate per 100,000 of the population.
3 - Synthesis method	Summarising effect estimates will be attempted however may not be possible as the data reported in each study is likely to be specific to the local health and economic context and may not generalisable to other contexts.(69)
4 - Criteria used to prioritise results for summary and synthesis	1. Type of study is primarily an evaluation reporting the metrics listed in 2-Standardised metrics above. 2. Low risk of bias using either the Joanna Briggs Institute (JBI) or Risk of Bias in Systematic reviews (ROBIS) tool as appropriate. 3. Directly relevant to the study question.
5 - Investigation of heterogeneity in reported effects	Meta-regression will not be possible. Heterogeneity will be minimised by analysing sub groups based on similar study characteristics (see 1 above such as methodological and study population characteristics and economic and geographic context.
6 - Certainty of evidence	Will be assessed using the Grading of Recommendations, Assessment, Development, and Evaluation (GRADE) Evidence Profile.(70,71)
7 - Data presentation methods	Results will be presented in a table with the following headings: • Type of study • Risk of bias • GRADE quality • Country/region of study • World Bank Income status of country of study • Condition or group of conditions studied • Burden of disease (see 2 – 'Standardised metrics' above) • Overall quality assessment Bar charts were chosen over box-and-whisker plots as bar charts allow comparison of trends between multiple studies over time.
Results	
8 - Reporting of results	The results will be reported in Table and box-and-whisker plots as described in 7 above.
Discussion	
9 - Limitations of the synthesis	The limitations of the systematic review will be outlined in full in the discussion section. These are expected to be due to incomplete or low-quality data, bias in reporting of outcomes

	and difficulty in comparing economic outcomes between different countries, regions and contexts(69)

2.2.5 Risk of bias

A formal risk of bias assessment was conducted on the included studies. This was performed using the Joanna Brigg's Institute (JBI) checklist for analytical cross-sectional studies for primary research papers or the ROBIS tool for systematic reviews.(72,73) The JBI is based at the University of Adelaide and promotes high quality analysis and interpretation of evidence through developing evidence based resources such as the checklist for analytical cross sectional studies.(72) The Risk Of Bias in Systematic Reviews (ROBIS) tool was developed by the University of Bristol as a tool to guide researchers in assessing for risk of bias in systematic reviews.(73)

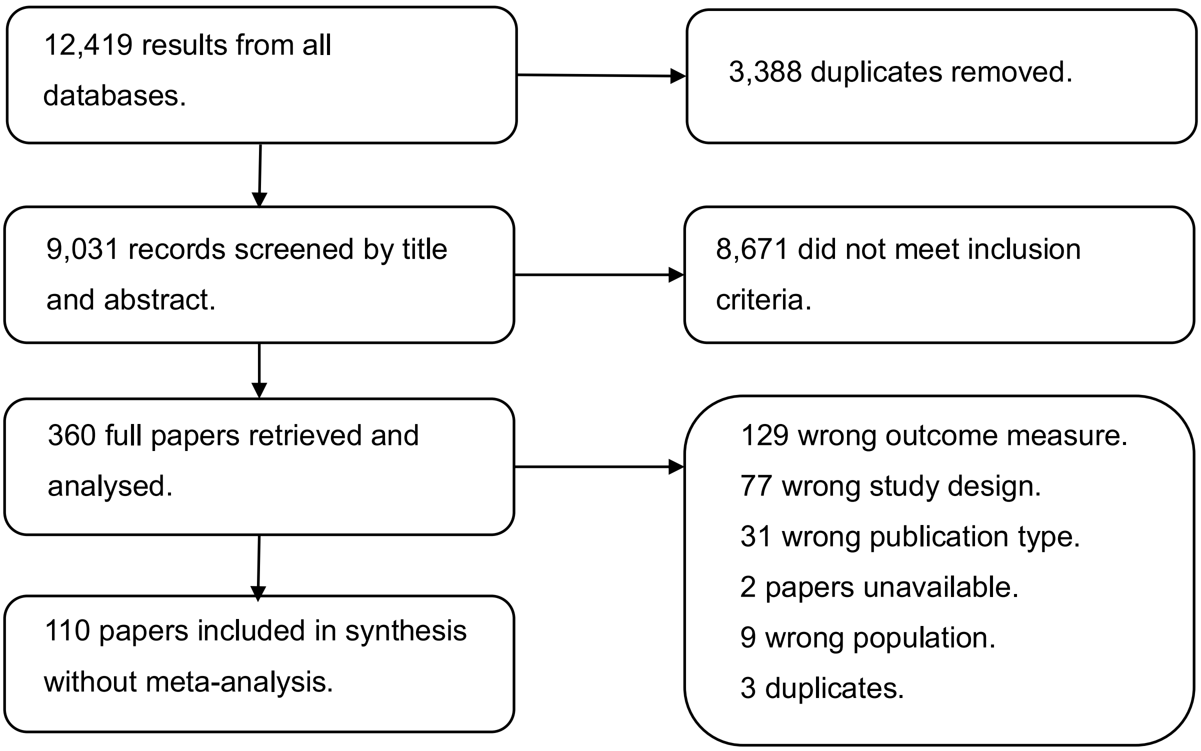
2.2.6 Certainty of evidence

Evidence was assessed using the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) framework to assess certainty.(71)

2.3 Results

In total, 12,419 results were returned after the systematic searching of the databases and grey literature search outlined above. After de-duplication, initial screening and assessment of full articles, 110 papers were included. The Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) flow diagram can be seen in Figure 2.

Figure 2-2. *PRISMA flow diagram.*



2.3.1 Inter-rater reliability

Inter-rater reliability was assessed using Cohen's kappa.(74) This was comparing Researcher 1 against Researcher 2. Three separate reviewers were used as Researcher 2 but Researcher 1 was constant throughout. SPSS® (IBM® SPSS® Statistics, Version 27) was used for the calculation – see Figure 3. Cohen's Kappa was 0.523 indicating a moderate degree of agreement. This was prior to the discussion between researchers to clarify any disagreements.

Figure 2-3. *Cohen's kappa assessing inter-rater reliability from the screening stage.*

Symmetric Measures

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Measure of Agreement	Kappa	.523	.021	58.433	.000
N of Valid Cases		8963			

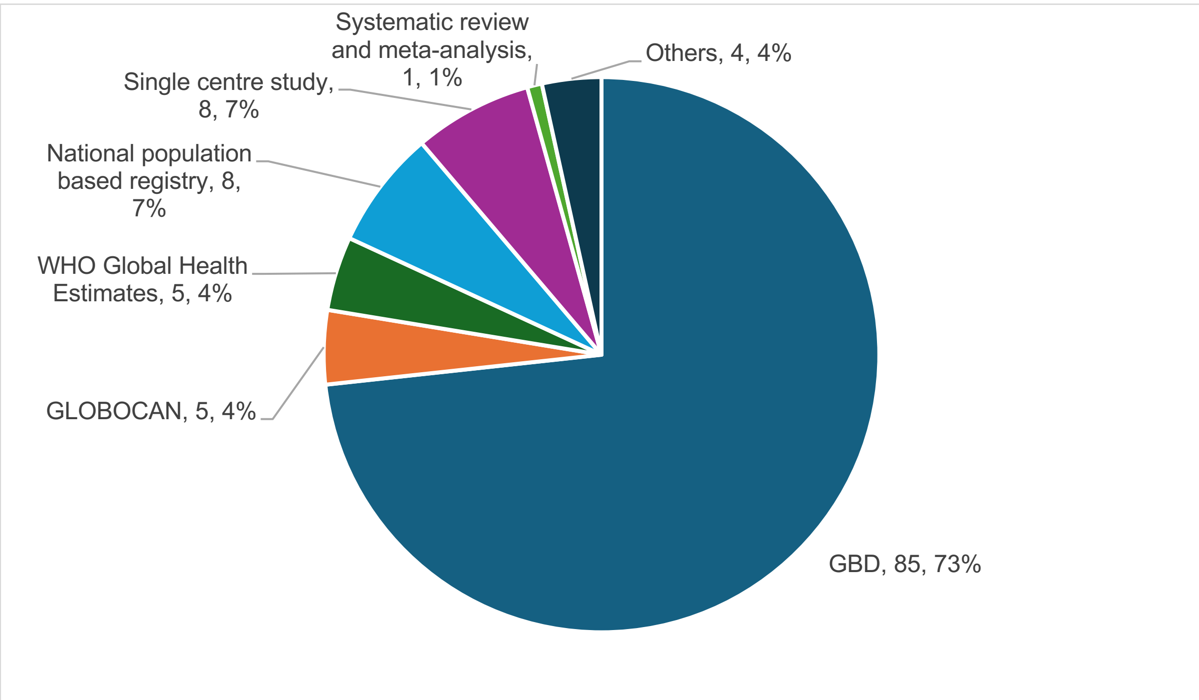
a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

2.3.2 Source of data

The most frequently used source of data for included studies was the Global Burden of Disease (GBD). This ongoing study releases updates every 2 years and was used by 84 (74.68%) of included studies. The GBD study appears to be increasingly popular with the 2019 iteration of the study the most frequently used source of data (35, 29.31%). Other notable inclusions were the five studies (4.31%) based on the GLOBOCAN database and the four (3.44%) based on the WHO Global Health Estimates – see Figure 4.

Figure 2-4. *Data sources from the included studies. Note some studies used multiple data sources.*



2.3.2 Diseases studied

Cancers were the most studied disease (72, 66.06%) with breast cancer (9, 8.26%) the single most frequently reported cancer overall. Traumatic injuries were investigated by 12 (11.00%) studies and congenital anomalies (including, gastrointestinal, cardiac and orofacial clefts) were reported by 8 (7.33%) studies.

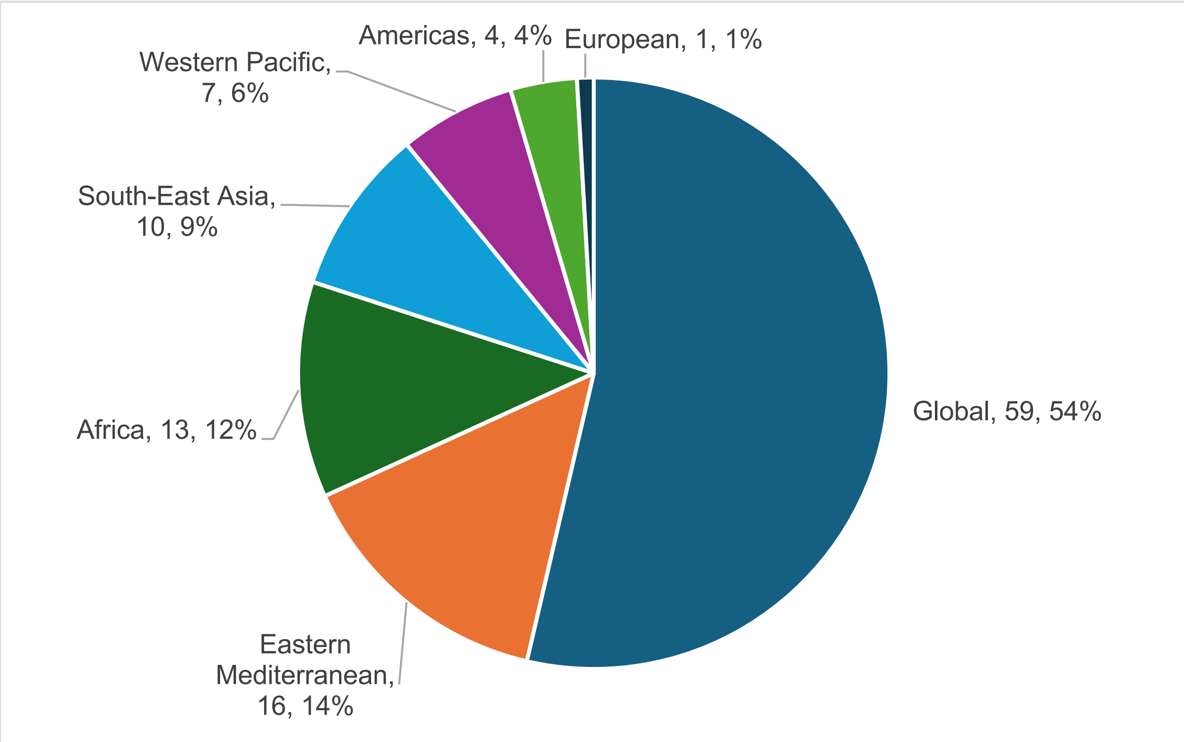
2.3.3 Regional and national burden of disease

The burden of disease has been divided into the six World Health Organization (WHO) regions(75):

- African Region (AFR),
- Region of the Americas (AMR),
- South-East Asian Region (SEAR),
- European Region (EUR),
- Eastern Mediterranean Region (EMR),
- Western Pacific Region (WPR).
- A 'Global' region has been added as a majority of studies reported from multiple WHO regions.

A majority (59, 53.63%) of included articles assessed multiple geographic regions or the entire world and are recorded as 'Global' in this systematic review. EMR (16, 14.54%) was the second most studied region followed by SEAR (10, 9.09%) and AFR (13, 11.81%) – see Figure 5.

Figure 2-5. *Geographic region of study. Note high income countries were excluded from analysis.*



2.3.4 African Region

Of the 13 included studies from the African Region, six (46.15)% were based on analysis of the GBD study(76–81), five (38.46%) were based on single centre databases(82–86), one (7.69%) was based on data from Operation Hernia (a UK based NGO) combined with US census data(87) and one (7.69%) on a systematic review of snake envenoming(88). Congenital anomalies were the most commonly studied disease at five (38.46%)(82–84,86,89), three (23.08%) studied cancer(77,78,81), three (23.08%) multiple diseases(79,80,85) and one (7.69%) inguinal hernia(87).

Gouda et al 2019 reported the cancers causing the largest burden of disease in sub-Saharan Africa based on data from the GBD 2017 study. These were reported in broad groupings of disease (Figure 6) and specific diseases (Figure 7). The top three diseases by DALY rate per 100,000 were: ileus and obstruction at 1887.40 (1398.70-2249.40), cervical cancer 1706.9 (1457.60 – 1901.40), and breast cancer at 1701.9 (1475.20 – 1975.10).

Figure 2-6. *DALY rates due to non-communicable disease groups in sub-Saharan Africa by Gouda et al 2019, with 95% confidence intervals.*

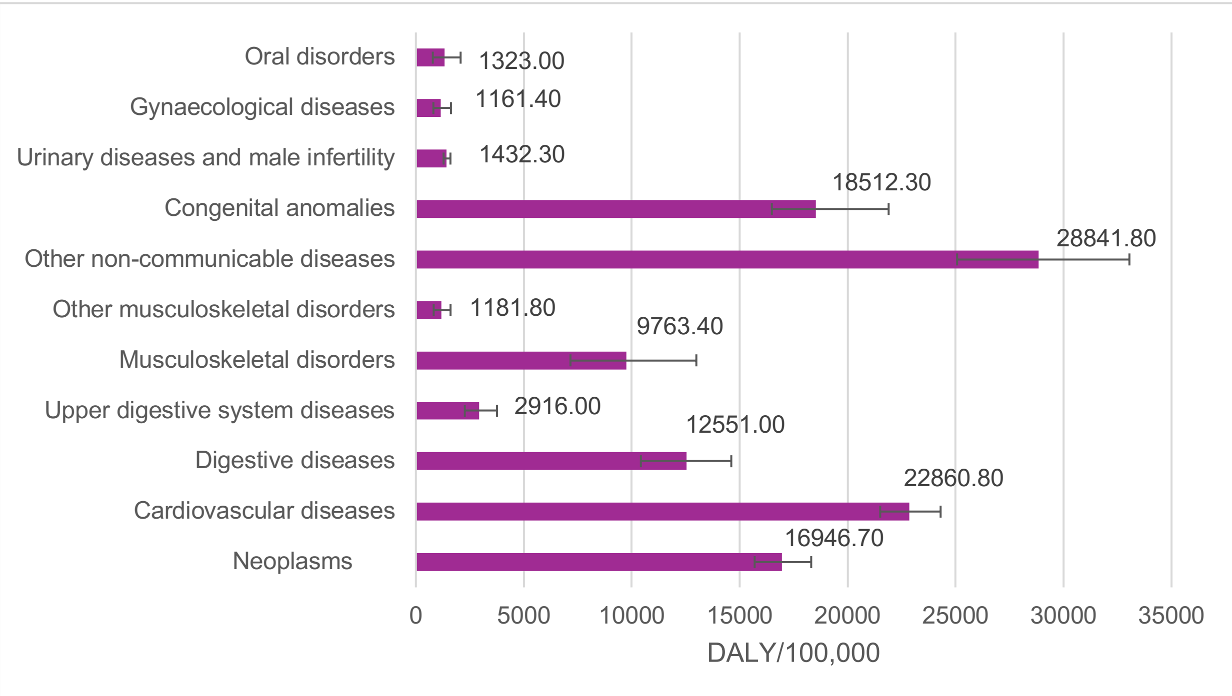
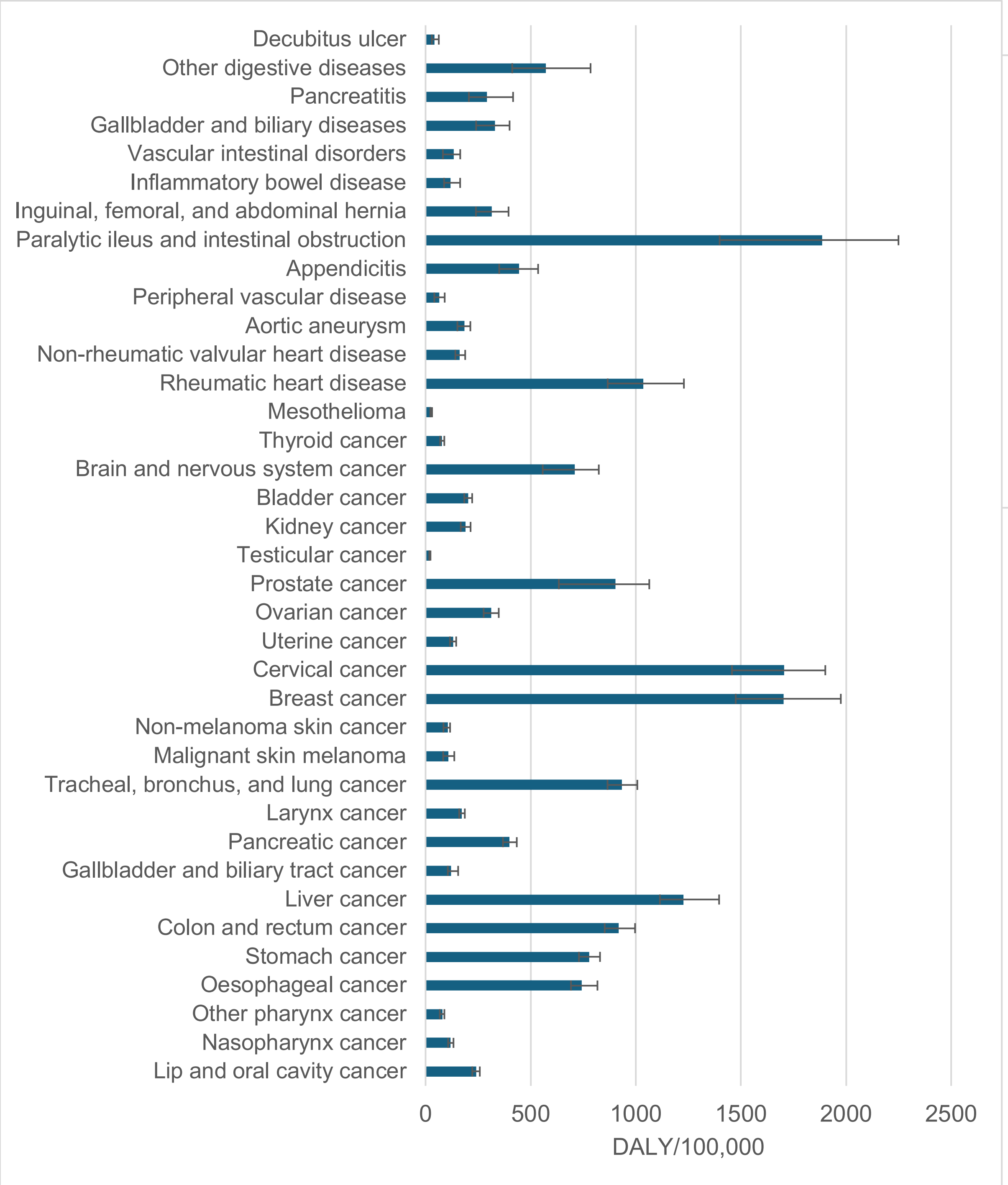


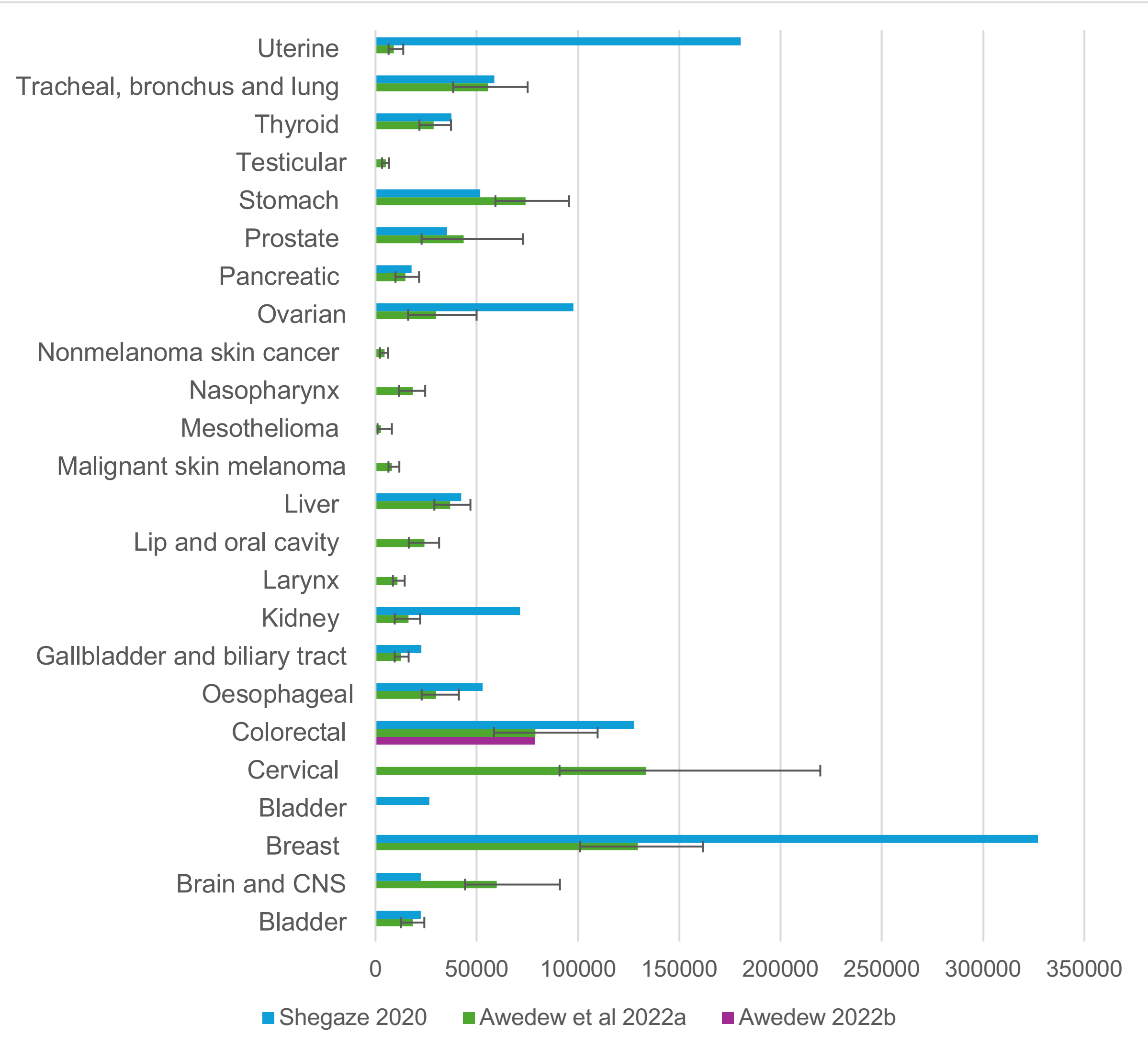
Figure 2-7. *DALY rates due to specific diseases in sub-Saharan Africa by Gouda et al 2019, with 95% confidence intervals.*



Two studies reported multiple cancer types in Ethiopia, these are displayed in Figure 8. Shegaze et al 2020 using GBD 2016 data and Awedew et al 2022(a) using GBD 2019 data.(77,81) Shegaze et al 2020 reported breast cancer having the highest burden at 327,000 DALYs, whereas Awedew et al 2022(a) reported cervical cancer causing the highest burden at 133,580 DALYs. The burden of most cancers decreased across the three-year period between the two studies, with only stomach, prostate and brain and CNS cancers increasing.

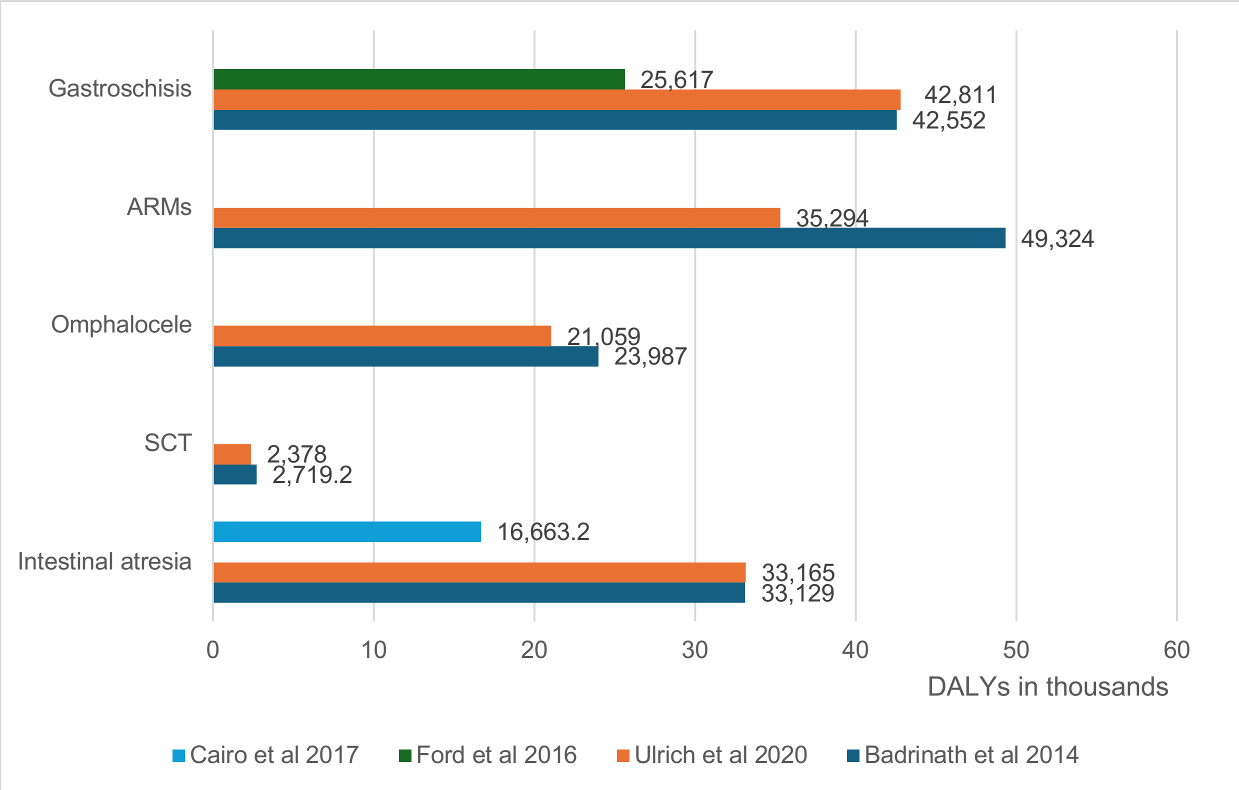
Three studies reported the burden of colorectal cancer in Ethiopia. Shegaze et al 2020 reported 127,800 DALYs from GBD 2016 data, whereas this fell to 79,000 DALYs by Awedew et al 2022(a) and 79,050 DALYs by Awedew et al 2022 (b) both using the GBD 2019 data.(77,79)

Figure 2-8. DALYs due to cancer in Ethiopia, by Shegaze et al 2019, Awedew 2022 (a), Awedew et al 2022 (b), with 95% confidence intervals displayed for the studies that reported them.



Four studies reported the burden of congenital anomalies in Uganda – see Figure 9.(82–84,86) All of these studies were single centre studies with a 'low' or

Figure 2-9. *DALYs (in thousands) due to congenital anomalies in Uganda.*



'very low' GRADE rating of certainty. The burden of gastroschisis was estimated as: 42,552 DALYs/yr by Badrinath et al 2014, 25,617 by Ford et al 2016, and 42,811 by Ullrich et al 2020. (82,84,86)

Intestinal atresia was reported as causing 33,129 DALYs/yr by Badrinath et al 2014 and 33,165 DALYs/yr by Ullrich et all 2020, however, Cairo et al 2017 reported 16,663 DALYs/yr.(82,83,86) Badrainath et al 2014 and Ullrich et al 2020 also reported sacrococcygeal teratomas (SCT) and omphalocele with relatively similar results - 2,719.2 DALYs and 2,378 DALYs for SCT and 21,059 DALYs and 23,987 DALYs for omphalocele respectively.(82,86) These two studies reported significantly different burden due to anorectal malformations; 49,324 DALYs/yr by Badrinath and 35,294 DALYs/yr by Ullrich.

2.3.5 Eastern Mediterranean Region

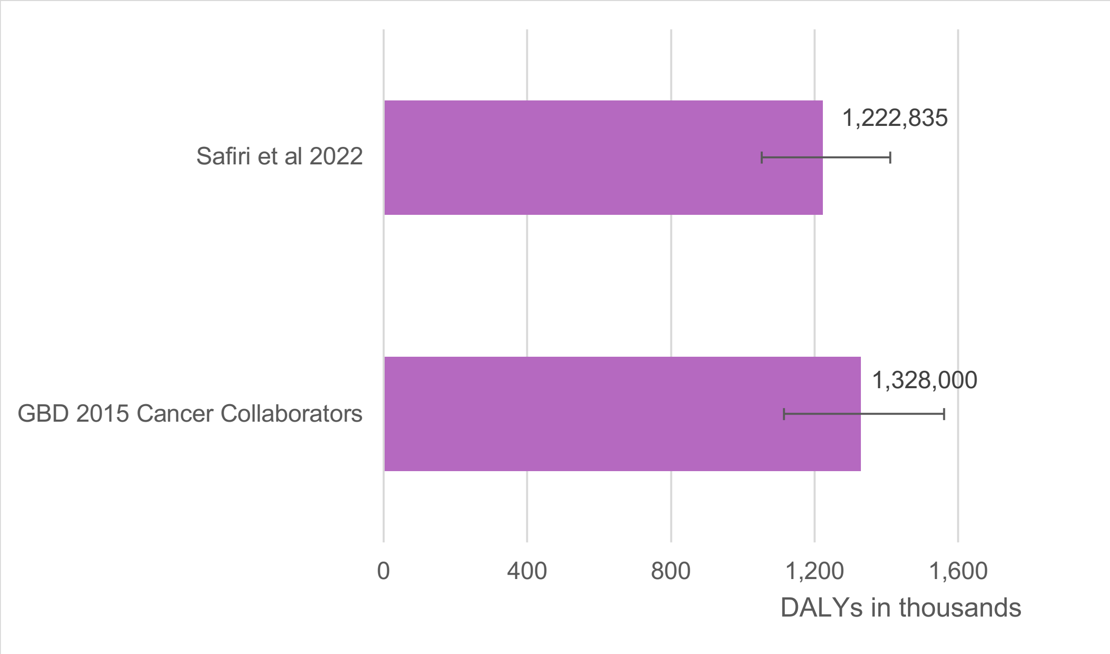
Sixteen studies were included that reported on burden of disease in the Eastern Mediterranean Region (EMRO). One study (6.25% of EMRO studies) used national data – Naghavi et al 2003 which used Iranian Ministry of Health data.(90) One further study (Bawazir 2017) combined data sets from GBD, GLOBOCAN and single centre data.(91) The remaining 14 studies (87.50%) used iterations of the GBD database from 2002 - 2019.(92,93,102–105,94–101) Most studies (8,50%) estimated burden on a regional basis, Iran was the single most studied country (5, 31.25%).

Four (25.00%) studies reported the burden of various types of injuries in either adults or children.(93,94,100,104) Cancer was the most studied disease with 10 articles, and breast cancer was the most commonly studied type of cancer.

When looking at the regional burden of cancer, the GBD 2015 Cancer Collaborative estimated the cancers causing the highest burden, by age standardised DALY rate, were: tracheal, bronchial and lung cancer - 1330 DALYs/100,000, breast cancer - 1328 DALYs/100,000 and gastric cancer – 769 DALYs/100,000.(95)

The burden due to female breast cancer across the region was estimated at 1,328,000 DALYs by the GBD 2015 Cancer Collaborators and 1,222,835 DALYs by Safiri et al 2022 using the GBD 2019 data – see Figure 10.(95,99) The lower figure by Safiri et al may be partly explained by that study focussing exclusively on female breast cancer only. The burden of breast cancer in Yemen was reported at 39,870 DALYs by Safiri et al 2022 whereas Bawazir 2017 reported a much higher figure of 344,925 using a combination of the GBD 2010, GLOBOCAN 2012 and a single centre database from Aden.(91,99)

Figure 2-10. *DALYs (in thousands) due to breast cancer in the EMRO region with 95% confidence intervals.*

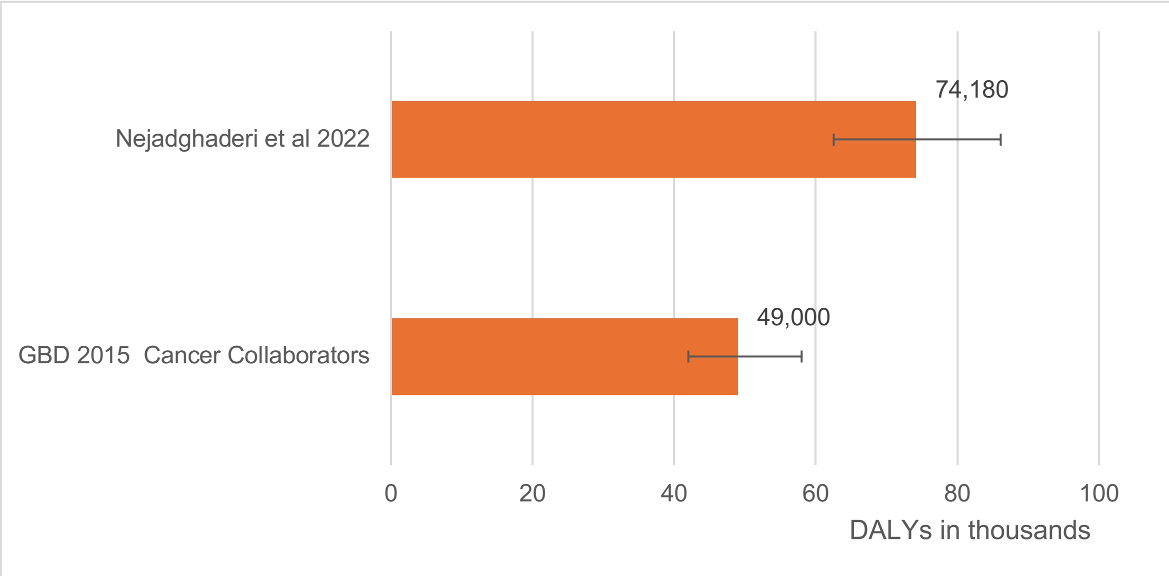


Malekzadeh et al 2015 estimate the burden of GI and liver disease in Iran according to GBD 2010 data. Gastric cancer caused the highest burden at 55,751 DALYs, followed by oesophageal (23,823 DALYs) and colorectal cancer (23148 DALYs). Pancreatitis caused the lowest number of DALYs at 988.(106)

Shokri et al 2022 estimated the DALYs due to lung cancer in Iran according to the estimate based on 2019 GBD data at 24,8254.(101)Ramazani et al 2021 used GBD 2017 data to estimate age-standardised DALY rates due to gastric cancer, and reported Iran as 296.79 DALYs/100,000 or 250,802 DALYs using World Bank estimates of the Iranian population in 2017.(102,107)

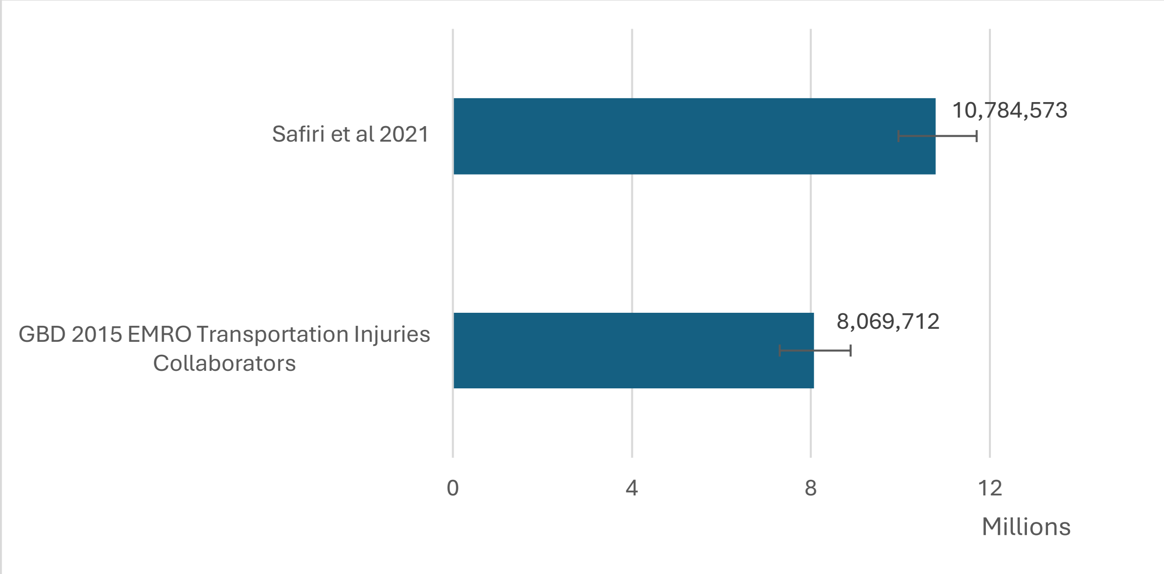
Two studies estimated the regional burden of disability due to thyroid cancers, the GBD 2015 Cancer Collaborative estimated 49,000 (42,000–58,000) DALYs and Nejadghaderi et al 2022 estimated 74,180 (62,526 to 86,119) DALYs using GBD 2019 data – Figure 11.(98)

Figure 2-11. *DALYs (in thousands) due to thyroid cancer in the EMRO region, with 95% confidence intervals.*



DALYs due to transport related injuries in the Eastern Mediterranean region increased from 2015 to 2017 according to the GBD estimates - see Figure 12. The GBD EMRO Transportation Injuries Collaborators estimated 8,069,712 DALYs whereas this rose to 10,784,573 DALYs according to Safiri et al.(94,100) Al-Hajj et al 2020 estimated that children had a much higher burden of injury, estimating 61,039,122 DALYs across the Eastern Mediterranean region.(93) Focussing on Iran alone, Naghavi et al 2009 estimated 3,971,813 DALYs from all injuries, of which 1,305,714 DALYs were due to Road Traffic Injuries.(104) Afghanistan was the nation with the highest burden of injury in the region with an age-standardised DALY rate of 3151.7 per 100,000 population and Lebanon was the lowest at 429.7 DALYs/100,000.(100)

Figure 2-12. *DALYs (in millions) due to transportation related injuries in the EMRO region with 95% confidence intervals.*



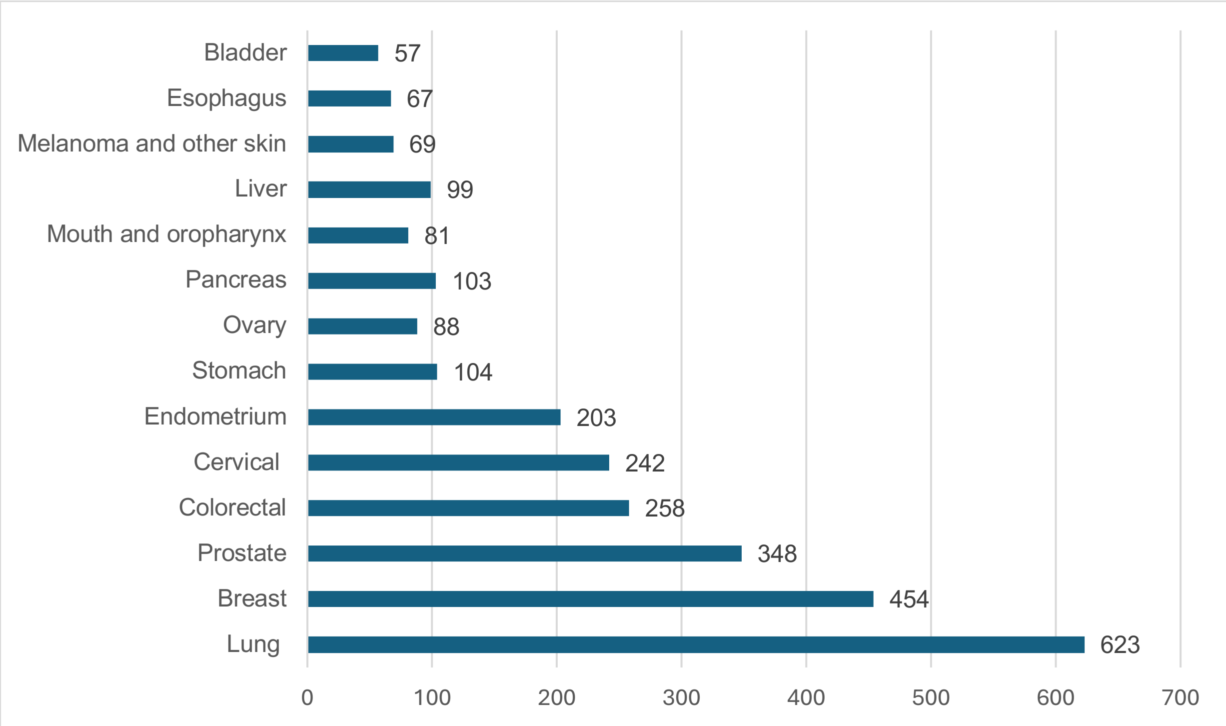
The regional burden of prostate cancer was estimated at 243,000 (180,000-297,000) DALYs by the GBD Cancer Collaborators in 2015.(95) Abbasi-Kangevari et al 2022 estimated this was 186.8 DALYs per 100,000 population from GBD 2019 data.[51] Using the World Bank population estimates this would result in 883,940 (698,919.02 - 1,038,677.90) DALYs.(108)

2.3.6 Region of the Americas

Of the four included studies from the Americas Region, two (50%) were based on Cuba, one (25%) on Mexico and one (25%) on Brazil. One of these studies was based on a national database and the other three (75%) were from GBD data from 2002, 2017 and 2019. All cancers were analysed by Dominguez-Alonso et al 2009(109), breast, endometrial, cervical, and ovarian cervical cancer by Dominguez et al 2014(110), cervical cancer by Reis et al 2020(111) and injuries by Dávila-Cervantes & Pardo-Montaño 2021(112).

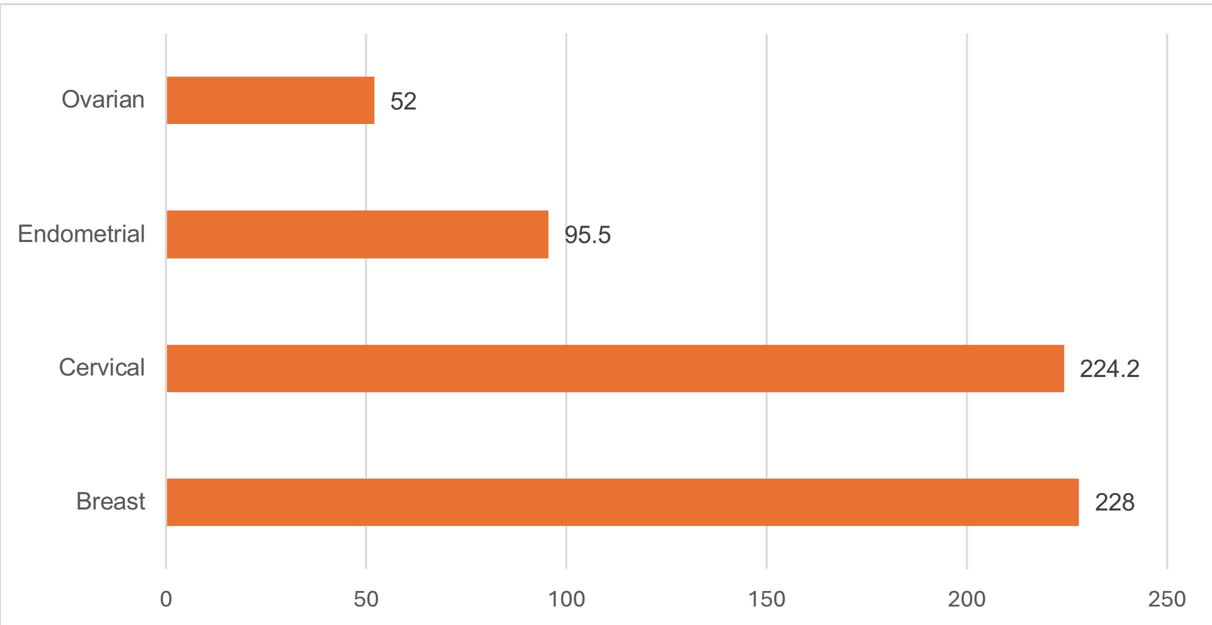
Using GBD 2002 data, Dominguez Alonso et al estimated the DALY rates of all cancers in Cuba and highlighted that lung, breast and prostate were the largest contributors to the burden of disease. These are shown in Figure 13.

Figure 2-13. *DALY rates per 100,000 due to cancers in Cuba.*



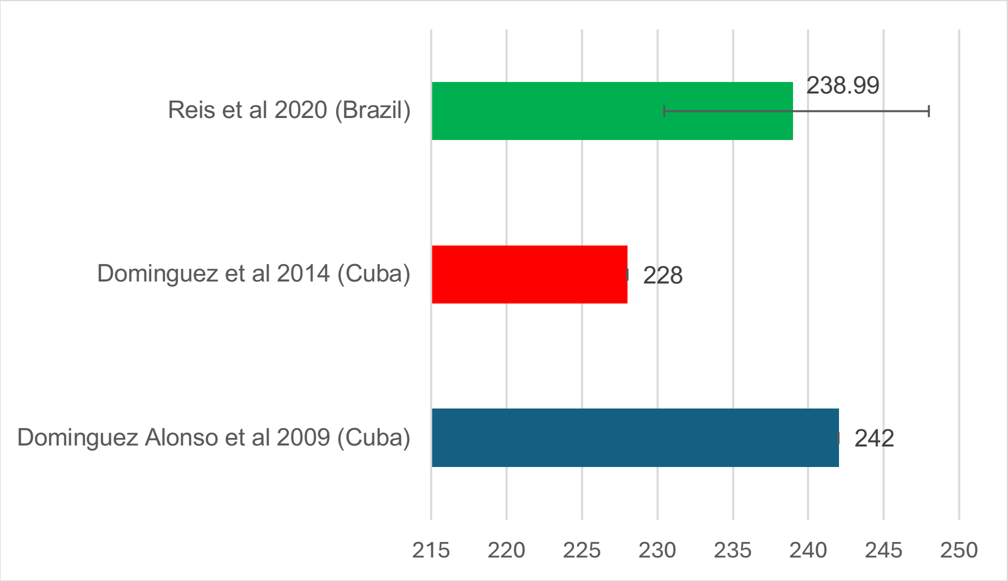
More recently, Dominguez et al 2014 estimated the burden of female reproductive system cancers in Cuba using data from a national database in 2006. These estimates of DALY rates per 100,000 are shown in Figure 14.

Figure 2-14. *DALY rates per 100,000 of female reproductive cancers in Cuba in 2006 by Dominguez et al 2014.*



Three studies estimated the DALY rates due to cervical cancer across the Americas Region, and these are shown in Figure 15. Note that units are in DALY rates per 100,000 and 95% confidence intervals are only shown for the one study that reported them.

Figure 2-15. *DALY rates per 100,000 due to cervical cancer in the Americas Region, 95% confidence intervals shown for the one study that reported them.*



Dávila-Cervantes & Pardo-Montaño used GBD 2019 data to estimate the DALY rate due to injury across Mexico at 3785.6 (3321.8, 4314.3) DALYs/100,000.

2.3.7 South-East Asian Region

From the South-East Asian Region 10 studies were included. Five studies (50%) used GBD data, of these five, one study also used the Million Death Study. One (10%) study used GLOBOCAN data, two (20%) studies were based on single centre case studies and three (30%) were based on national population-based cancer registries. Six (60%) studies focussed on India, three (30%) were regionally focussed, one (10%) studied Nepal and one (10%) studied Bhutan. Cancers were the most frequently studied group of disease, representing seven (70%) of included studies, two (20%) studied injuries, one (10%) studied surgical disease and one (10%) studied rheumatic disease.

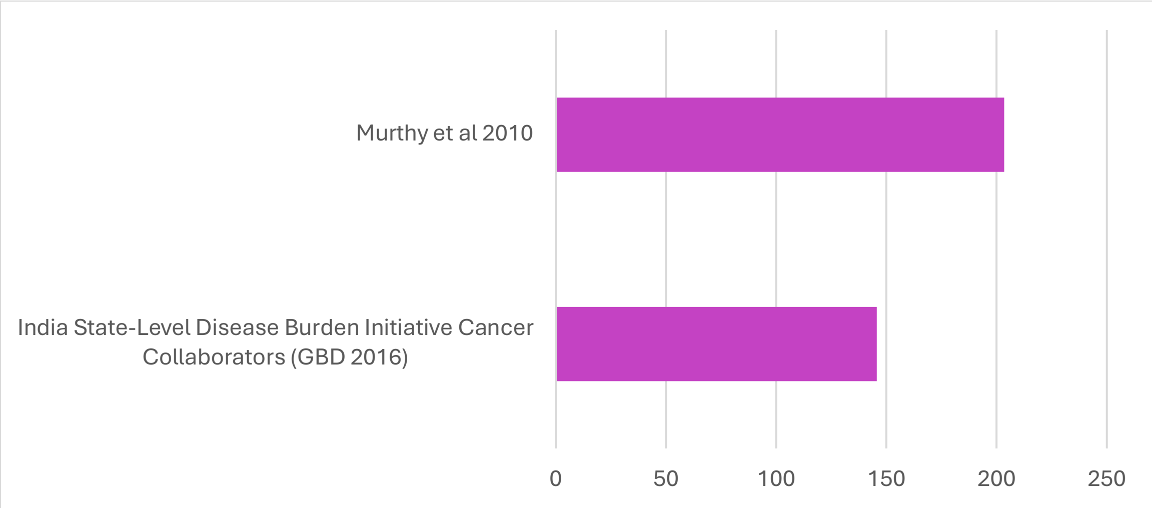
The India State-Level Disease Burden Initiative Cancer Collaborators used GBD 2016 estimates to report the burden of various cancers. The authors reported that gastric cancer caused the highest burden (159.5 DALYs/100,000) followed by breast (145.7 DALYs/100,000) and lung (133.8 DALYs/100,000).(113) Kulothungan et al 2022 used National Cancer Registry 2016 data to estimate the total burden due to all cancers in India at 1277 DALYs/100,000, this is comparable to the estimate of 1400 DALYs/100,000 by Menon et al 2019.(114,115) Murthy et al 2010 used national population-based registries to estimate the burden of various cancers within India. The authors reported that oral cavity cancer caused the highest burden with 1,140,297 DALYs followed by oesophageal cancer (293,997 DALYs) and gastric cancer (244,1010 DALYs).(116)

Kimman et al 2012 used GLOBOCAN 2008 estimates to report the DALY rates due to all cancers in the Association of Southeast Asian Nations (ASEAN). This study estimated the highest rates in Laos (1941 DALYs/100,000) followed by Vietnam (1863 DALYs/100,00) and Myanmar (1853 DALYs/100,000).(117)

Shrestha et al 2021 used GBD 2017 data to estimate the burden of cancers within Nepal. The authors reported the largest burden was due to tracheal, bronchial and lung cancer at 54760.72 (35,829.35 - 76,709.73) DALYs. This was followed by breast cancer at 48,474.7 (35,210.61 – 88,091.39) DALYs and gastric cancer at 42,129.89 (34,853.01 – 49,963.98) DALYs.(118)

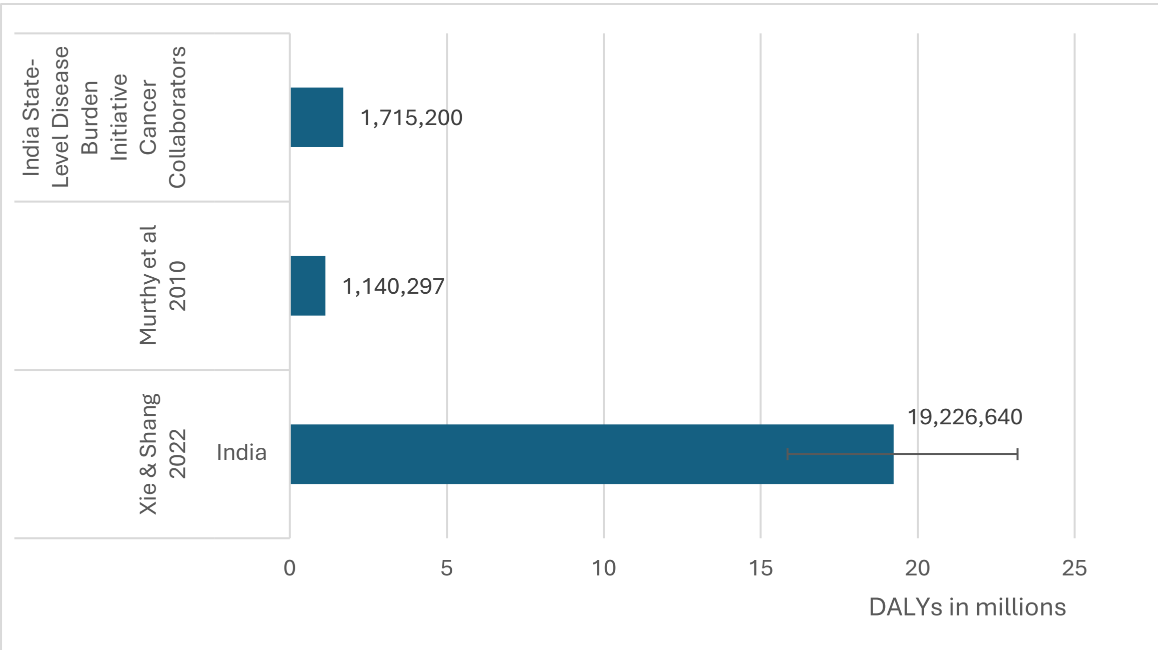
Three studies reported DALYs due to breast cancer. The India State-Level Disease Burden Initiative Cancer Collaborators used the GBD 2016 data to estimate the DALY rate as 145.7 DALYs/100,000.(113) Murthy et al estimated 203.5 DALYs/100,000 using population-based cancer registries – see Figure 15.(119) Kunnavill et al 2015 used a different methodology and a combination of six population-based registries and estimated 40,209 DALYs/100,000. Due to the use of different methodology Kunnavil et al 2015 has not been added to Figure 16. Shrestha et al 2021 used GBD 2017 data to estimate the burden of breast cancer in Nepal as 48474.7 (35210.61–88091.39) DALYs.

***Figure 2-16**. DALY rate per 100,000 females due to breast cancer in India.*



One study focused purely on oral cancer.(120) The authors used GBD 2019 estimates and reported that India had the highest national burden at 19,226,640 (15,853,850-23,180,250) DALYs. This is significantly larger than the figure reported by Murthy et al 2010 (1,140,297 DALYs) using national population-based registries and the India State-Level Burden Initiative Cancer Collaborators (1,715,200 DALYs) using GBD 2016 estimates – see Figure 17.(113,121)

***Figure 2-17.** DALYs (in millions) due to oral cavity cancer in India, with 95% confidence intervals for the one study that reported them.*



Two studies reported DALYs due to injuries. Gosselin et al 2012 reported 5161 DALYs due to injury from the national trauma referral centre in the Kingdom of Bhutan, a DALY rate of 766.57 DALYs/100,000 using World Bank population estimates.(122,123) Menon et al 2019 used a combination of the GBD 2016 data and the India Million Death Study which estimated the burden of road traffic accidents in India as 1200 DALYs/100,000 and burden of musculoskeletal injuries as 1000 DALYs/100,000.(115) When using the World Bank estimates for the population of India in 2016, these equate to 16,080,000 DALYs due to road traffic accidents and 13,400,000 DALYs due to musculoskeletal disorders.(124)

Gupta et al 2020 reported the burden of rheumatic heart disease in ‘high burden countries’ using GBD 2017 data. The authors reported India having the highest burden at 3,733,300 DALYs followed by Pakistan (296,210 DALYs) and Bangladesh (134,990 DALYs). (125)

2.3.8 European Region

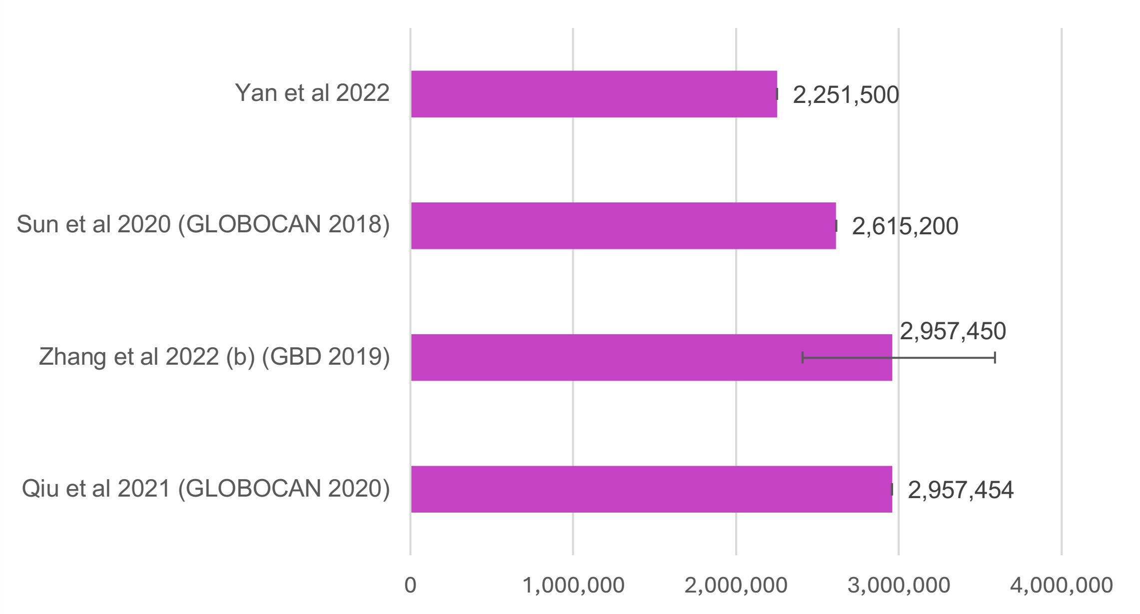
There was one included study from the European Region: Jankovic et al 2007 which studied 18 surgical diseases in Serbia. This data was collected from the year 2000 using methodology based on the GBD study. This study reported that lung tracheal and bronchial cancer has the highest burden of disease with 59,088 DALYs, followed by road traffic injuries (30,4658 DALYs) and self-inflicted injuries (27,938 DALYs).

2.3.9 Western Pacific Region

Of the seven included studies from the Western Pacific Region, all 7 (100%) studied China, one (14.28%) also included Mongolia, and all seven (100%) studied cancer. Four (57.14%) studies were based on GBD data, two (28.57%) were based on GLOBOCAN and one from a national cancer registry report.

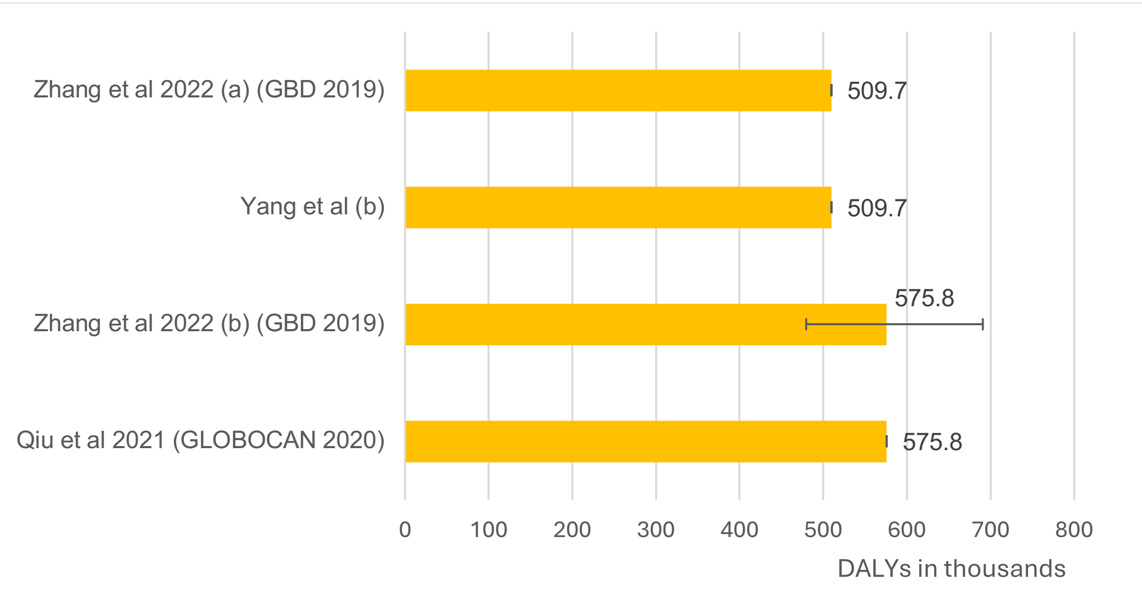
Four studies estimated the burden of breast cancer, with the burden estimated between 2,251,500 DALYs by Yan et al 2022 using national cancer registry data from 2015 and 2,957,454 DALYs by Qiu et al 2021 based on GLOBOCAN 2020 data – see Figure 18.(126,127)

Figure 2-18. *DALYs due to breast cancer in China. Note 95% CIs are shown for the one study that reported them.*



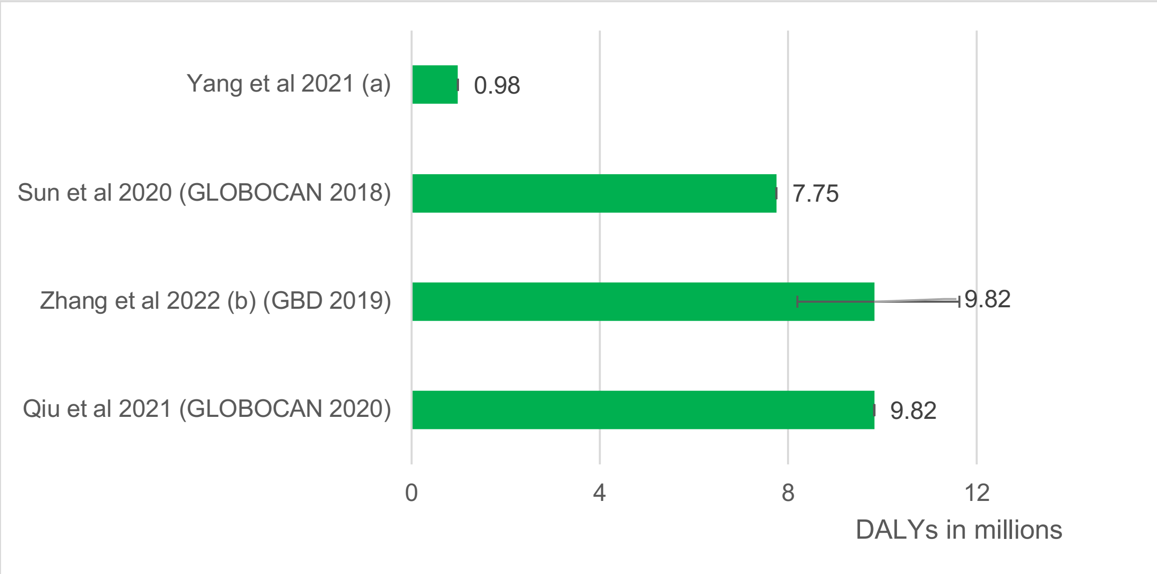
Four studies analysed the burden of lip and oral cancer in China.(128–130) Estimates ranged from 509,746 DALYs by Zhang et al 2022(a) using GBD 2019 data and 575,805 DALYs by Qiu et al 2021 using GLOBOCAN 2020 data – see Figure 19.(128,131)

Figure 2-19. *DALYs (in thousands) due to lip and oral cancer in China. Note that 95% confidence intervals have been shown for the one study that reported them.*



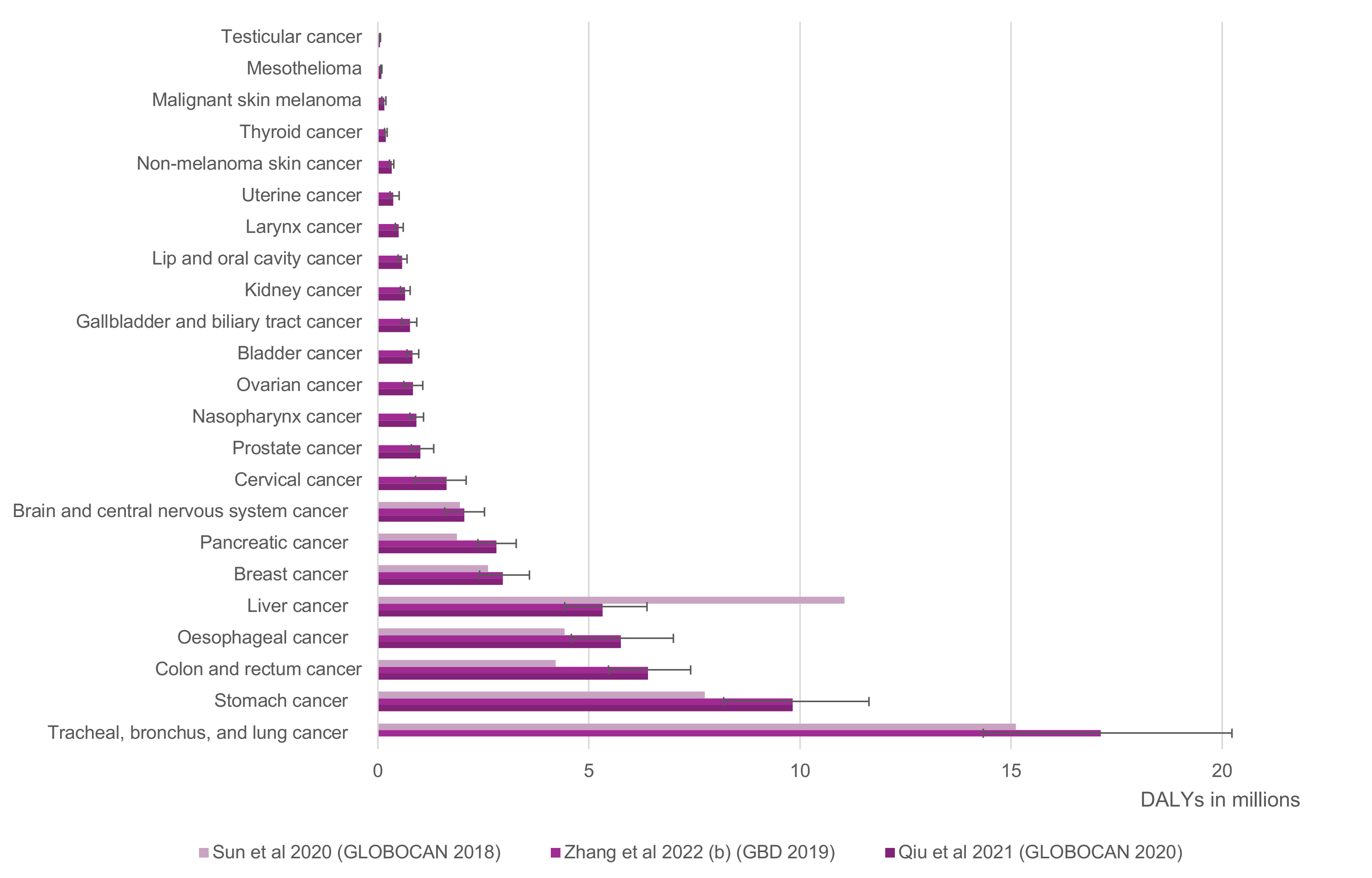
Four studies reported estimates of gastric cancer in China, (130–133) estimates of the DALYs caused ranged from 982,500 by Yang et al 2021 using GBD 2019 data to 9,824,993 by Qiu et al 2021 using GLOBOCAN 2021 data – see Figure 20.

Figure 2-20. *DALYs (in millions) due to gastric cancer in China. Note the confidence intervals are shown for the one study that reported them.*



Three studies reported estimates based on multiple cancers in China.(131,134,135) Tracheal, bronchus and lung cancer were reported as the highest burden cancer by Sun et al 2020 using GLOBOCAN 2018 and by Zhang et al 2022(b) using GBD 2019 data.(135,136) Gastric cancer was estimated to be the second largest cause of DALYs by Zhang et al 2022(b) and Qiu et al 2021; however Sun et al 2020 reported liver cancer as the second highest cause of DALYs in China – see Figure 21.(131,134,135)

Figure 2-21. *DALYs (in millions) due to cancer in China, with 95% CIs for the study that reported them.*

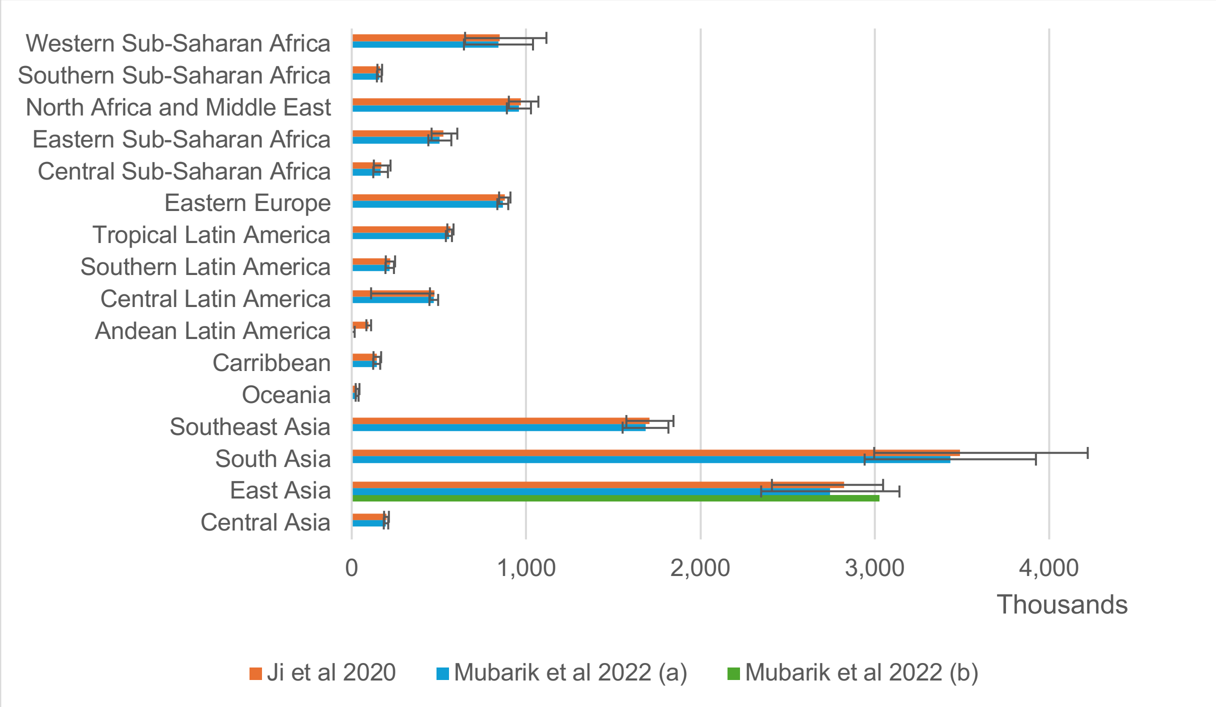


2.3.10 Global

There were 59 studies included that reported burden of disease globally or across multiple WHO regions. Of these, 51 (86.44%) used GBD data, with GBD 2019 the most frequently used with 23 studies (38.98%). WHO Global Health Estimates were used by three (6.78%) studies. GLOBOCAN 2008 was used by one (1.69%) study, Surgeons OverSeas Assessment Survey (SOAS) was used by one (1.69%) study, WHO Disease Control Priorities used by one (1.69%) study and a combination of Beard et al 2013 and US Census database was used by one (1.69%) study. Cancers were studied by 43 (72.88%) studies, with breast cancer the most commonly studied, by six (10.17%) studies.

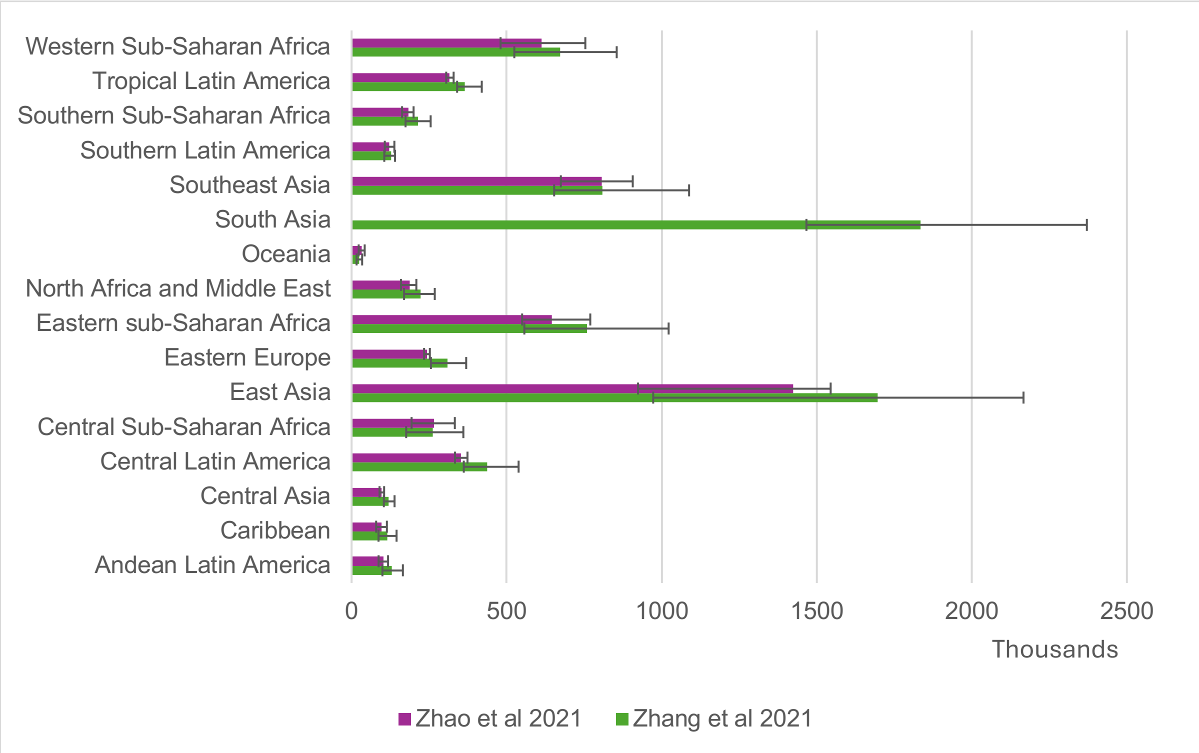
Of the six studies reporting breast cancer, Yi et al 2021 reported breast, ovarian, cervical and uterine cancer by World Bank income status(137) This study reported that of the female reproductive cancers, breast caused the highest burden, and the burden was highest in Middle Income countries. Allaqholi et al 2022 used GBD 2019 data and estimated the highest burden of breast cancer in the South East Asia Region at 4,512,018 (3,779,387-5,324,973) DALYs.(138) This study analysed regions by WHO regions rather than GBD regions and for this reason has not been displayed in Figure 22. Liu et al 2022 reported that DALYs due to breast cancer in China and the East Asian region increased significantly from 1990 to 2019, estimating 29,574,500 (24,085,100-39,501,700) DALYs due to breast cancer in China alone. Lv et al 2022 reported that the burden of DALYs was highest in Lower Middle Income countries with an increasing burden when compared to 1990.(139) The DALYs due to breast cancer globally were estimated by Mubarik et al 2022(a) and Ji et al 2020, both using GBD 2017 data, and have been displayed in Figure 22.(140,141) These two studies both show that South Asia has the highest burden, followed by East Asia and Southeast Asia. Mubarik et al 2022 (b) used GBD 2019 data and reported a higher figure of 3,024,987 (2,477,984, 3,659,370) DALYs and this is also displayed in Figure 22.(142)

Figure 2-22. *DALYs (in thousands) due to breast cancer globally with 95% CIs.*



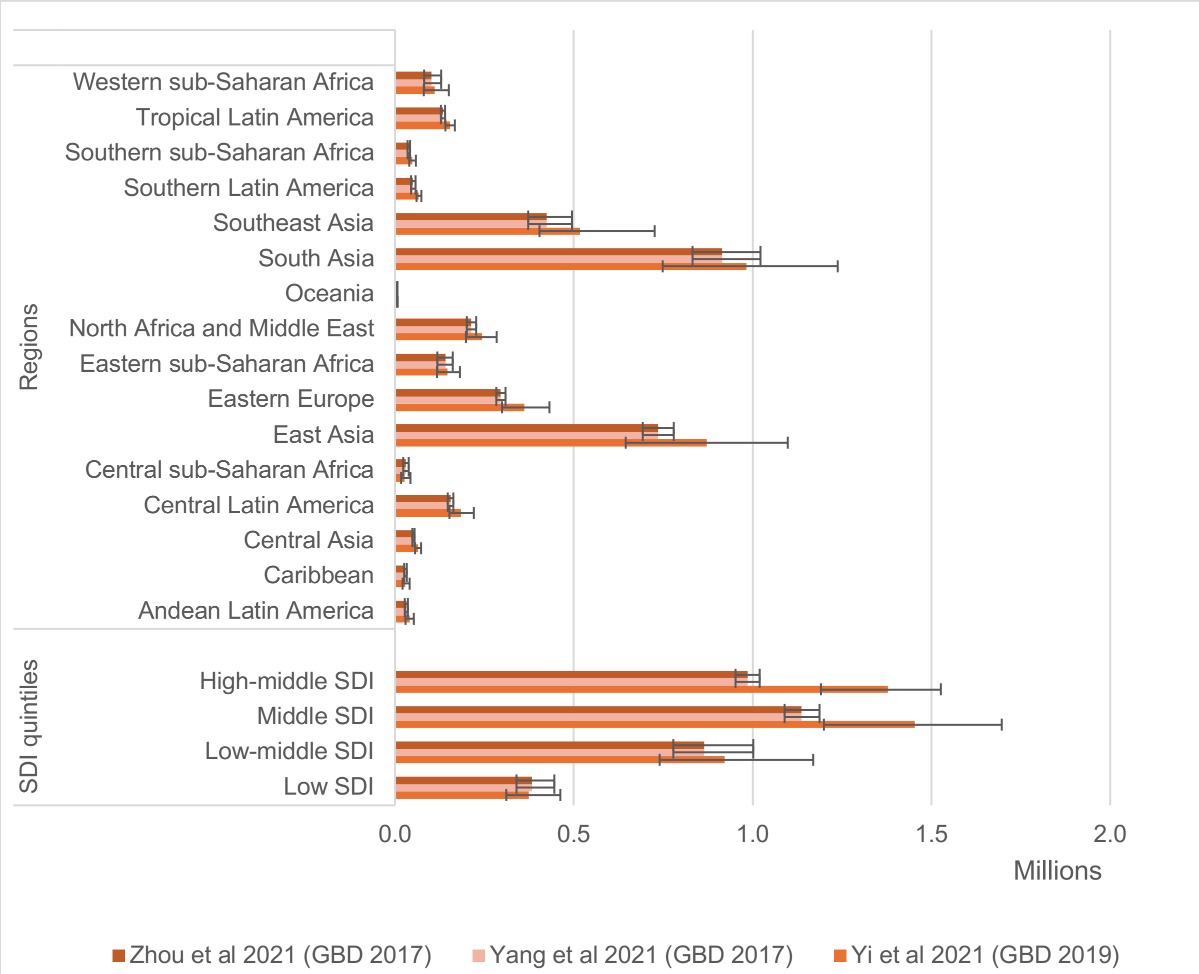
Four studies reported the burden of cervical cancer. Momenimovahed et al 2022 used WHO regions as opposed to GBD regions and reported South East Asia as the region with the highest burden of disease at 2,258,636 (1,842,723-2,972,147) DALYs using GBD 2019 data.(143) Zhao et al 2021 used GBD 2017 data whereas Zhang et al 2021 used GBD 2019 data to report the global burden of cervical cancer – see Figure 23.(144,145) Both studies reported similar trends, Zhao et al 2021 reporting East Asia as the highest burden region, whereas Zhang et al 2021 reported South Asia as having the highest burden followed by East Asia and South East Asia. Overall, there was an increase in burden of cervical cancer from 2017 to 2019 according to the GBD data. Yi et al 2021 used GBD 2019 data and studied burden by sociodemographic index (SDI) quintiles - SDI value is a measure of a country's development status, which is scored from 0 to 1 by calculating the geometric mean of fertility rate, length of education, and per capita income.(137) The authors reported the highest burden was in the Middle SDI quintile with 2,817,250 (2,223,190 ~ 3,217,720) DALYs.(137)

Figure 2-23. *DALYs (in thousands) due to cervical cancer globally with 95% Cis..*



Yang et al 2021 used GBD 2017 estimates to report the global burden of ovarian cancer, both by SDI quintile and region. This study reported South Asia as having the highest burden at 914,746 (831,993 - 1,021,947) DALYs.(146) Zhou et al 2021 performed a similar analysis using GBD 2017 data. This study reported almost identical results to Yang et al 2021.(147) Yi et al 2021 also reported the burden of ovarian cancer globally, by SDI quintile and region but using GBD 2019 data. The authors reported a general increase in the burden of ovarian cancer (see Figure 24), South Asia again having the highest burden at 982,470 (748,580 - 1,238,010) DALYs.(137)

Figure 2-24. *DALYs (in millions) due to ovarian cancer globally with 95% CIs.*



Two included studies reported the burden of nasopharyngeal cancer globally, both using GBD data sets.(148,149) Ramsey et al 2019 used GBD 2015 data to analyse the world on a national basis and reported Malaysia having the highest burden worldwide with a DALY rate of 90.04 DALYs/100,000.(148) Zhang et al 2022 used GBD 2019 to analyse the world on a regional basis and reported Central Asia and the Caribbean as having the highest increase in age-standardised DALYs, East Asia as having the highest overall burden of DALYs and South East Asia as highest the DALY rate at 52.27/100,000. On a national level, Malaysia was again reported as having the highest rate at 152.29/100,000 based on 2019 GBD data.(148)

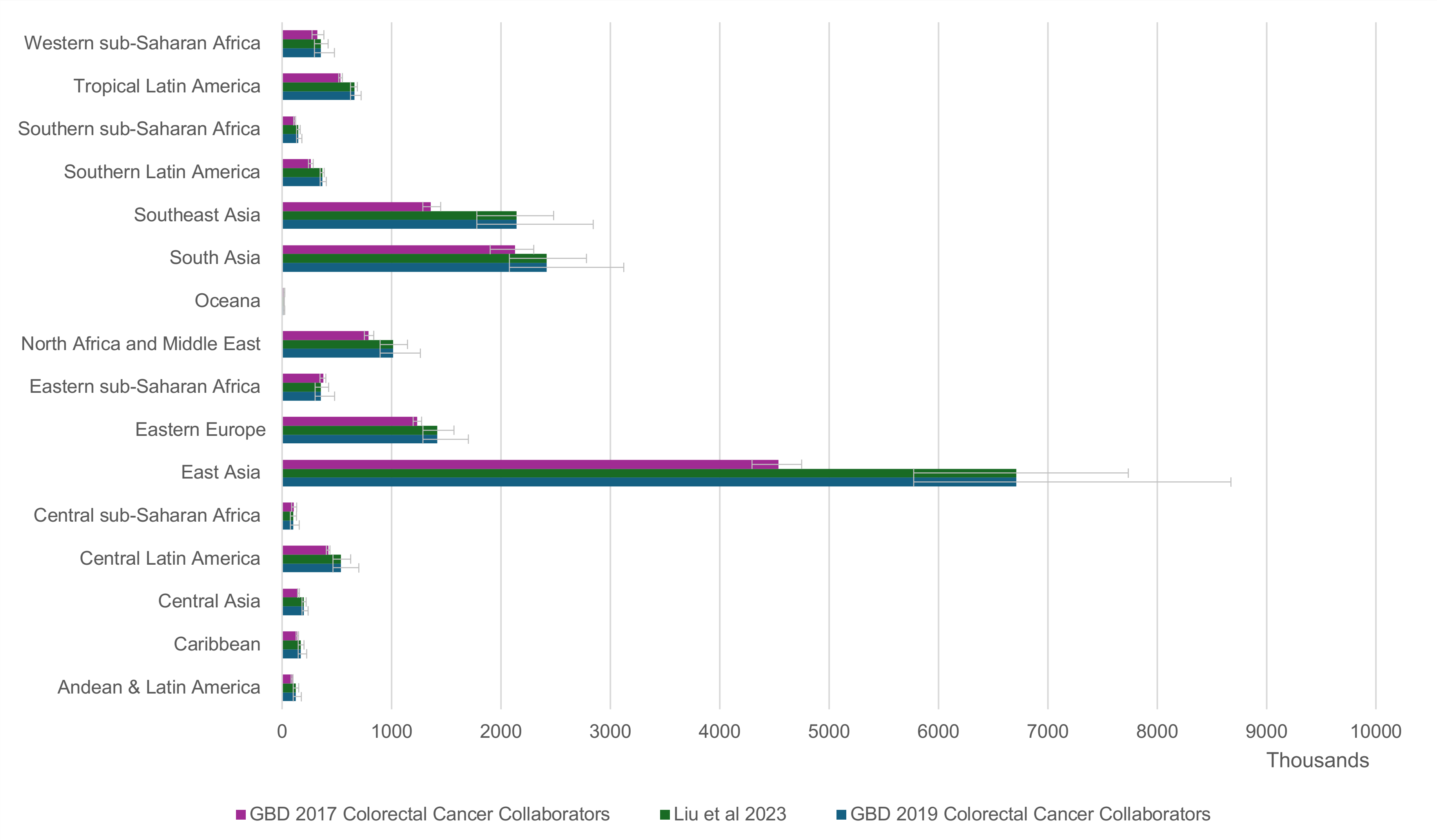
Two studies reported the global burden of oral cancer.(128,150) Ren et al 2020 used GBD 2017 data on a regional basis and reported South Asia having the highest DALY rate at 180.83 (165.54-195.14) DALY/100,000.(150) Zhang et al 2022 used GBF 2019 data to analyse the burden in the ten most populous countries in the world on a national basis. India was reported as having the highest burden with

1,922,663.79 DALYs. Pakistan had the highest age-standardised DALY rate (421.87/100,000 and China had the highest rate of increase (158.62%).(128)

Two studies reported the burden of pancreatic cancer, both using GBD 2017 data.(151,152) The GBD 2017 Pancreatic Cancer Collaborators estimated China as having the highest overall burden with 1,890,853 (1,801,159-1,974,469) and Armenia as having the highest DALY rate of LMICs at 191.5 (180.7-202.2) DALYs/100,000 causing 8027 (7588-8486) DALYs.(152) Lippi & Mattiuzi 2020 estimated the burden by regions based on their SDI values and reported that DALY rates increased with increasing SDI, with low SDI values reporting 753 DALYs per million and high-middle SDI values reporting 59888 DALYs per million.(151)

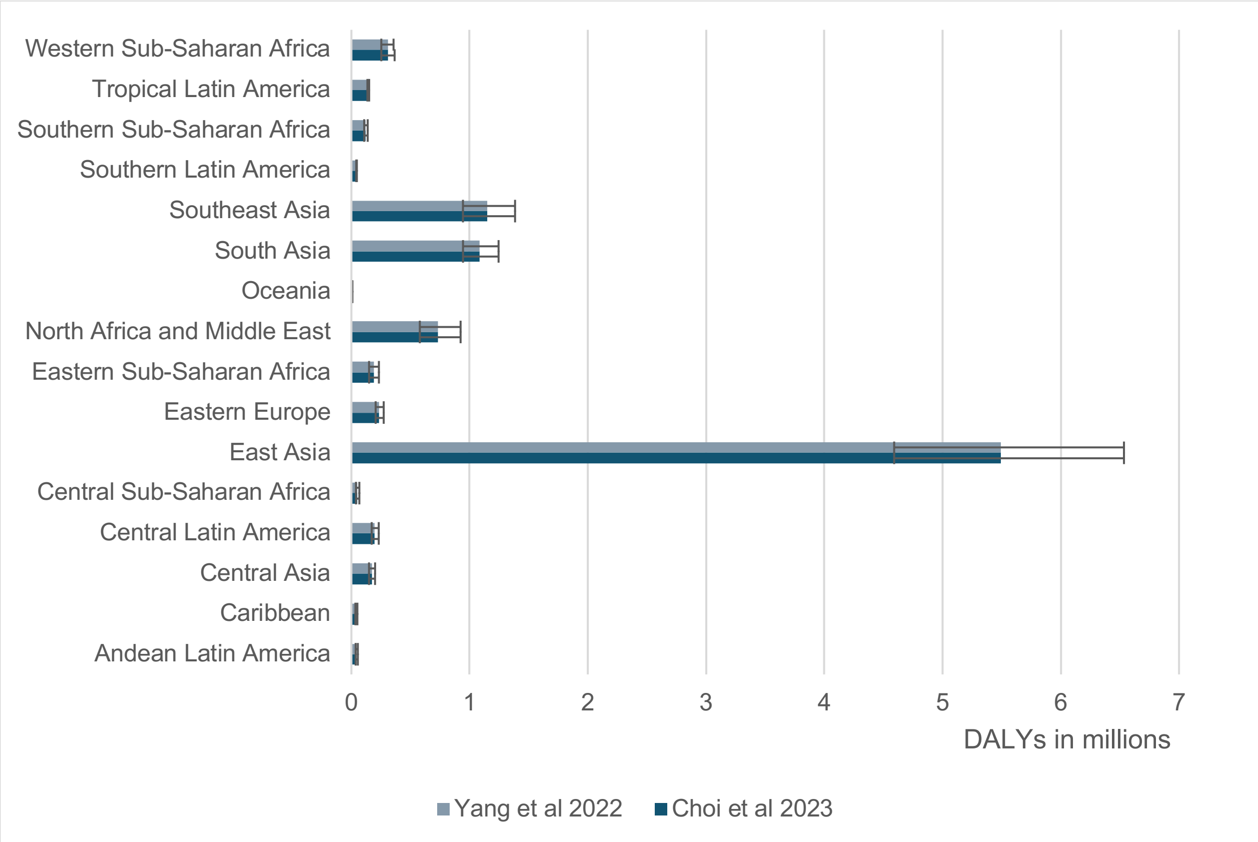
Of the five (10.00%) studies reporting colorectal cancer, one reported early onset cancer only, and one reported figures in DALY rates per 100,000. The other three studies have been displayed in Figure 25. All three studies used GBD data, the 2017 and 2019 GBD Colorectal Cancer Collaborators using the respective datasets and Liu et al using GBD 2019 data.(153–155) All of these studies highlight that East Asia has the highest burden of colorectal cancer, followed by South Asia and South East Asia. Wu et al 2023 used GBD 2019 data to assess the age-standardised DALY rate due to colorectal cancer and found East Asia reporting the highest increase although the highest overall DALY rate was Southern Latin America (excluding high income regions).(156) Pan et al 2022 studied early onset (aged less than 50 years old) colorectal carcinoma, and also reported the highest burden in East Asia.(157)

Figure 2-25. *DALYs due to colorectal cancer globally with 95% confidence intervals.*



Two includes studies reported the burden of primary liver cancer, both using GBD 2019 data on a regional basis.(158,159) Both studies reported the exact same figures with East Asia having the highest DALY rate and overall burden with 5,491,479 (4,590,535 – 6,534,290) DALYs – see Figure 26. Central Asia reported the highest increase at 150.2%.(158,159)

Figure 2-26. *DALYs (in millions) due to primary liver cancer on a regional basis with 95% CIs.*



Two studies reported the burden of kidney cancer globally, both used GBD 2017 estimates and reported very similar results.(160,161) Both studies reported East Asia as having the highest burden with Bai et al 2020 reporting 472,460 (417,970 – 507,410) DALYs and Safiri et al 2020 reporting 472,461 (417,968 - 507,412) DALYs – see Figure 27.

Two studies reported the burden of thyroid cancer globally, both using GBD 2017 data and reporting the exact same estimates.(162,163) Both studies reported South Asia as having the highest overall burden with 297,710 DALYs – see Figure 28.

Figure 2-28. *DALYs (in thousands) due to kidney cancer globally, with 95% CIs.*

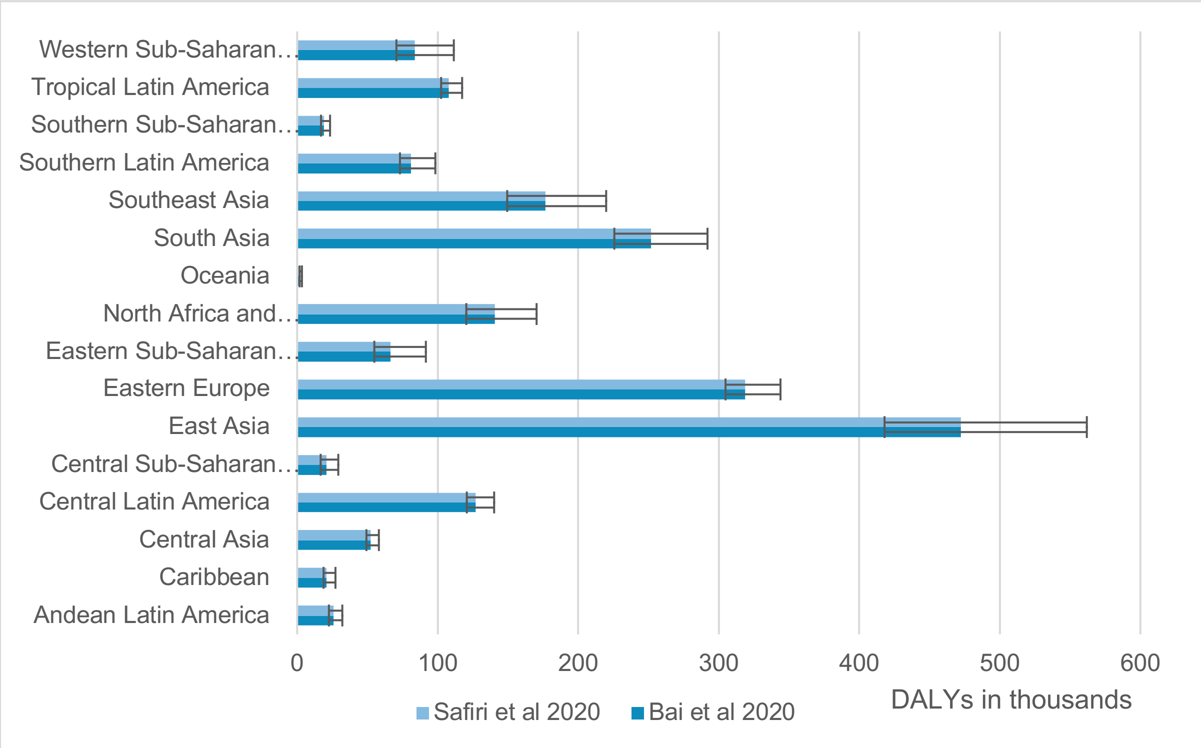
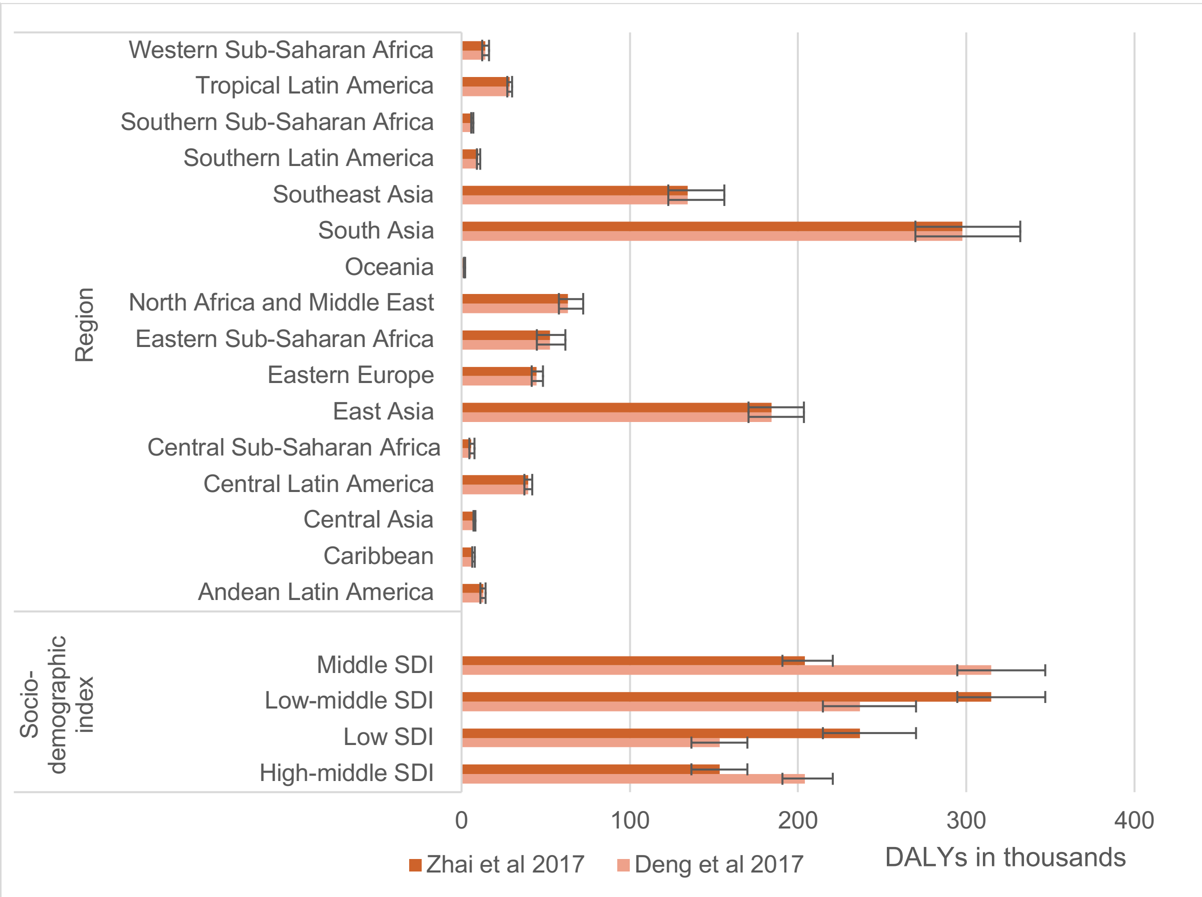


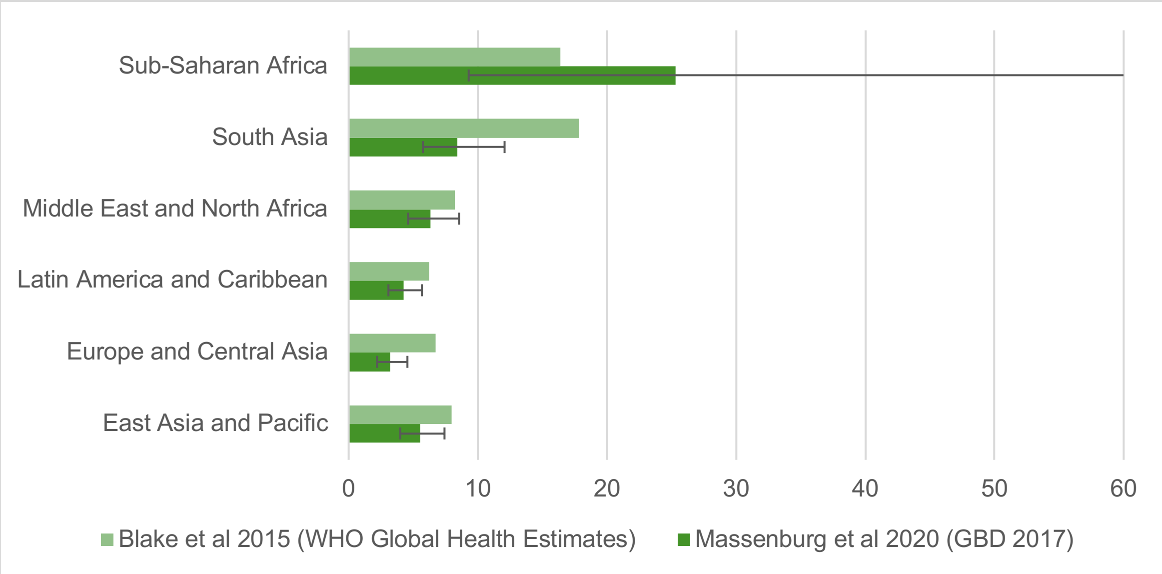
Figure 2-27. *DALYs (in thousands) due to thyroid cancer globally, with 95% CIs.*



Two studies were included that reported the burden of brain and central nervous system (CNS) cancers.(164,165) The GBD 2016 Brain and Other CNS Cancer Collaborators reported East Asia having the highest burden with 1,986,794 (1,793,427 – 2,244,266) DALYs.(165) Age standardised DALY rates were highest in tropical Latin America at 151.07 DALYs/100,000.(165) Kang et al 2021 used GBD 2019 data and analysed South East Asia and Western Pacific WHO regions.(164) The authors reported South East Asia as having 1,532,948 (1,153,447 - 1,796,140) DALYs and Western Pacific 2,470,092 (1,887,397 – 2,919,034) DALYs, this difference is largely due to China being part of the Western Pacific WHO region rather than the East Asia GBD region.

Four studies reported the burden of congenital anomalies.(166–169) Higashi et al 2015 used GBD 2010 estimates to report the burden of three congenital anomalies (orofacial clefts, congenital heart anomalies, neural tube defects) that were estimated to be amenable to surgery in LMICs. The authors estimated that South Asia had the highest burden of congenital anomalies amenable to surgery at 4,030,975 DALYs and estimated the total burden amenable to surgery in all LMICs was 12,408,485 DALYs. South Asia was estimated to have the highest burden of orofacial clefts (128,182 DALYs) and neural tube defects (2,923,628 DALYs), whereas East Asia Pacific was estimated to have the highest burden of congenital heart defects (2,774,235 DALYs).(167) Farmer et al 2015 used WHO Global Health Estimates 2013 to estimate the global burden of congenital anomalies.(168) The authors report a total global burden of 57 million DALYs and that cardiac anomalies make up the largest part of this with over 20 million DALYs. Blake et al 2015 used WHO Global Health Estimates 2013 to estimate the global burden of orofacial cleft, and reported South Asia as having the highest burden at 17.85 DALYs per 100,000 – Figure 29.(169) Massenburg et al 2020 used GBD 2017 data to estimate the burden of orofacial cleft globally – also Figure 29.(166) The authors reported the burden reduced in every region across the world from 1990-2017 and estimated the highest burden was in sub-Saharan Africa at 25.29 (9.29-61.61) DALYs/100,000 and the countries with the highest burden were Burundi 89.14 (13.76-290.57) DALYs/100,000, Central Africa Republic 71.90 (13.48-228.70) DALYs/100,000 and Sierra Leone 57.44 (14.57-168.10) DALYs/100,000.(166)

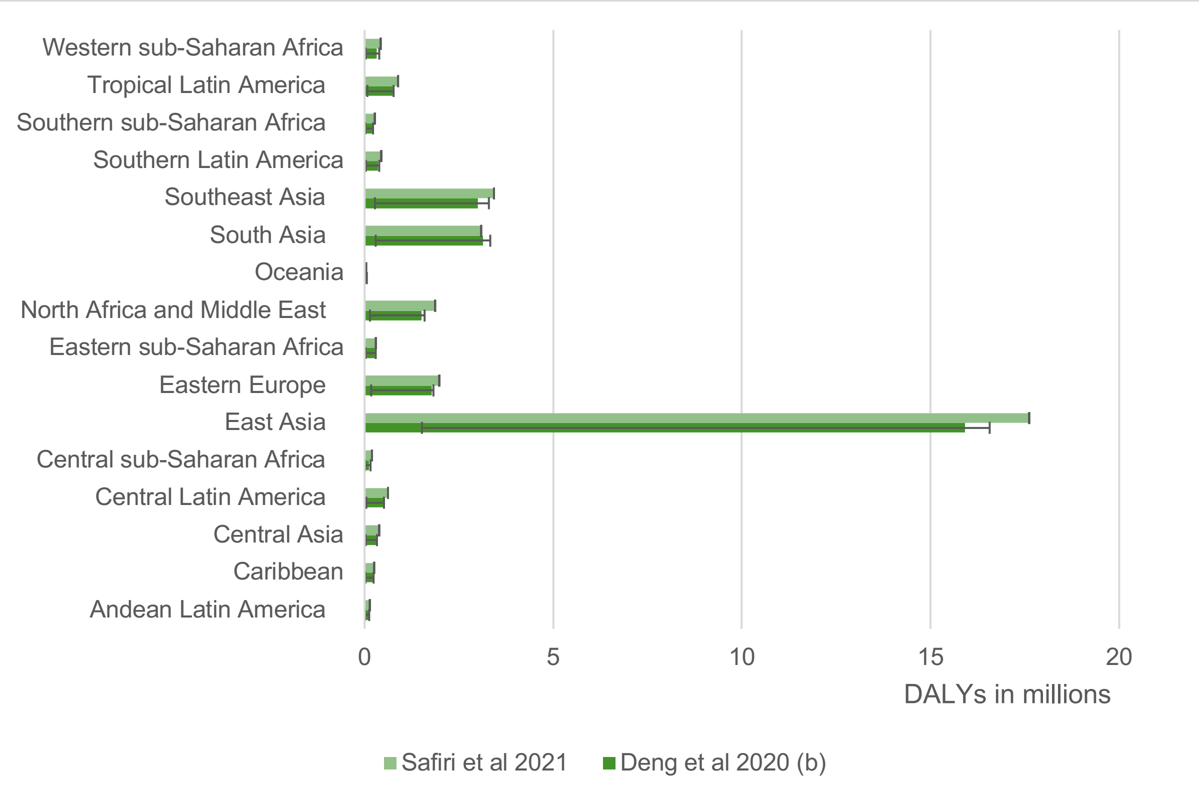
Figure 2-29. *DALYs/100,000 globally for orofacial cleft, with 95% CIs for the one study that*



Four studies reported the burden of respiratory tract cancers globally.(170–173) Deng et al 2020(a) reported the burden of larynx cancer globally using GBD 2017 estimates.(173) The authors reported South Asia having the highest burden with 1,236,890 (1,170,380 – 1,309,340) DALYs.(173) This study also highlighted that although DALYs increased from 1990 – 2017, the DALY rate showed a downward trend. Deng et al 2020(b) used the same GBD 2017 estimates to reported the burden of TBL cancers globally.(171) The study reported East Asia as having the highest burden at 15,905,050 (15,198,330 – 16,566,970) DALYs, and additionally that DALYs due to trachea, bronchial and lung (TBL) cancer were increasing worldwide.(171) (172) Safiri et al 2021 also used GBD 2019 estimates to report DALYs due to TBL cancer globally.(170) Showing similar results to the Deng et al 2020 (b) (see Figure 30), the authors reported a rising burden of DALYs due to TBL cancer, estimating East Asia as the region with the highest burden at 17,614,063 (14,810,292, 20,721,521) DALYs.(170) The GBD 2019 Respiratory Tract Collaborators reported that the age-standardised DALY rates for TBL cancer as well as larynx fell from 2010-2019.(172) For TBL cancer, DALY rates were highest in the high-middle SDI quintile at 680.7 (620.1-743.5) DALYs/100,000 and lowest in the low SDI quintile at 291.9 (188.7-259.9) DALYs/100,000.(172) DALY rates due to larynx cancer were highest in the low-middle SDI quintile at 563. (49.2-64.6)

DALYs/100,000 and lowest in the high SDI quintile at 20.1 (19.1-21.2) DALYs/100,000.

Figure 2-30. *DALYs (in millions) due to tracheal, bronchial and lung cancers globally with 95% CIs.*



Two studies reported multiple cancer types globally; John & Ross 2010 and Kocarnik et al 2022.(174,175) Kocarnik et al 2022 used GBD 2019 estimates to report the burden of cancers across the world by SDI quintiles.(175) The study reports that the burden of cancer is rising from 216,000,000 (208,000,000 – 223,000,000) DALYs in 2010 to 250,000,000 (235,000,000 – 264,000,000) DALYs in 2019 and was the second largest cause of death globally, behind only cardiovascular diseases.(175) TBL cancers caused the highest burden at 45,900,000 (42,300,000 – 49,300,000) followed by colorectal cancer at 24,300,000 (22,600,000 – 25,700,000) DALYs and gastric cancer at 22,200,000 (20,300,000 – 24,100,000) DALYs. When broken down to SDI quintiles, the middle SDI quintile reported the highest burden with 76,300,000 (69,700,000 – 83,200,000) DALYs and the low SDI quintile reported the lowest burden at 18,000,000 (15,900,000 – 20,200,000) DALYs – see Figure 31.

John & Ross 2010 used WHO Global Burden of Disease 2004 estimates to estimate the burden of cancers globally.(174) The authors reported that TBL cancer caused the highest burden at 12,811,000 DALYs, followed by gastric cancer (7,960,000) and liver cancer (7,116,000). They also reported China having the highest overall burden of cancer with 19,302,000 DALYs followed by India with 8,487,000 DALYs – see Figure 32.

Figure 2-31. *DALYs (in millions) due to cancer by SDI grouping by Kocarnik et al 2022.*

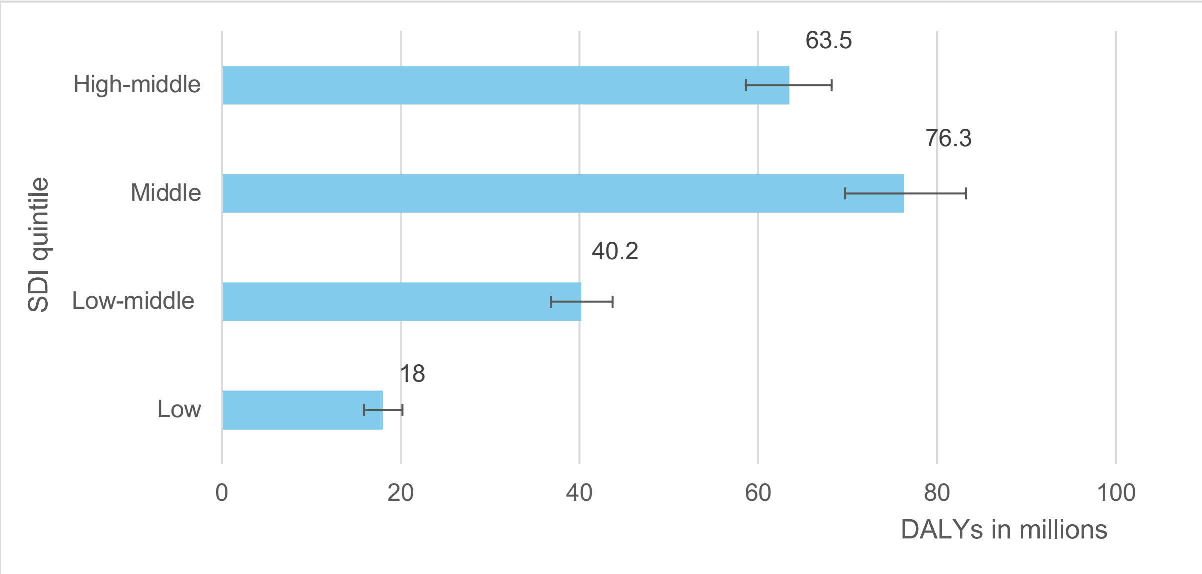
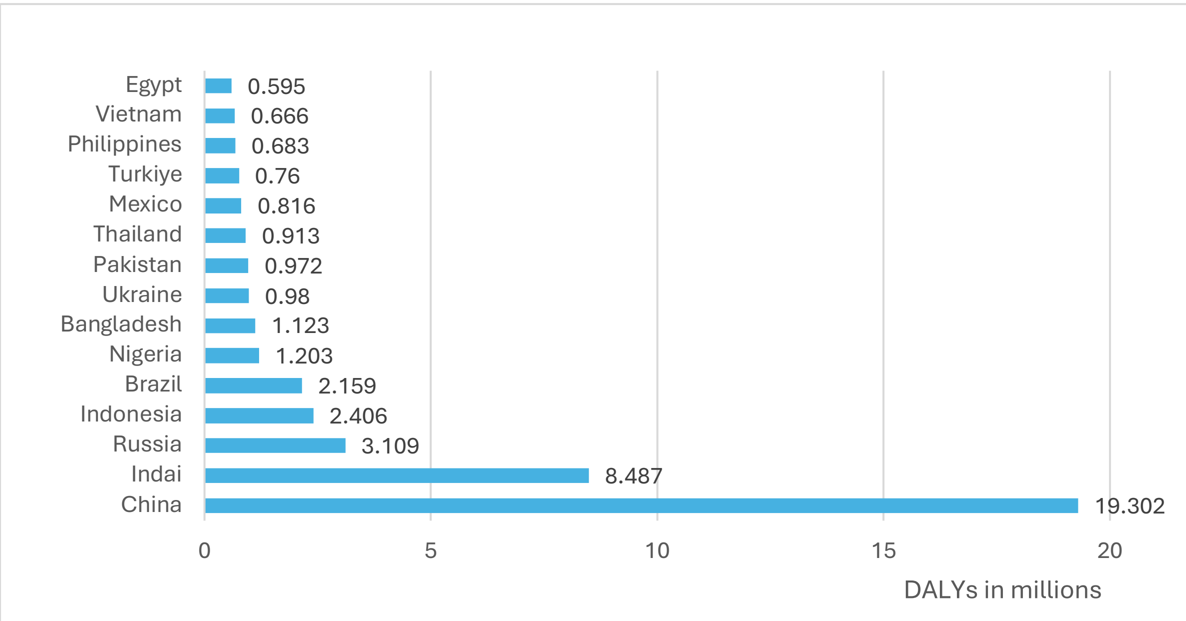
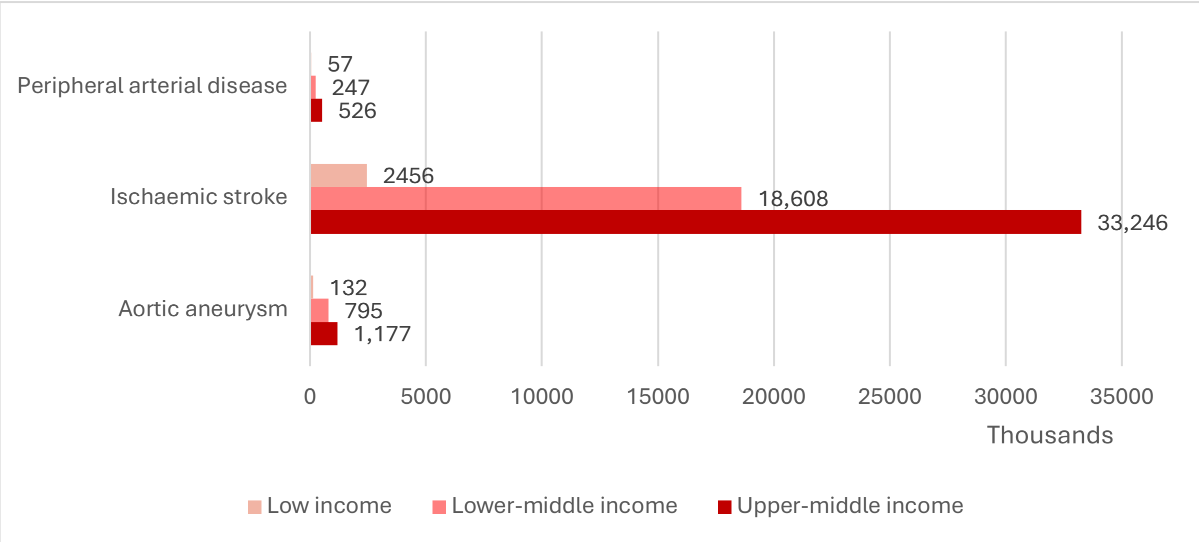


Figure 2-32. *DALYs (in millions) due to cancer in the 25 top highest burden LMIC countries by John*



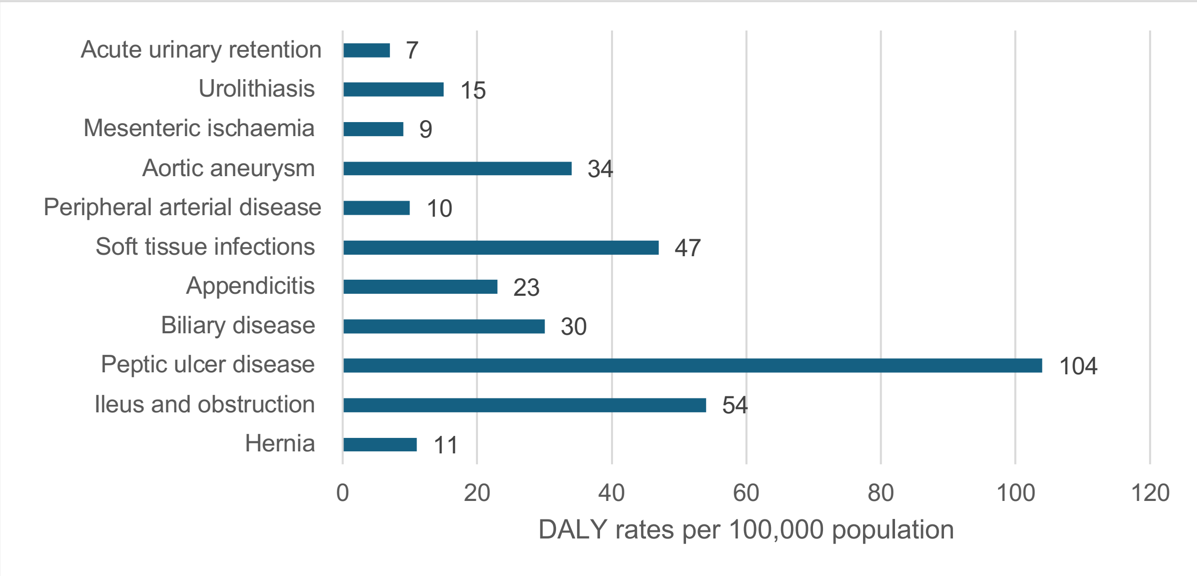
Bencheikh et al 2023 used GBD 2019 data to report the burden of vascular disease in LMICs.(176) The burden of aortic aneurysm, ischaemic stroke and peripheral arterial disease stratified by World Bank income status is shown in Figure 33. This study reports that the burden of aortic aneurysm, ischaemic stroke and peripheral vascular disease are all highest in upper-middle income countries and lowest in low-income countries. This is the case for both absolute DALYs and DALYs/100,000.

<u>Figure 2-33.</u> *DALYs (in thousands) due to vascular diseases by World Bank income status by Bencheikh et al 2023.*



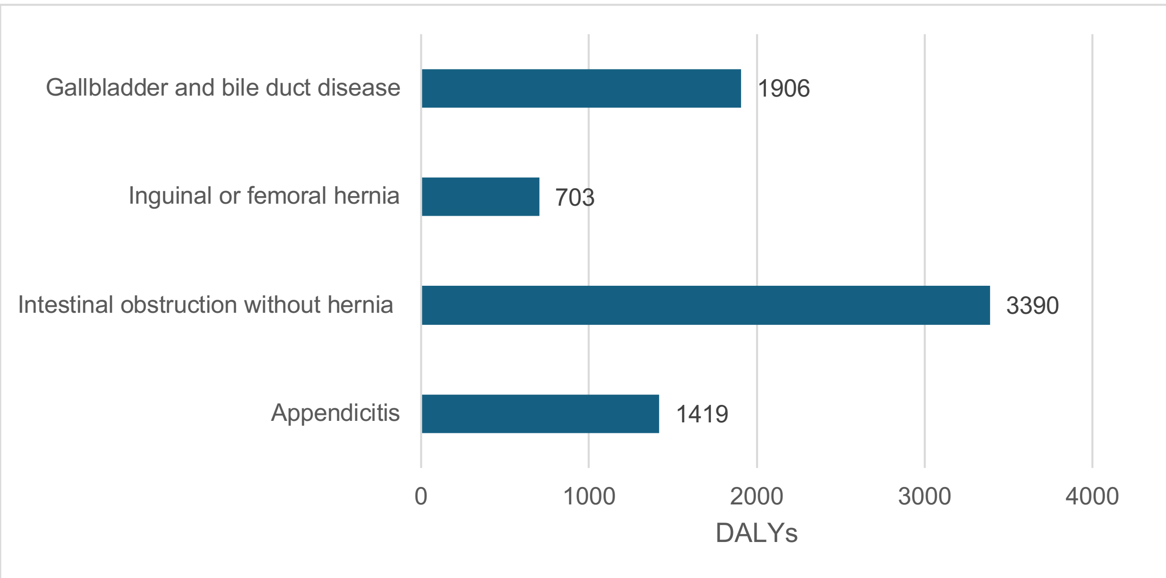
Five studies reported surgical diseases; Stewart et al 2014 and Highashi et al 2015 both used GBD 2010 data to estimate the burden of surgical disease in LMICs.(177,178) Stewart et al 2014 estimated the Peptic Ulcer disease caused the highest rate at approximately 104 DALYs/100,000 followed by ileus and obstruction (54 DALYs/100,000) and soft tissue infections (47 DALYs/100,000). These are reported in Figure 34.

Figure 2-34. *DALYs due to surgical disease in LMICs by Stewart et al 2014.*



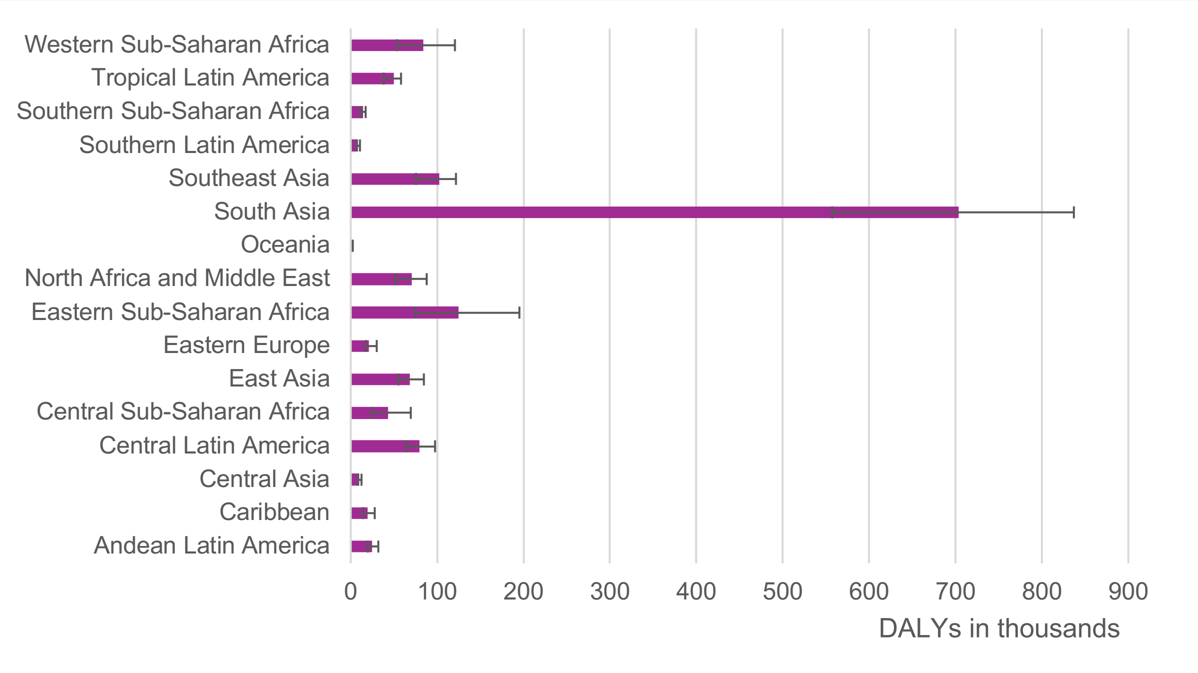
Higashi et al 2015 also used GBD 2010 data to report the absolute number of DALYs due to surgical diseases in LMICs. This study reported intestinal obstruction causing the highest burden at 3,390,000 DALYs followed by biliary pathology (1,906,000 DALYs) and appendicitis (1,419,000 DALYs) as shown in Figure 35.

Figure 2-35. *DALY rates due to surgical disease requiring emergency surgery in LMICs by Higashi*



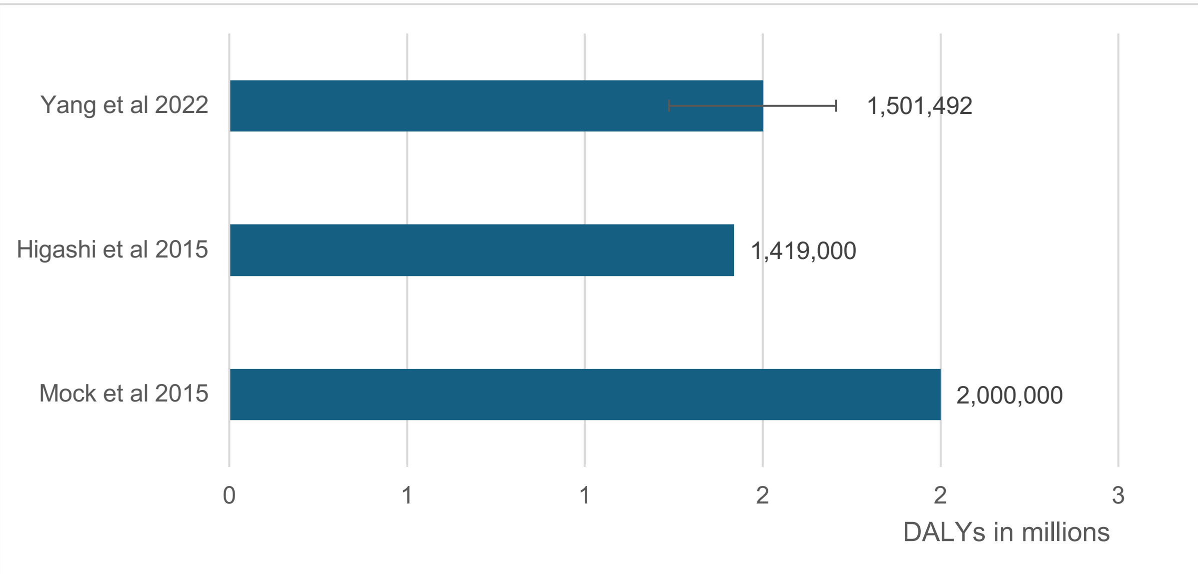
Yang et al 2022 used GBD 2019 data to estimate the burden of appendicitis globally.(179) The authors reported South Asia as having the highest burden at 703,819 (557,425-836,936) – see Figure 36.

Figure 2-36. *DALYs (in thousands) due to appendicitis globally by Yang et al 2022.*



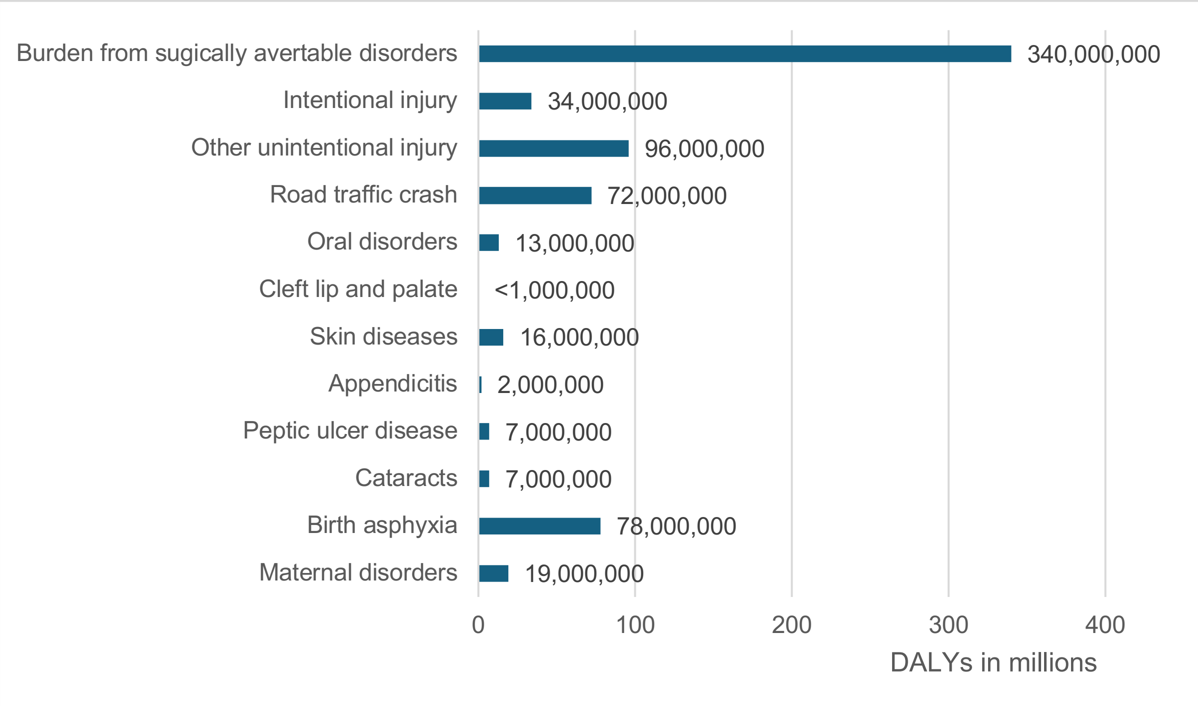
The data from Yang et al 2022 has been displayed alongside the data from Higashi et al 2015 and Mock et al 2015 in Figure 37.

Figure 2-37*. DALYs due to appendicitis in LMICs globally, in millions of DALYs, with 95% CIs for the one study that reported them.*



Mock et al 2015 used WHO Global Health Estimates 2014 to report the burden of disease addressed by surgery across LMICs.(180) The authors estimate the total burden as 340 million DALYs, with the single largest burden due to unintentional injury at 96 million DALYs – see Figure 38.

Figure 2-38. *Burden of disease addressed by surgery in LMICs in millions of DALYs.*

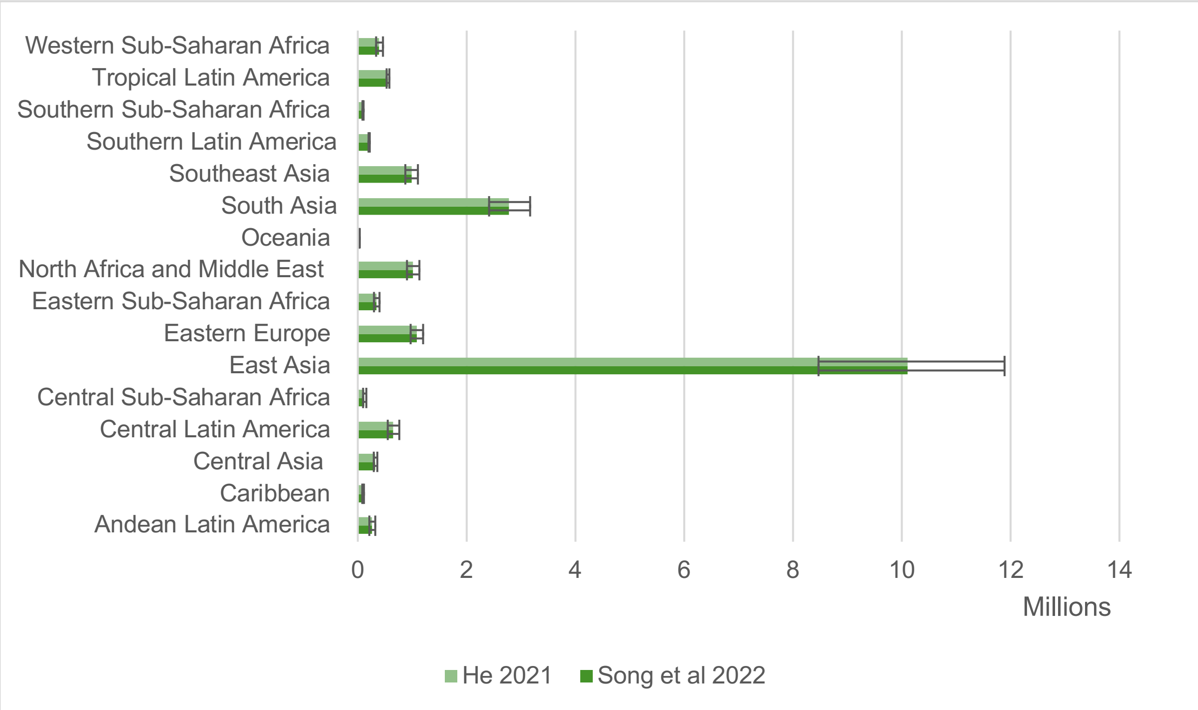


Beard et al 2015 estimated the global burden of groin hernias, using a combination of 2 published studies and the US census database.(181) The authors reports over 3.8 million DALYs worldwide and the Western Pacific region having the highest regional burden with over 1.3 million DALYs.

Higashi et al 2015 used GBD 2010 data to estimate the burden of injuries in LMICs.(182) This study reported that South Asia was the region with the highest burden of overall injuries with 17,445,988 DALYs. Within South Asia, road injuries represented the largest factor causing 4,700,000 DALYs, and was the largest overall, causing 16,100,000 DALYs across all LMICs.(182) Stewart et al 2016 also reported on the burden of fractures, specifically in Sierra Leone and Nepal.(183) The authors used the results of the Surgeons OverSeas Surgical Assessment Survey (SOSAS) conducted in 2014 and reported the burden in Nepal as 741,000 (527,000 – 853,000) DALYs and 597,000 (520,000 – 687,000) DALYs in Sierra Leone.

Two studies reported the burden of gastric cancer globally. Both He et al 2021 and Song et al 2022 used GBD 2019 data to estimate the global burden of gastric cancer – see Figure 39.(184,185) East Asia was estimated to have the highest burden at 15,905.05 (15198.33-16,566.97) DALYs/100,000.(184)

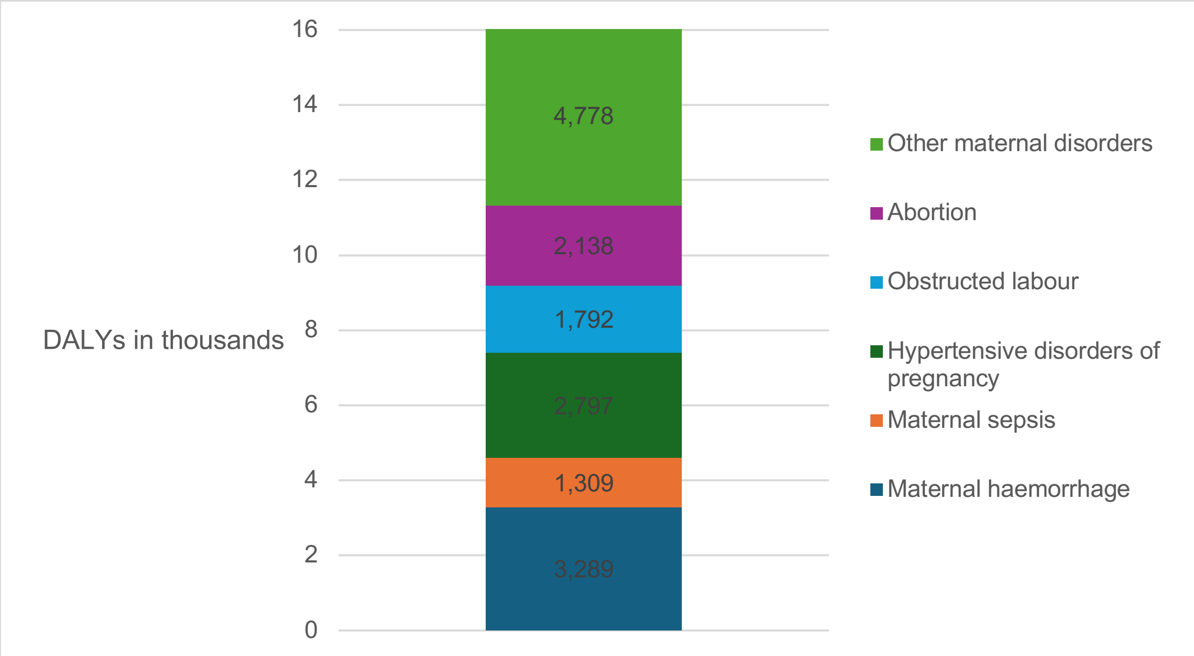
Figure 2-39. *DALYs (in millions) due to gastric cancer globally, with 95% CIs.*



Karimkhani et al 2015 used GBD 2015 data to estimate the global burden of melanoma.(186) Eastern Europe had the highest burden of the regions including LMICs, with a rate of 65.21 (50.91-84.67) DALYs/100,000.

Johnson al 2015 adapted GBD 2010 estimates reported in Murray et al 2012 to report the burden of obstetric conditions worldwide in *Essential Surgery, Chapter 5: Obstetric Surgery.*(187,188) These studies estimated that all maternal disorders caused 16,104,000 (12,972,000 – 18,912,000) and the largest single contributor to this burden was from maternal haemorrhage which caused 3,289,000 DALYs(2,619,000 – 3,860,000) – see Figure 40.(187,189)

Figure 2-40. *DALYs (in thousands) of maternal disorders by Johnson et al 2015.*



He et al 2020 used GBD 2017 data to estimate the burden of bladder cancer globally.(190) The study reported East Asia as having the highest burden at 621,400 DALYs, excluding HIC regions.(190)

Niederman et al 2015 used WHO Global Health Estimates 2013 to report the global burden of dental disease.(191) The authors reported the total burden at over 15 million DALYs and that periodontitis was the most significant contributor with over 5.5 million DALYs. South Asia had the highest number of DALYs regionally with over 3.5million DALYs.

Khanali et al 2021 used GBD 2017 data to estimate the global burden of gallbladder and biliary tract cancer.(192) The authors reported that, of the regions containing LMICs, East Asia had the highest burden at 619,726 (474,276 – 679,363) DALYs although South Asia had a higher age-standardised DALY rate at 86.3 DALYs/100,00 compared to 29.8 DALYs/100,000 in East Asia.(192)

Di Pardo et al 2016 used GLOBOCAN 2008 data to estimate the burden of oesophageal cancer globally and for the five ‘less developed nations’ with the highest burden. The authors reported 3,955,919 DALYs globally and China having the highest burden by number of DALYs (1,885,642) whereas South Africa had the highest rate at 1.62/100,000 – see Figures 42 and 41.

Figure 2-41. *DALYs (in millions) due to Oesophageal cancer globally.*

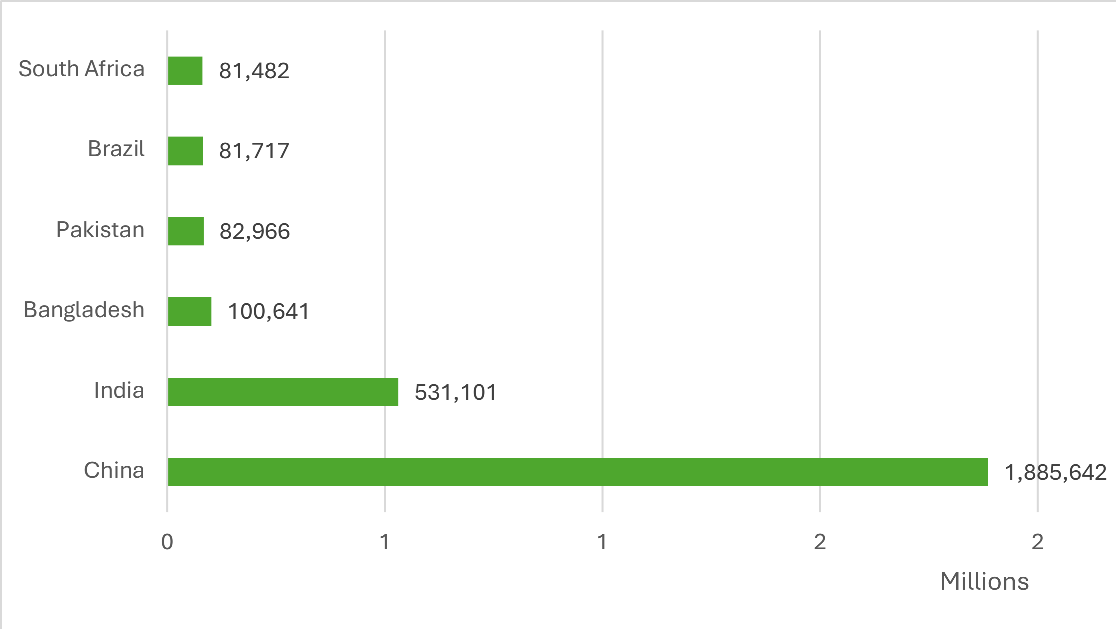
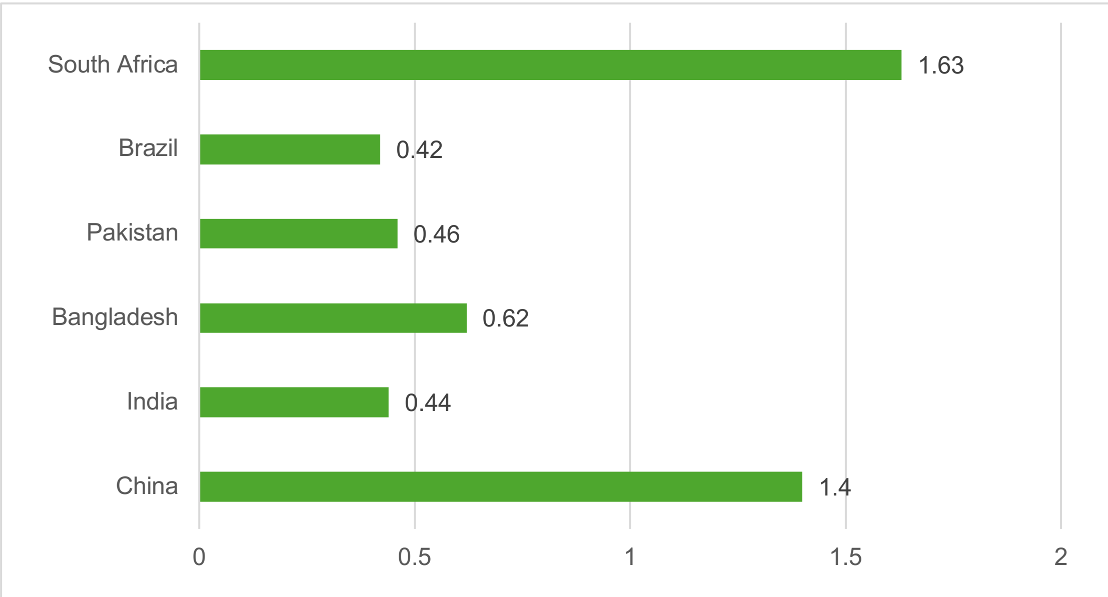


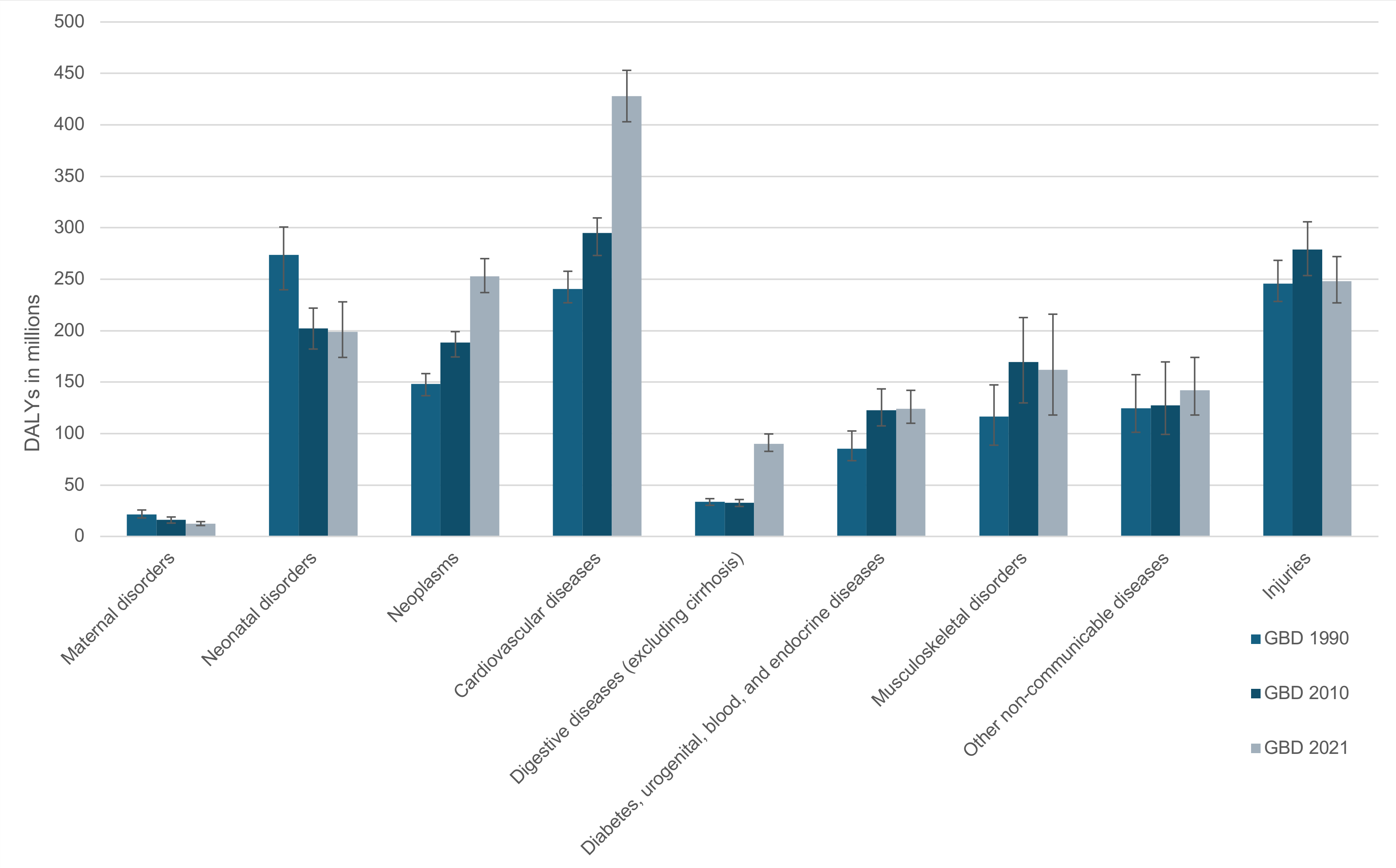
Figure 2-42. *DALY rates/100,000 due to oesohpageal cancer globally.*



Murray et al 2013 was one of the main studies from the GBD 2010 collaborators. This study provided an overview of the burden of disease by major disease groupings globally and compared this to the original GBD 1990 data. The two datasets are shown in Figure 43. This study highlighted the trend of reducing disease burden from communicable, neonatal, maternal and nutritional disorders and the rising burden of non-communicable, cardiovascular, neoplasms, diabetes, musculoskeletal and injuries.(193)

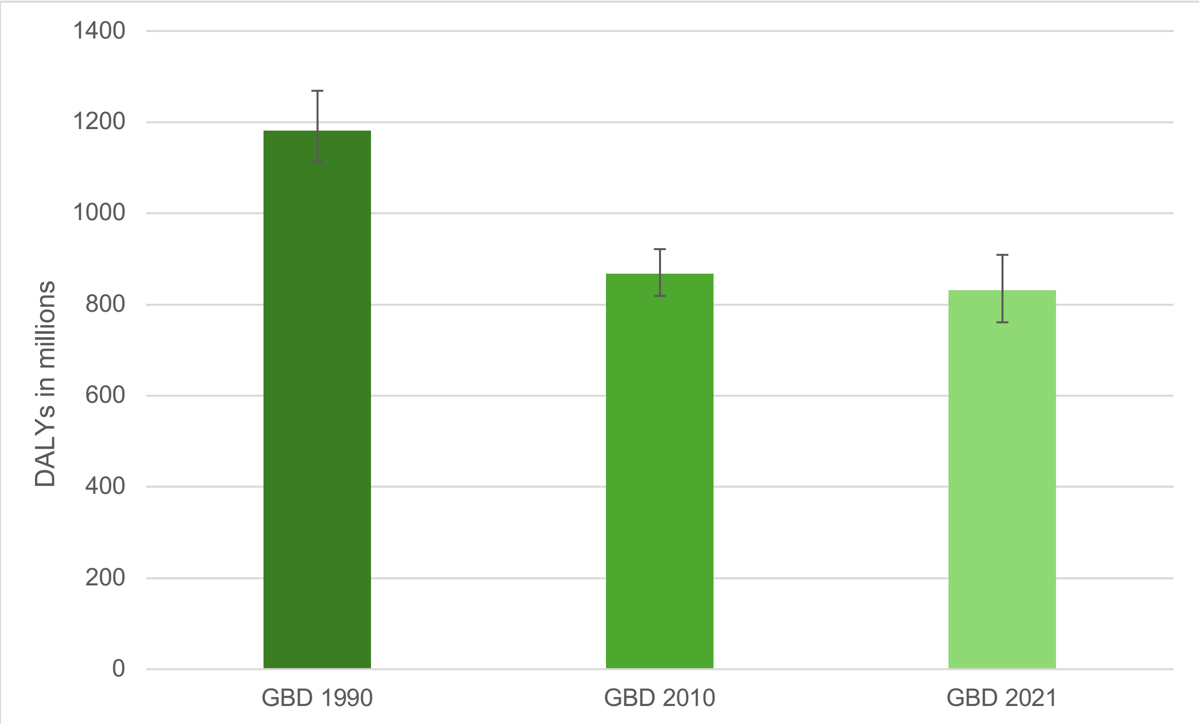
Ferrari et al 2024 reported updated DALYs from 371 diseases and injuries using the updated GBD2021 data on behalf of the GBD 2021 Diseases and Injuries Collaborators. (194) These data are also displayed in Figure 43 alongside GBD data from 1990 and 2010 taken from Murray et al 2013. Note caution must be applied to comparing the different publications of the GBD data as the estimate for each year is revised on every new iteration of the data set. The trends highlight the increasing burden of neoplasm, cardiovascular and digestive disease alongside a reduction in maternal and neonatal disorders alongside a new reduction in DALYs due to injury.

Figure 2-43. *DALYs (in millions) due to surgical disease groupings globally from 1990 – 2021 with 95% CIs from Murray et al 2013 and Ferrari et al 2024.*



For comparison of the trend of the surgical burden of disease against other categories, the DALYs due to communicable diseases have been displayed in Figure 44, below. This highlights the falling burden of disease form communicable diseases, despite the increasing population.

Figure 2-44. *DALYs due to communicable diseases with confidence intervals, from Murray et al 2013 and Ferrari et al 2024.*



2.3.11 Risk of Bias

As no meta-analysis was performed, and all studies were either observational or based on observational data, no studies were removed due to the risk of bias (ROB). Concerns regarding the risk of bias have been highlighted in the associated text. A formal ROB assessment was undertaken by one researcher following the JBI checklist for analytical cross-sectional studies or the ROBIS tool for systematic reviews as appropriate.(72,73) The full ROB assessments using either the JBI checklist (for observational studies) or the ROBIS tool (for systematic reviews) can be found in Tables 2 - 5.

2.3.12 Certainty of evidence

Given that all studies were observational in nature, or systematic reviews of observational studies, the starting rating of certainty of evidence was ‘low’, following the GRADE methodology.(71) Certainty of evidence was upgraded for large database studies with rigorous methodology, for example the Global Burden of Disease (GBD) study, and downgraded for high or moderate risk of bias or no estimate of precision. A significant majority, (92, 83.64%) of studies were ranked ‘moderate’ certainty, 12 (10.90%) were rated ‘low’ certainty and 6 (5.45%) ‘very low’. – see Figure 45.

Figure 2-45. *GRADE ranking of included studies.*

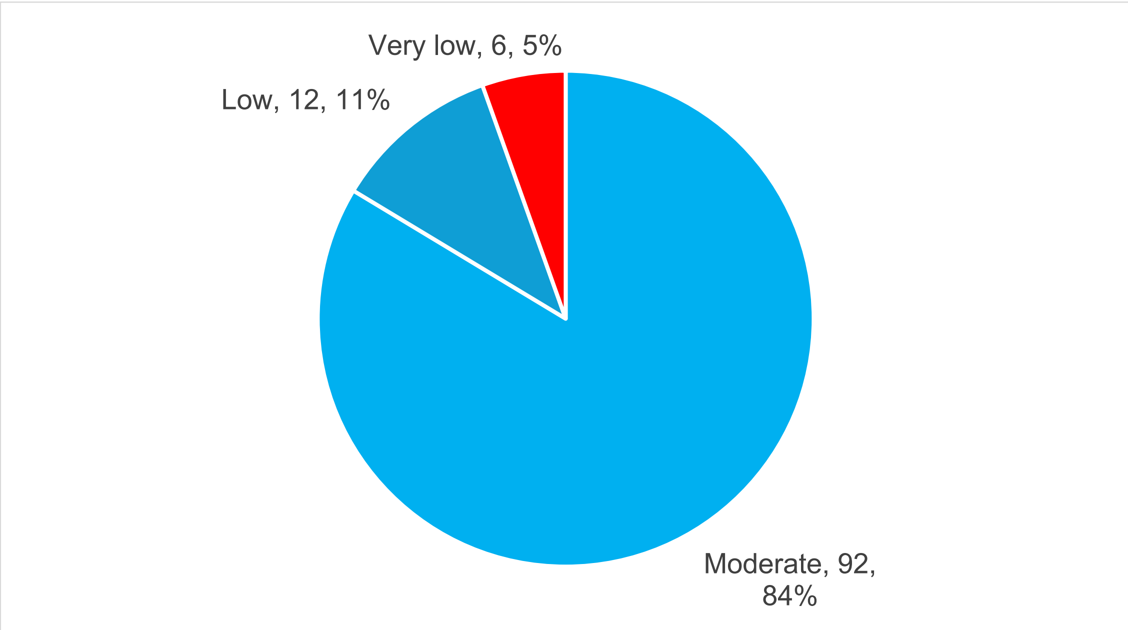


Table 2-3. *Risk of bias assessment and GRADE rating for the included studies, excluding the one systematic review.*

Name of paper	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**GRADE rating**
Abbasi-Kangevari et al 2022	Yes	Yes	N/A	N/A	Yes	N/A	Yes	Yes	Unclear	Moderate
Al-Hajj et al 2020	Yes	Unclear	N/A	Yes	No	N/A	Yes	Yes	Unclear	Moderate
Allahqoli et al 2022	Yes	No	N/A	Yes	N/A	N/A	Yes	Yes	Unclear	Moderate
GBD 2019 Colorectal Cancer Collaborators	Yes	Unclear	N/A	Yes	Unclear	N/A	Yes	Yes	Unclear	Moderate
Alkire et al 2011	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Moderate
GBD 2019 Respiratory Tract Cancer Collaborators	Yes	Unclear	N/A	Yes	Yes	Yes	Yes	Yes	Unclear	Moderate
India State-Level Disease Burden Initiative Cancer Collaborators	Yes	Unclear	N/A	Yes	No	N/A	Yes	Yes	Unclear	Moderate
Awedew et al 2022	Yes	No	N/A	Yes	Yes	No	Yes	Yes	Unclear	Moderate
Awedew et al 2022	Yes	No	N/A	Yes	No	N/A	Yes	Yes	Unclear	Moderate
Badrinath et al 2014	Yes	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Unclear	Low
Bai et al 2020	Unclear	No	N/A	Yes	No	N/A	Yes	Yes	Unclear	Moderate
Bawazir 2017	No	No	N/A	Yes	Yes	Yes	Yes	Yes	Unclear	Moderate
Beard et al 2013	Unclear	No	N/A	No	No	N/A	Yes	Yes	Unclear	Very low
Bencheikh et al 2023	Yes	No	N/A	Yes	Yes	No	Yes	Yes	Unclear	Moderate
Cairo et al 2017	Yes	Yes	N/A	Yes	Yes	No	Yes	Yes	Unclear	Low
Choi et al 2023	No	No	N/A	Yes	Unclear	No	Yes	Yes	Unclear	Moderate
GBD 2015 ENRO Transportation Injuries Collaborators	Unclear	No	N/A	Yes	No	N/A	Yes	Yes	Unclear	Moderate
GBD 2015 EMRO Cancer Collaborators 2018	Unclear	No	N/A	Yes	Yes	No	Yes	Yes	Unclear	Moderate
Deng et al 2017	Yes	Yes	N/A	Yes	Yes	Yes	Yes	Yes	Unclear	Moderate
Deng et al 220	Yes	Yes	N/A	Yes	Yes	No	Yes	Yes	Unclear	Moderate
Deng et al 2020	Yes	Yes	N/A	Yes	Yes	No	Yes	Yes	Unclear	Moderate
Di Pardo et al 2016	No	No	N/A	Yes	Yes	No	Yes	Yes	Unclear	Moderate
Dominguez et al 2014	Yes	Unclear	Unclear	No	Unclear	Unclear	Unclear	No	Unclear	Very low
Ford et al 2016	Yes	Yes	No	No	Unclear	Yes	Yes	No	Unclear	Very low
Ghosselin et al 2012	No	Yes	Unclear	No	Unclear	Unclear	Unclear	No	Unclear	Very low
Gouda et al 2019	Yes	Yes	Yes	No	Unclear	Yes	Yes	Yes	Unclear	Moderate
He et al 2020	Yes	Yes	Yes	No	Unclear	Yes	Yes	Yes	Unclear	Moderate

He 2021	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	N/A	Moderate
Higashi et al 2015	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Unclear	Unclear	Moderate
Higashi et al 2015	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Unclear	Unclear	Moderate
Higashi et al 2015	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Unclear	Unclear	Moderate
Ilbawi et al 2013	Unclear	Yes	Unclear	Yes	Unclear	Yes	Unclear	No	Unclear	Very low
Jankovic et al 2007	Unclear	Unclear	Unclear	No	Unclear	Unclear	Yes	No	Unclear	Low
Ji et al 2020	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
John & Ross 2010	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Kang et al 2021 (GBD OG Cancer Collaborators)	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Karimkhani et al 2015	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Kimman et al 2012	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Kocarnik et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Kulothungan et al 2022	Yes	N/A	Yes	No	Unclear	Yes	Yes	No	N/A	Low
Kunnavil et al 2015	Yes	N/A	Yes	No	Unclear	Unclear	Unclear	No	N/A	Low
Lippi & Mattiuzzi 2020	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Low
Liu et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
LV et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Malekzadeh et al 2015	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Menon et al 2019	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Misganaw et al 2017	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Modirian et al 2015	Yes	N/A	Yes	Unclear		Yes	Yes	No	N/A	Moderate
Momenimovahed et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Mubarik et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Mubarik et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Murray et al 2013	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Murthy et al 2010	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Naghavi et al 2003	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Nejadghaderi et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Pan et al 2022	Yes	N/A	Yes	Yes	Unclear	Yes	Yes	Yes	N/A	Moderate
Patel et al 2019	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Pourshams et al 2019	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Qiu et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate

Ramsey et al 2019	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Reis et al 2020	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Ren et al 2020	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Safiri et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Safiri et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Safiri et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Shegaze et al 2020	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Shokri et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Shrestha et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Song et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Stewart et al 2014	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Stewart et al 2016	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Unclear	Moderate
Sun et al 2020	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Wu et al 2023	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Xie & Shang 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Yan et al 2022	Yes	Yes	Yes	No	Yes	Yes	Yes	No	N/A	Moderate
Yang et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Yang et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Yang et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Yang et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Yang et al 2021	No	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Yi et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Zhai et al 2017	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Zhang et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Zhang et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Zhang et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Zhang et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Zhang et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Zhao et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Zhou et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Liu et al 2023	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Ramazani et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate

GBD 2017 Colorectal Cancer Collaborators	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Dávila-Cervantes & Pardo-Montaño	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Gupta et al 2020	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Mock et al 2015 (Essential Surgery Chapter 1)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Ben Abdelaziz 2019	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Dominguez Alonso et al 2009	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Khanali et al 2021	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Safiri et al 2020	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Naghavi et al 2009	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Al Saidi et al 2022	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Massenburg et al 2020	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate
Ullrich et al 2020	Unclear	Yes	Unclear	Yes	Unclear	Yes	Yes	No	N/A	Low
Blake et al 2015 (Essential Surgery Chapter 21)	Yes	N/A	Unclear	Unclear	Unclear	Yes	Yes	No	N/A	Low
Farmer et al 2015 (Essential Surgery chapter 8)	Unclear	N/A	Unclear	Unclear	Unclear	Yes	Yes	No	N/A	Low
Beard et al 2015 (Essential Surgery Chapter 9)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	No	N/A	Very low
Niederman et al 2015 (Essential Surgery Chapter 10)	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Low
Johnson et al 2015 (Essential Surgery Chapter 5 Obstetric Surgery)	Yes	N/A	Yes	No	Unclear	Yes	Yes	Yes	N/A	Moderate
Ferrari et al 2024 (GBD 2021 Diseases and Injuries Collaborators)	Yes	N/A	Yes	Unclear	Unclear	Yes	Yes	Yes	N/A	Moderate

Questions in the JBI checklist for analytical cross-sectional studies: 1. Was the sample frame appropriate to address the target population? 2. Were study participants recruited in an appropriate way? 3. Was the sample size adequate? 4. Were the study subjects and setting described in detail? 5. Was data analysis conducted with sufficient coverage of the identified sample? 6. Were valid methods used for the identification of the condition? 7. Was the condition measured in a standard, reliable way for all participants? 8. Was appropriate statistical analysis used? 9. Was the response rate adequate, and if not, was the low response rate managed appropriately?

Table 2-4. *Domains 1 and 2 of the ROBIS tool assessment of the one included systematic review.*

Name of paper	**1.1**	**1.2**	**1.3**	**1.4**	**1.5**	**Domain 1**	**2.1**	**2.2**	**2.3**	**2.4**	**2.5**	**Domain 2**
Habib et al 2015	Probably yes	Yes	Probably yes	Probably yes	Yes	Low concerns	No	Yes	Yes	Yes	Probably no	High concerns

Table 2-5. *Domains 3 and 4 of the ROBIS tool assessment of the one included systematic review.*

3.1	**3.2**	**3.3**	**3.4**	**3.5**	**Domain 3**	**4.1**	**4.2**	**4.3**	**4.4**	**4.5**	**4.6**	**Domain 4**
Probably no	Probably no	Probably yes	No	No information	High concerns	Probably yes	Probably yes	Yes	Probably yes	Yes	No information	High concerns

Table 2-6. *Domain 5 of the ROBIS tool assessment of the one included systematic review.*

A	**B**	**C**	**Phase 3**	**Overall risk of bias.**	**Grade of evidence**
Probably yes	Probably no	Yes	High concerns (any answer no or probably no)	High risk of bias	Low

2.6 Discussion

This systematic review has highlighted the ongoing significant burden of surgical disease in low- and middle-income countries (LMICs). The most significant contribution to measuring this burden has been the Global Burden of Disease (GBD) study.(195) This single database accounted for over 75% of all publications on the topic. To date, it is the largest and most comprehensive effort to accurately measure the global burden of disease and the iterative improvements to increase accuracy and granularity of data have ensured that it is increasingly popular amongst global health researchers.(195) Other databases, such as the GLOBOCAN study and the WHO Global Health Estimates, have also made significant contributions. It is important to note that estimates from these large databases can vary significantly.(196)

The high proportion of large databases such as the GBD study has also had a significant effect on the quality of studies. This systematic review demonstrated that the majority of studies has a ‘moderate’ rating of evidence. Smaller studies based on extrapolating results from single centre case series showed significantly different estimates compared to the more consistent estimates based on the large databases such as the GBD study.

The number of studies per region, and number of studies per country within regions differed significantly. A majority of included studies analysed multiple regions or at a global level, reflecting the global reach of the GBD study. However, there were more included studies from the Eastern Mediterranean region (population: 493 million) than sub-Saharan Africa (population 1.2 billion) highlighting the continued need to increase research capacity in under-served regions such as sub-Saharan Africa. There was also further inequity within regions - every study in the Western Pacific was focussed on China, with one also including Mongolia. Similarly, half of all included studies from the Southeast Asian region focussed on India, with Nepal and Bhutan included in one study each, other than the pan-region studies.

2.6.1 The Global Burden of Disease Study

Originally funded by the World Bank and now by the Bill and Melinda Gates Foundation, the Global Burden of Disease Study (GBD) is an international academic collaboration led by the Institute for Health Metrics and Evaluation (IHME) at the University of Washington. It was first commissioned in 1993 and also included the development of the DALY metric.(59) It now reports on 291 diseases from 187 countries. The core principles of the GBD study are best estimates, comprehensiveness, comparability, morbidity and validity. The GBD study uses best estimates even when there is uncertainty regarding the data, believing that some data is better than none, and that accuracy will improve over time. Comprehensive accounting across disease, injuries and risks ensures that it remains relevant to populations across the world and can actively influence decision makers and policy. Meaningful comparison of measurements across time, conditions and geography allows comparison and evaluation of health systems against global health targets such as the Millennium Development Goals. Through focussing on morbidity and disability in addition to mortality the impact of any disease can be measured, encouraging focus on those conditions that whilst not fatal, can cause lifelong disability and morbidity. Finally, a high degree of face validity through transparent reporting, and by using a collaborative approach to data collection and analysis ensures that the conclusions drawn from the GBD are considered trustworthy.

The most recent GBD study (GBD 2019) highlighted a number of interesting trends. Overall, it reported that global health has improved steadily since the GBD study was started 30 years ago. Although absolute number of DALYs due to most conditions has remained stable, when considered alongside a growing and aging population, this represents a fall in the rate of DALYs per 100,000. The health of those under 50 has improved at a faster rate than previously, and the most rapid increase in health has been in those aged under 9. Interestingly, an increasing proportion of DALYs are due to non-communicable diseases and injuries, and 11 countries report non-communicable diseases and injuries as responsible for over half of the national disease burden.(197) This could be interpreted as due to the success of the United Nations' Millennium Development Goals (MDGs) which helped to focus the global community on eradicating hunger, reducing child mortality, improving child maternal health and combatting HIV/AIDS, malaria and other infectious diseases.(198)

There are limitations however, with the GBD study. There remain large areas (both geographically and with respect to specific conditions) where data is missing or of low quality such as the use of verbal autopsy or household surveys. The GBD authors also report that it is unclear whether researchers using their data are fully aware of the uncertainty and likely inaccuracy of some data points. Additionally, the large range of sources used also leads to a significant potential opportunity for the introduction of bias into the data. Most significantly for those in LMICs is the fact that relative risks are extrapolated across populations, this is due to the fact that most cohort data are available from high income countries, making the estimates from LMICs less likely to be accurate.(195) The GBD study also does not correlate diseases together (for example, obesity, diabetes and cardiovascular disease) meaning the interdependence of many disease is not appreciated from this data.(199) Importantly, each time a new data set is released the estimates from all previous years are revised. This makes comparing publications using different iterations of the GBD data set unreliable, and therefore makes tracking progress more challenging.

Despite these limitations, it remains the most significant contribution to measuring global health and is likely to continue to increase in scope, accuracy and relevance to the global health community.

2.6.2 GLOBOCAN

Led by the International Agency for Research on Cancer (IARC) the GLOBOCAN database has published regular estimates on the incidence and mortality from cancer on a global and national level.(200) This dataset combines incidence and survival statistics from population based cancer registries with mortality data from vital registries, where cause of death is recorded. Frequency data such as case series from hospitals and laboratories are also added to local or national data estimates to indicate relative importance of certain cancers. Prevalence data is also added for certain diseases by using ‘partial prevalence’

As the GLOBOCAN database is drawn from population-based registries, it has been argued that the GLOBOCAN data is more objective and reproducible than those relying on lower quality sources such as verbal autopsies.(201) There remains the inherent risk of bias of all large scale registry studies, in that it is reliant on the quality of the data imputed to these registries. This is especially, true in certain conditions within geographic such as non-melanoma skin cancer in Australia, where the estimates are based on a single registry in the area of the country with the lowest skin cancer incidence. More relevant to this study is the fact that due to the lack of data on mortality in LMICs, mortality was extrapolated from other populations based on the countries' Human Development Index.(201) The authors also caution against making comparisons between different iterations of the GLOBOCAN study as significant changes in data can be due to improved data reporting within countries over a period of time. Furthermore, GLOBOCAN is focussed on incidence, prevalence and mortality and less on morbidity. This likely represents one reason why there were significantly less studies from GLOBOCAN as compared to the GBD study included in this systematic review that focussed on burden.

There are noted differences between estimates provided by the GBD study and the GLOBOCAN study which have been highlighted by Yu and colleagues.(202) These are in part due to the different methods of data collection and also in the coding of diseases, with the ICD-10 coding of gallbladder and biliary tract cancers causing significantly different estimates between the two data sets.(202) Researchers, and policy makers must ensure they are aware of the limitations and differences of each of these data sets when making decision on resource allocation to improve healthcare systems.

2.6.3 WHO Global Health Estimates

The World Health Organization (WHO) provides Global Health Estimates from 2000 onwards by combining various data sources including the WHO's technical programs, United Nations' groups and, most importantly, the GBD study. The main difference between the GBD and the WHO's GHE is the classification of diseases and injuries.

2.6.4 Regional trends

The regional trends in this study show a varied picture. When looking at high level disease groupings, cardiovascular diseases caused the highest burden of disease across the African region, this was followed by congenital anomalies and neoplasms. Within specific diseases, intestinal obstruction and paralytic ileus caused the highest burden, followed by cervical and breast cancers. The burden of most cancers appears to be falling, with only stomach, prostrate and neurological cancers the exceptions to this. Within congenital anomalies, gastroschisis and anorectal malformations were estimated to cause the highest burden, although this data was restricted to Uganda.

Studies from the Eastern Mediterranean highlighted that the highest burden of disease from cancers were TBL, breast and gastric, this was significantly different to the African region. The Eastern Mediterranean region also reported increasing burden of disease from injuries, and in particular transportation-related injuries, and the DALY rate for transportation injuries was highest in Afghanistan.

There were relatively few studies from LMICs in the Americas region. These studies highlighted the large burden of disease due to cervical cancer across Cuba and Brazil and the significant burden of transport injuries within Mexico.

In the South East Asian region, the largest burden of cancer DALYs in India was from lip and oral cavity cancer, whereas the highest DALY rate was due to gastric cancer, a similar patterns was found in the Western Pacific region. Nepal on the other hand reported the largest cancer burden due to TBL, breast and cervical cancers. India also reported a large burden of disease due to injuries, particularly transport related injuries.

The studies from the Western Pacific region were exclusively Chinese studies focussing on cancer, with one of these studies also including Mongolia. The highest cancer burden was caused by TBL, gastric and then either colorectal or liver cancer depending on the study.

When looking at studies that evaluated multiple regions, South, East and South East Asia repeatedly recorded the highest absolute burden of disease, and especially cancer. South Asia reported the highest burden of ovarian, thyroid, and larynx cancers as well as congenital anomalies, dental disease, appendicitis and injuries. East Asia reported the highest burden of colorectal, primary liver, kidney, neurological, gastric, TBL and gallbladder and biliary tract cancers. South East Asia reported the highest burden of breast and cervical cancers, Eastern Europe reported the highest burden of skin melanoma.

Finally, the macro level data highlights that there is great variability in academic and research interest across differing regions of the world. The region of South East Asia was the subject of only 9% of identified studies despite making up nearly 25% of the world’s population. This inequity of research adds compounds the difficulties associated with a vast, and growing, burden of disease.

2.6.5 Temporal trends

The trends on a global basis over time are readily appreciated by Murray et al 2013 and Ferrari et al – displayed in Figures 43 and 44.(194) These data highlights that health has improved in many areas, represented by a fall in absolute number of DALYs due to neonatal, maternal and communicable disorders. This is contrasted against a rise in DALYs due to neoplasms, cardiovascular disease, and diabetes and urogenital disorders. This trend is sometimes described as the 'westernisation' of health as national health trends of low- and middle-income countries tend to mirror those of high-income countries as their income status increases. This regions and countries with the highest burden of disease measured by absolute number of DALYs tends to be those regions and countries of low- and middle-income status and large populations such as China and India. Overall, the largest burden of disease amenable to surgical care was found to be due to cardiovascular disorders, overtaking neonatal disorders since 1990. This trend continued in the more recent GBD 2019 paper, which also showed a general reduction in mortality (YLL), and corresponding increase in morbidity (YLD). The GBD studies have also consistently showed accelerating improvements in health in countries at the lower ends of the SDI scale, indicating that investments in these countries have significant potential to improve health.(203)

Kocarnik et al 2022, on behalf of the GBD 2019 Cancer Collaborators, highlighted the relationship between SDI quintile and cancer.(175) The authors demonstrated the growing burden of cancer, with the largest increases being found in the lower SDI quintiles. This study also reported that whilst absolute burden increased, age-standardised rates remained similar across the 19 year study period, indicating some improvements in cancer care globally. Additionally, there was a relationship between mortality, morbidity and SDI quintiles. The largest contributor to DALYs was found to be YLL but this was more pronounced in the lower SDI quintiles, suggesting lower SDI quintiles suffer more mortality whereas higher SDI quintiles experience more morbidity at the expense of lower mortality.

The 2021 iteration of the GD data set was released this year, and Ferrari et al highlighted the significant effect that the COVID-19 pandemic had on health care across the world.(194) Overall, all cause DALYs increased globally, although this was mainly due to COVID-19. Despite an increasing and ageing population, DALYs due to maternal and neonatal disorders, musculoskeletal disorders and injuries reduced. The burden due to cardiovascular diseases and neoplasms increased significantly and non-communicable disease in total were the only disease grouping to increase in burden.(194)

2.6.7 Limitations

There are a number of limitations of this systematic review. Given the heterogeneity of the data, a formal meta-analysis was not possible. Efforts to conduct a thorough and systematic analysis of the data were undertaken by following the SWiM guideline. A grey literature database was not searched as it was unlikely to provide many reliable articles given the dominance of large and academically rigorous studies in the academic literature.

Additionally, there will be an element of publication bias in these results. The GBD study routinely reports DALYs routinely due to its stated focus on morbidity, so this may explain why so many included studies were based on GBD data as opposed to GLOBOCAN. Furthermore, the academic institutions involved in these collaborations are mostly based in High Income Countries, mostly in North America and Western Europe possibly introducing bias into the included studies.(204) Most importantly, much of this data is based on estimates due to the lack of high quality primary data in some areas of the world.(204) This can cause significant variations in the reported estimates, particularly at the national level, as outlined above. Countries with well-established and high quality population based cancer registries have minor differences, generally these are high-income countries, and the estimates on low- or middle-income countries are less likely to be accurate. (202)

There are also some limitations with the synthesis without meta-analysis method. Reporting the results either in a narrative review, bar chart or box and whisker plot does not account for the differences in the population size of each study.(69) This can make it difficult to interpret which study is estimating the more accurate result. The GRADE methodology for assessing certainty was used to give an overall assessment of the quality of each study in an effort to mitigate this.

2.7 Conclusion

This systematic review has outlined the large, and growing, burden of surgical disease in low- and middle-income countries. The temporal trends have highlighted an overall improvement in global health and specifically a shift in disease away from communicable, neonatal and maternal disorders and towards cardiovascular diseases, neoplasms, and injuries. Surgical care is essential to treat these conditions and so must be seen as an essential area of focus to continue the global trend of increasing health. Additionally, research interest and academic focus are inequitably spread across the world, with some of the countries and regions with the highest burden of disease being the regions with the fewest studies reporting data from their rpopulations. The limitations raised are reflective of the difficulty of accurately collecting data from low resource settings, and work to improve accuracy and coverage of mortality and morbidity data should continue at pace alongside efforts to improve the delivery of surgical care across the world. Having established the vast burden of surgical disease in LMICs, the next chapter will evaluate the workforce gap that needs addressing in order to tackle this burden.

Chapter 3 - The surgical workforce gap in low- and middle-income countries

"… an additional 1.27 million specialist surgical, anaesthetic providers will need to be trained…" (10)

3.1 Introduction

A critical part of addressing the global burden of surgical disease is the surgical workforce. An adequate surgical workforce requires an appropriate number of surgical and anaesthetic providers being trained, retained and working within a larger healthcare system. The surgical team involves a complex network of surgeons, physicians, nurses, anaesthetists, obstetricians, physician associates, health officers, laboratory technicians, as well as non-clinical works such as hospital managers and government workers.(205,206) The maintenance of this complex team relies on adequate recruitment, training, continued professional development, and retainment of existing staff. The entirety of this complex process is essential if safe surgery is to be delivered in resource poor settings worldwide, however, the majority of academic and organisational focus in recent years has been on surgical, anaesthetic and obstetric (SAO) providers, following the lead of the Lancet Commission on Global Surgery (LCoGS).(10) The LCoGS highlighted two related but different issues with the current surgical workforce:

1. Major shortage in the overall number of surgical care providers. To meet the estimated projected population need, the surgical workforce would need to double in size within 15 years. This translates as an additional 2.2 million surgeons, anaesthetists and obstetricians or an additional 143 million individual procedures per year.(10)
2. Geographical maldistribution of the existing providers. Currently the poorest half of the world's population have access to one fifth of the global surgical workforce.(10)

Both of these issues combined have led to the current situation whereby low- and middle-income countries (LMICs) are disproportionately affected by low surgical workforce density, with Africa and Southeast Asia being particularly underserved.(10,207) Within LMICs, there is further inequity, as those in rural areas, with lower mean income and marginalised areas of society are worst affected.(10)

There is a clear incentive for increasing the density of SAO providers; for each increase of 10 providers per 100,000 of the population, maternal mortality decreases by 13%, with a particularly sharp improvement up to 20 per 100000 and a much more gradual improvement after 40 per 100,000. For this reason, the LCoGS set the interim target of all countries reaching the 20 per 100,000 target by 2030.(10) Davies and colleagues recommended an updated version of these targets in 2021, specifying that specialists, non-specialists physicians and non-physician practitioners should all be reported individually in addition to the combined SAO density metric.(14)

3.1.2 Task shifting & sharing

The massive uplift in SAO providers necessary cannot realistically be delivered with reliance solely on specialist surgeons, anaesthetists or obstetricians. Using the extended surgical team of general practitioners (GPs) and associate clinicians such as nurse practitioners or health officers is essential. In some countries this is commonplace, with upwards of 80% of surgical obstetric and orthopaedic procedures being performed by associate clinicians in Malawi and Mozambique as an example.(208–210) This tactic is known as task shifting or task sharing.(10) Whilst there have been some ethical concerns with clinicians with less training performing complex procedures, it has been shown to be safe and effective across the world in both HICs and LMICs.(10,208,210,211) Furthermore, task shifting has been a proven method of expanding access to care more quickly and less expensively than relying on physicians alone.(10)

3.1.3 NSOAP

The provision of surgical care is a complicated process requiring national and international collaboration and long term, strategic planning. In order to facilitate this the WHO described six core components or 'building blocks' that make up a functioning health system.(212) In addition, Meara and colleagues designed the National Surgical Obstetric and Anaesthesia Plan (NSOAP) as a standardised, strategic document that can be modified by each nation to improve the quality of strategic planning.(213) This model, using the 6 WHO building blocks, has been widely adopted and in the case of Ethiopia has been proven to significantly increase funding from government as well as international bodies.(212,214)

3.1.4 Aim

The objective is to perform a systematic review and synthesis without meta-analysis on the density of SAO providers per LMIC country and compare this to the LCoGS targets of 20 and 40 per 100,000 population.(10)

3.2 Methods

This systematic review was conducted in concordance with the PRISMA-P guidelines.(215) No restrictions were imposed on language of publication, any articles in languages other than English were translated using Google Translate when required. Importantly 'Grey literature' was also included with reports and publications from national and international health organisations (see Appendix 3B). The protocol for this literature review was registered with PROSPERO (ID: CRD42023464914).

Table 3-1. *Inclusion and exclusion criteria*

	Include	**Exclude**
Type of article	Study reporting SAO providers per country. This can be either absolute number of SAO providers or as a proportion per 100,000 of population	Case reports (unless on national level), academic letter, correspondence or conference proceeding
	Primary quantitative, qualitative or mixed method study	Abstracts
	Literature or systematic review	
	Report or guideline from national or international health organisation	
Type of condition or care setting	Low- and Middle-Income Countries (LMICs) as defined by the World Bank Income Status	Non-SAO care as the main focus of assessment
		Non-accidental injury in children
		Disaster management
		Mental health
Subject of study	Whole health system assessment	Animal studies
	Assessment of health system access	Sub-speciality only
Setting according to World Bank status 2018	Includes low- or lower middle- or upper middle-income country	High-income country only

3.2.1 Search strategy

The following electronic databases were searched using a comprehensive search strategy:

- MEDLINE (Ovid)
- Global Health (Ovid)
- Embase (Ovid)
- Cochrane (Wiley)
- Global Index Medicus (WHO)
- Overton – See Appendix 2 for more detail

The search terms used for MEDLINE can be found in Appendix 3B and were chosen as a combination of the search terms used in a similar published systematic review, and a validated search term filter (the ScHARR LMIC filter for MEDLINE) and after consultation with a health data librarian.(63,207,216)

Although there is no agreed 'gold standard' for performing a rigorous search of grey literature, a four stage strategy has been used in previous similar studies and will be adopted.(65) These complementary approaches are searching of grey literature databases, a customised Google search, targeted websites and consultation with experts.(65) The search terms and data sources used in the grey literature review can also be found in Appendix 3B.

3.2.2 Selection of studies

Duplicate studies were removed using EndNote X8 following established and peer-reviewed method.(67) The Rayyan application will be used to screen for relevant key words and phrases, and clearly irrelevant studies were removed at this stage.

Abstracts and titles were screened collaboratively using the Rayyan QCRI online open-source web application.(217) Two researchers independently reviewed study titles and abstracts, and decided on inclusion or exclusion. Any disagreements were settled with discussion between the researchers and when required, a third researcher was used to advise on any remaining disagreement. All reasons for exclusion were recorded to ensure methodological rigour. Inter-rater reliability was assessed using Cohen's kappa.(68)

3.2.3 Definitions

Definitions of healthcare workers vary widely across the world.(218,219) For the purposes of this study, the following definitions were used:

- Surgical provider: any health worker providing surgery.
- General physician surgical provider (GPSP): a physician providing surgical care but without a formal post-graduate surgical qualification.
- Surgeon: a specialist physician with formal post-graduate surgical qualification.
- Anaesthesia provider: any health worker providing anaesthesia.
- Non-physician anaesthesia provider (NPAP): a non-physician health worker providing anaesthesia.
- General physician anaesthesia provider (GPAP): a physician providing anaesthesia but without a formal post-graduate surgical qualification.
- Anaesthetist: a specialist physician with formal post-graduate qualification in anaesthesia.
- Obstetrician/Gynaecologists (OBGYN): a specialist physician with formal post-graduate obstetric and/or gynaecological qualification.
- SAO provider: any healthcare worker providing surgical, anaesthetic, or obstetric care.
- Non-physician surgery provider: a non-physician health worker providing surgery.

3.2.4 Data extraction

Data extraction was performed using a single metric: number of surgical, anaesthetic and/or obstetric providers per 100,000 of the population, known as the surgical workforce density.(10) Where studies report numbers rather than density, the researchers calculated density according to the national population as reported by the World Bank for the relevant year.

3.2.5 SWiM Guideline

As a meta-analysis was not possible due to data collection from varied data source and across significantly different time periods a synthesis without meta-analysis was conducted. The synthesis without meta-analysis (SWiM) Guideline was used and the reporting items can be seen in Table 2 below.

Table 3-2. *Synthesis Without Meta-analysis (SWiM) Guideline.*

Methods	
1 - Grouping studies for synthesis	6. Individual country 7. Geographic/regional location of country e.g. 'North Africa' 8. World Bank Income status 9. Provider specific e.g. 'obstetric provider'
2 - Standardised metrics	2. Density of SAO providers per 100,000 of population. 3. Studies that report absolute numbers of SAO providers will be included as converted to density using the WHO database for country population
3 - Synthesis method	Summarising effect estimates will be attempted, however may not be possible as the data reported in each study is likely to be specific to the local health and economic context and may not be generalisable to other contexts (69)
4 - Criteria used to prioritise results for summary and synthesis	4. Type of study is primarily an evaluation reporting the metrics listed in 2-Standardised metrics above 5. Low risk of bias using the JBI checklist for analytical cross-sectional studies 6. Directly relevant to the study question
5 - Investigation of heterogeneity in reported effects	Meta-regression will not be possible. Heterogeneity will be minimised by analysing subgroups based on similar study characteristics - see 1 above such as methodological and study population characteristics and economic and geographic context
6 - Certainty of evidence	Will be assessed using the GRADE Evidence Profile (70,71)
7 - Data presentation methods	Results will be presented in a table with the following headings: • Type of study • Risk of bias • GRADE quality • Size of study population • Country/region of study • World Bank Income status of country of study • Condition or group of conditions studied • SAO provider density (see 2 – 'Standardised metrics' above • Overall quality assessment The CASP Economic Evaluation tool will be used to assess risk of bias in included studies (220) Should a summarising effects estimate synthesis be possible box-and-whisker plots will be used to present synthesised data following the Cochrane Handbook for systematic reviews guidance (69)
Results	
8 - Reporting of results	The results will be reported in Table and box-and-whisker plots as described in 7 above
Discussion	
9 - Limitations of the synthesis	The limitations of the systematic review will be outlined in full in the discussion section. These are expected to be due to incomplete or low-quality data, bias in reporting of outcomes and difficulty in comparing SAO providers between different countries, regions and contexts The limitations associated with a summarising effects estimate synthesis method are that it does not account for differences in the relative sizes of studies and that the performance in the statistics in the context of summarising effects has not been validated (69)

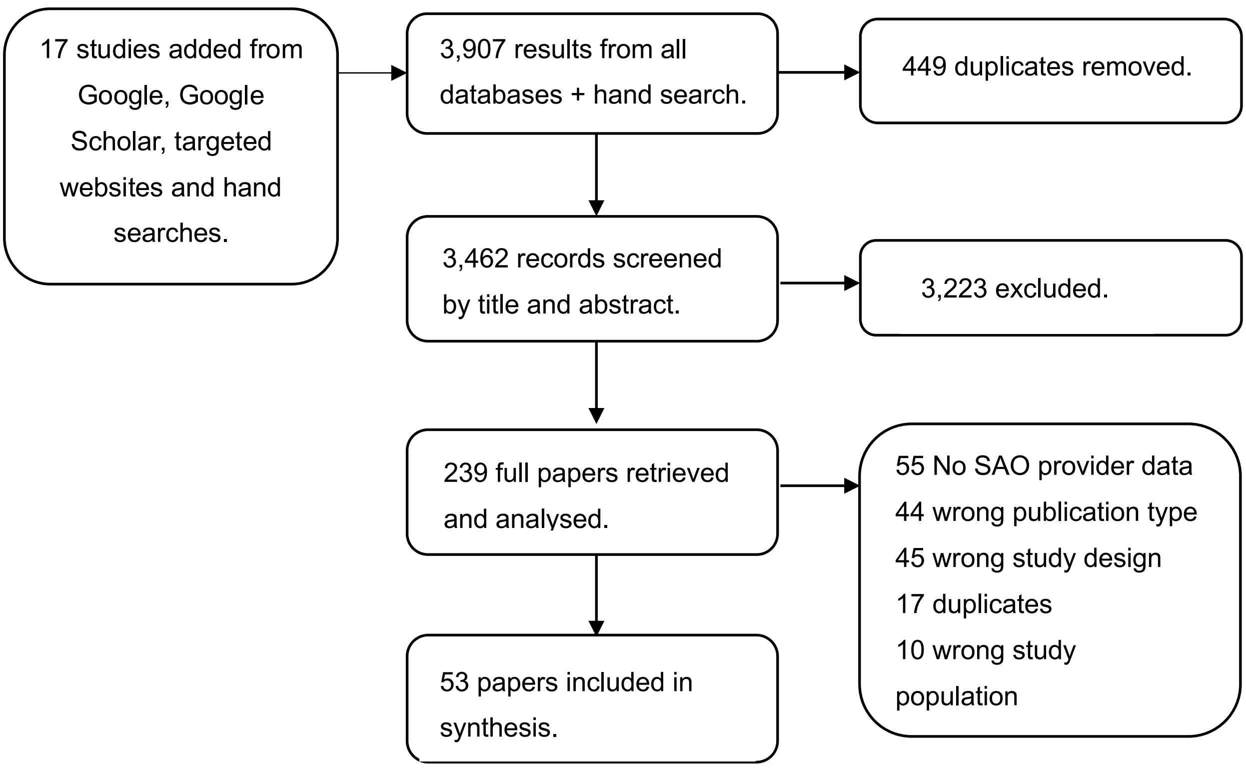
3.2.6 Risk of bias & certainty of evidence

A formal risk of bias assessment was conducted on the included studies. The JBI checklist was used for analytical cross-sectional studies and the ROBIS tool was used for systematic reviews.(72,73) Evidence was assessed using the GRADE (Grading of Recommendations, Assessment, Development and Evaluations) framework to assess certainty.(71)

3.3 Results

After the comprehensive data base search in addition to hand searching, 3907 studies were returned. After removing 449 duplicates, 3462 articles were screened by title and abstract and 53 studies were included in the final systematic review without meta-analysis – see Figure 2 for PRISMA flow diagram and reasons for excluding studies.

Figure 3-1. *PRISMA flow diagram.*



3.3.1 Inter-rater reliability

Inter-rater reliability was assessed using Cohen's kappa.(74) This was comparing Researcher 1 against Researcher 2. SPSS® (IBM® SPSS® Statistics, Version 27) was used for the calculation – see Figure 2. Cohen's Kappa was 0.483 indicating a moderate degree of agreement. This was calculated prior to the discussion between researchers to clarify any disagreements.

***Figure 3-2**. Cohen's Kappa of the two researchers after screening on titles and abstract.*

Symmetric Measures

		Value	Asymptotic Standard Error[a]	Approximate T[b]	Approximate Significance
Measure of Agreement	Kappa	.483	.024	39.248	.000
N of Valid Cases		3458			

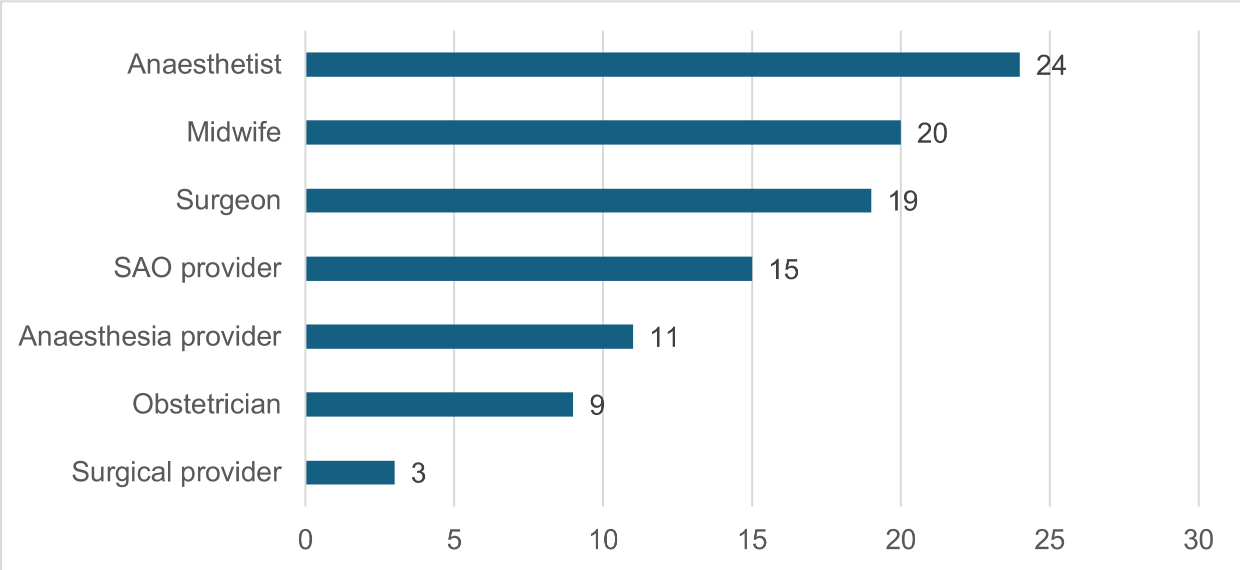
a. Not assuming the null hypothesis.

b. Using the asymptotic standard error assuming the null hypothesis.

Included studies

Of the 53 studies, 4 (7.55%) were systematic reviews, the remaining 49 (92.45%) were original research. Anaesthetists/anaesthesiologists were the most frequently reported profession (24 studies), followed by midwives (21) and surgeons (18). The professions reported are displayed in Figure 3 below, note that most studies reported more than one profession. Density (either per 1000, 10,000 or 100,000 of the population) was reported by 44 studies, absolute number of healthcare workers was reported by 35 studies.

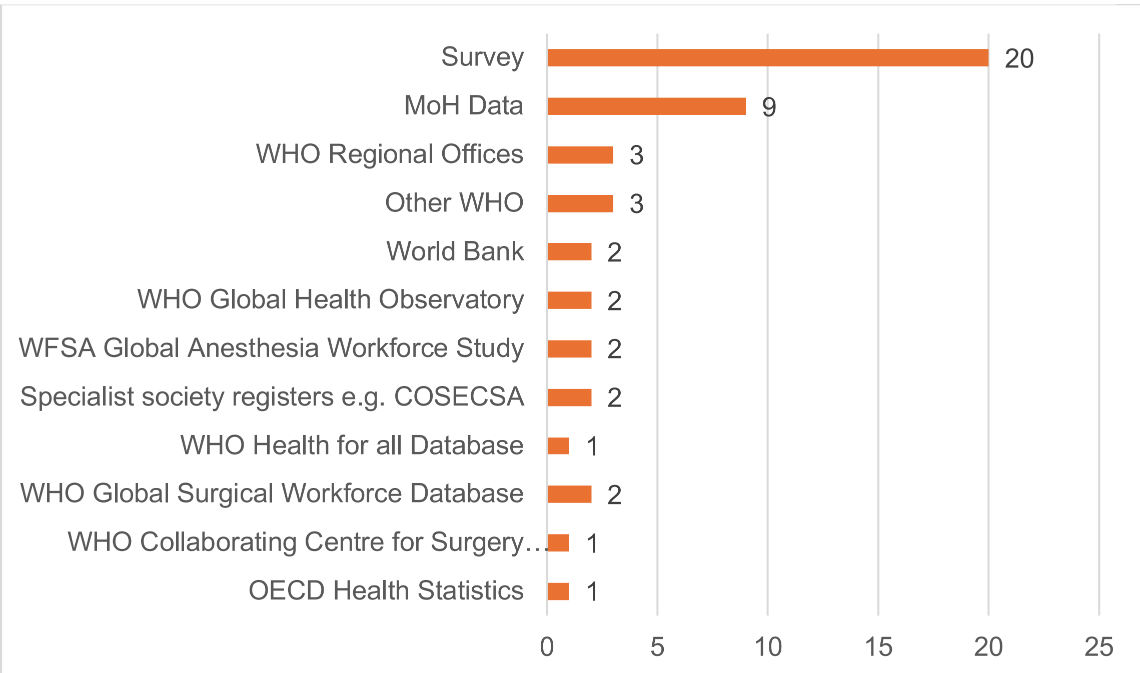
Figure 3-3. *Professions reported by included studies. Note most studies reported more than one profession,*



3.3.2 Data source

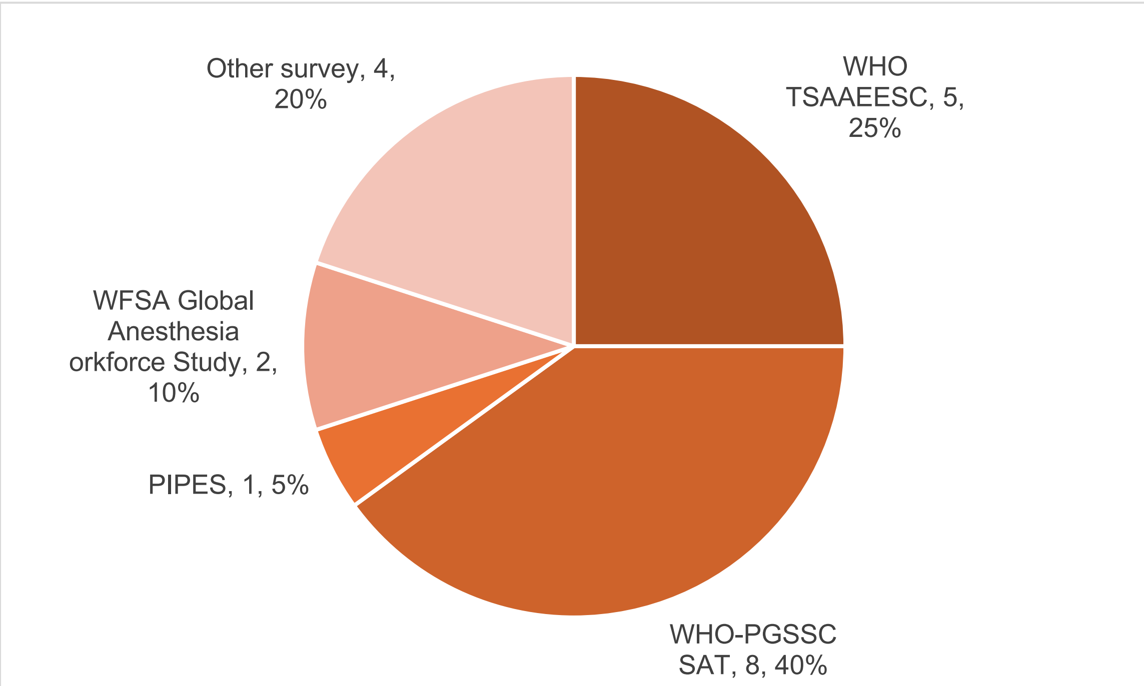
Surveys (20 studies, 41.67%) were the most frequently used data source, followed by national Ministry of Health data (9, 18.75%) – see Figure 4.

Figure 3-4. *Data sources used by included studies, note that some studies used multiple data sources.*



Of the 20 studies that used survey data, the WHO-PGSSC Situational Analysis Tool (SAT) was the most frequently used (eight studies) followed by the WHO's Tool for Situational Analysis to Assess Emergency and Essential Surgical Care (TSAAEESC) which was used by used by five studies. The World Federation of Societies of Anaesthesiologists (WFSA) survey was used by two studies and the Surgeons OverSeas' Personnel, Infrastructure, Procedures, Equipment and Supplies (PIPES) survey was used by one, and other bespoke surveys by four studies – see Figure 5.

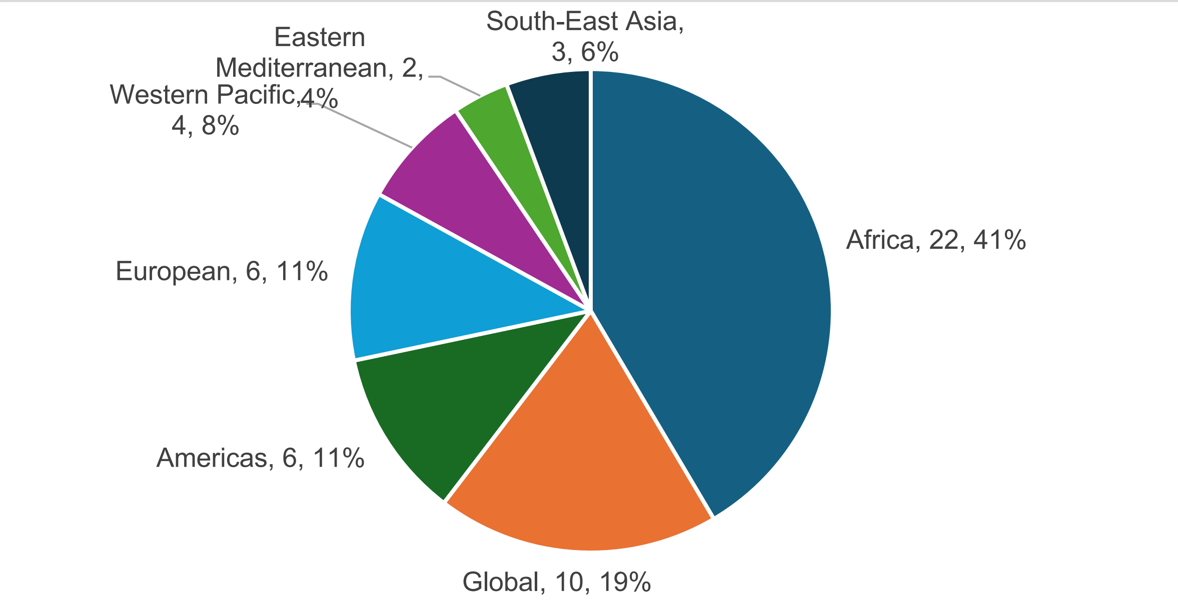
***Figure 3-5**. Surveys used by included studies.*



3.3.3 Regional trends

The most frequently studied region was Africa (22 studies, 41.51%) followed by global or multiple regions (10, 18.87%) and jointly the Americas and Europe (6, 11.32%) – see Figure 6.

Figure 3-6. *Region of study.*

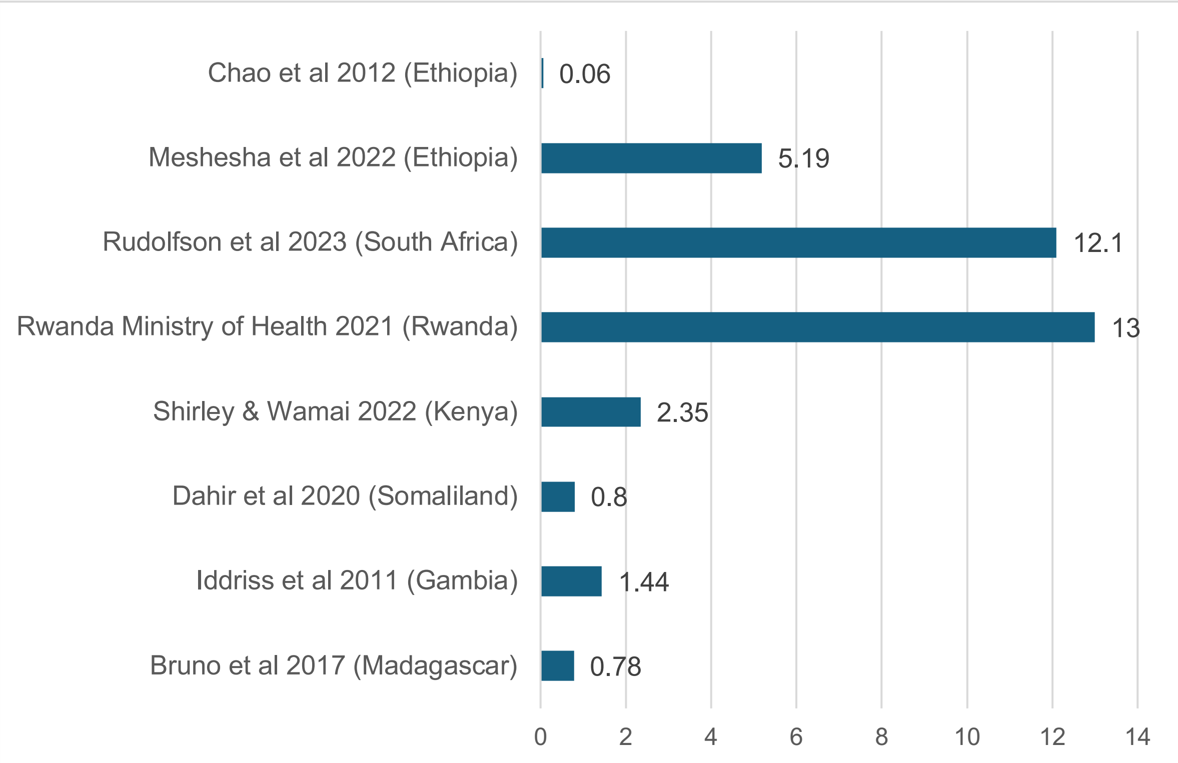


3.3.4 African Region

There were 23 studies included from the African Region, 16 of these (69.57%) used surveys, three (13.04%) used national Ministry of Health data, two (8.70%) used specialist medical registers (e.g. CANECSA membership), one (4.35%) used World Bank Development Indicators and one (4.35%) used the Ethiopian MNH Exemplar Study.

Nine studies reported SAO providers nationally within Africa. The Rwanda Ministry of Health 2021 used their national data to estimate the density of SAO providers as 13/100,000. Rudolfson et al 2023 estimated 12.1/100,000 in South Africa, using a combination of the Health Professions Council of South Africa and WHO global surgery workforce database.(221) Both of these estimates were was significantly higher than all other countries reported.(222) Shirley & Wamai 2022 estimated the density in Keyna as 2.35, and Idriss et al 2011 used the WHO TSAAEESC survey to estimate the density in Gambia as 1.44 per 100,000.(223,224) The lowest density was reported by Chao et al 2012 who used hospital surveys to estimate the density in Ethiopia as 0.06/100,000.(225) However a more recent study by Mesehsa et al 2022 reported a much higher estimate of 5.19/100,000.(226) These estimates are displayed in Figure 7 below. Osesbo et al 2022 was a systematic review that reported two estimates for Ethiopia: 0.54 and 5.10/100,000, as these were not synthesised into one figure, they have not been included in Figure 7.(227)

Figure 3-7. *Density of SAO providers in the African Region per 100,000 population.*



Iddriss et al 2011 also reported, in detail, the professional background of the SAO providers.(224) When comparing these rates the density of SAO specialist physicians is half (1.44/100,000) that of the density of all SAO providers, including general physicians and non-physicians providing surgical or anaesthetic care – see

Figure 3-8. *SAO density in Gambia by professional group per 100,000 by Idriss et al 2011*

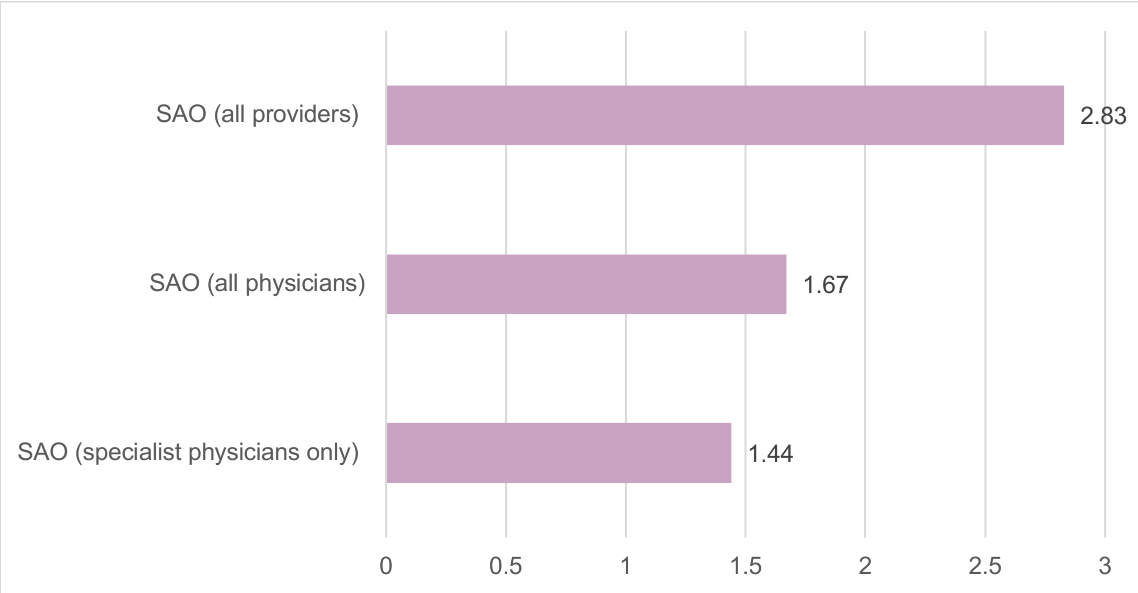
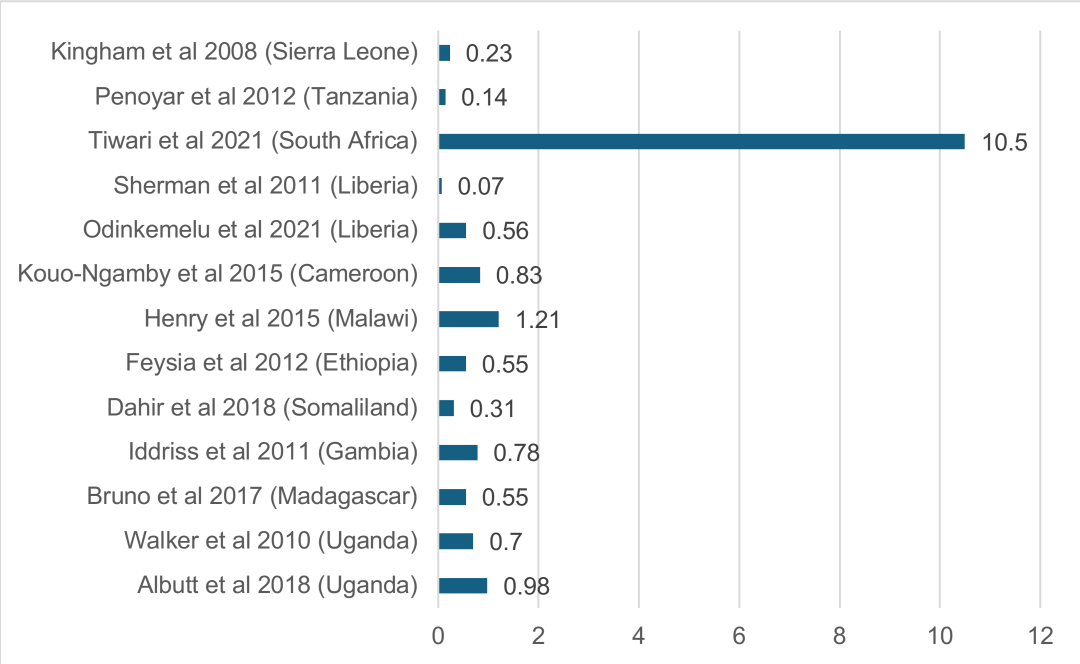


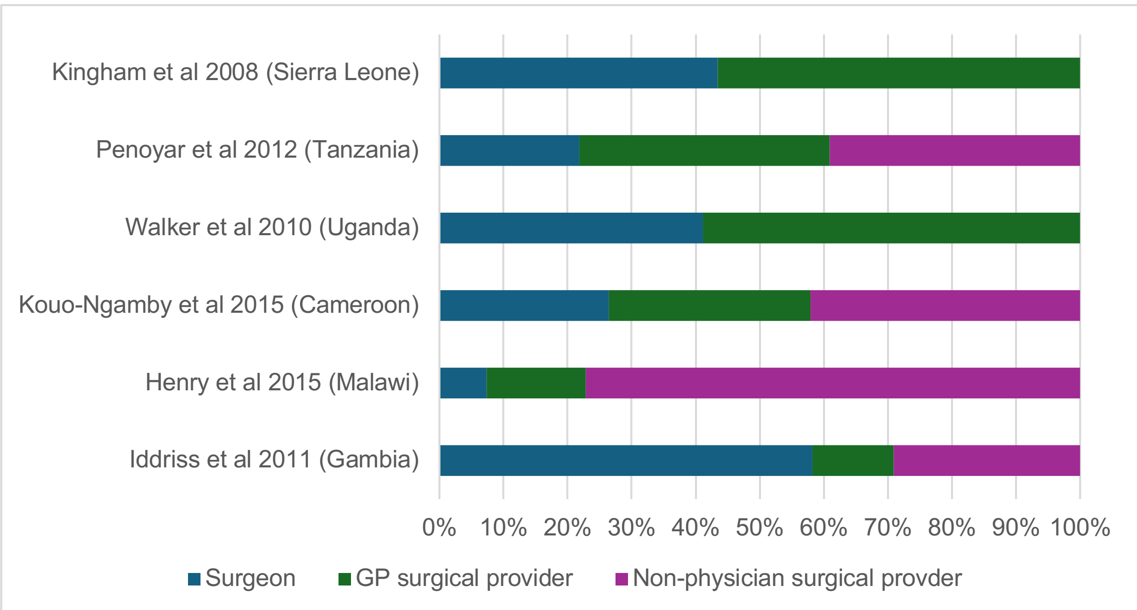
Figure 8.

There were 13 studies included that reported the density of surgical providers in the African region. The highest density of surgeons was found in South Africa by Tiwari et al 2021 by analysing the database of the Health Professionals Council of South Africa to estimate a density of 10.5 surgeons/100,000 population.(228) The second highest was Malawi, estimated at 1.21/100,000 by Henry et al 2015 using the PIPES survey.(229) The lowest density was found in Liberia, at 0.07/100,000 by Sherman et al 2011 who also used the WHO TSAAEESC survey.(230) Importantly, Liberia was also studied by Odinkemelu et al 2021, who reported a significant increase to 0.56/100,000 using the World Federation of Societies of Anaesthesiologists survey.(231) Two authors studied Uganda;. Wilson et al 2010 used a bespoke survey to collect data in 2008 and reported a density of 0.7/100,000.(232) Albutt et al 2018 used the WHO TSAAEESC survey to collect data in 2016 and reported a density of 0.98/100,000.(233)

Figure 3-9. *Density of surgeons per 100,000 population in Africa.*



Of these studies that reported density of surgeons in Africa, six also reported other surgical providers. The breakdown of surgical providers in Africa by percentage of professional group is displayed in in Figure 10. This data highlights that some countries have a low percentage of their surgical workforce made from specialist surgeons, the lowest being Malawi (7.35%), followed by Tanzania (21.88%) and



Cameroon (26.42%).(229,234,235) Gambia was estimated as having the highest proportion of surgeons with 58.21% of the surgical provider workforce.(224)

There were 12 included studies from the African region that reported anaesthesia providers. Of these, all reported anaesthetists, and seven also reported GP anaesthesia providers (GPAPs) and non-physician anaesthesia providers (NPAPs). The density estimates are displayed by study and by country in Figure 11.

The highest density of anaesthetists was found by Tiwari et al 2021 in South Africa who used Health Professionals Council of South Africa database to estimated 3.0/100,000.(228) Zambia was the second highest with 0.46/100,000, estimated by Juventine et al 2023.(236) The lowest density was found in Liberia which was reported as having no anaesthetists by Sherman et al in 2011, however this had risen to 0.02 per 100,000 by Odinkemelu et al in 2021.(230,231)

Of the 12 studies that reported anaesthesia providers, 7 included data on professional groups other than anaesthetists. This data is displayed in Figure 12 below. The lowest percentage of anaesthetists was found in Liberia (0%) by Penoyar et al 2012 and 0.02% in 2021 by Odinkemelu et al.(231,235) The highest percentage of anaesthetists was found in Malawi, at 10.89% by Henry et al 2015, followed by Uganda at 10% by Walker et al 2010.(229,232) Cameroon had the highest percentage of physicians providing anaesthesia at 29.35% including anaesthetists and GP anaesthesia providers.(234)

Figure 3-11. *Density of anaesthetists per 100,000 population in the African region.*

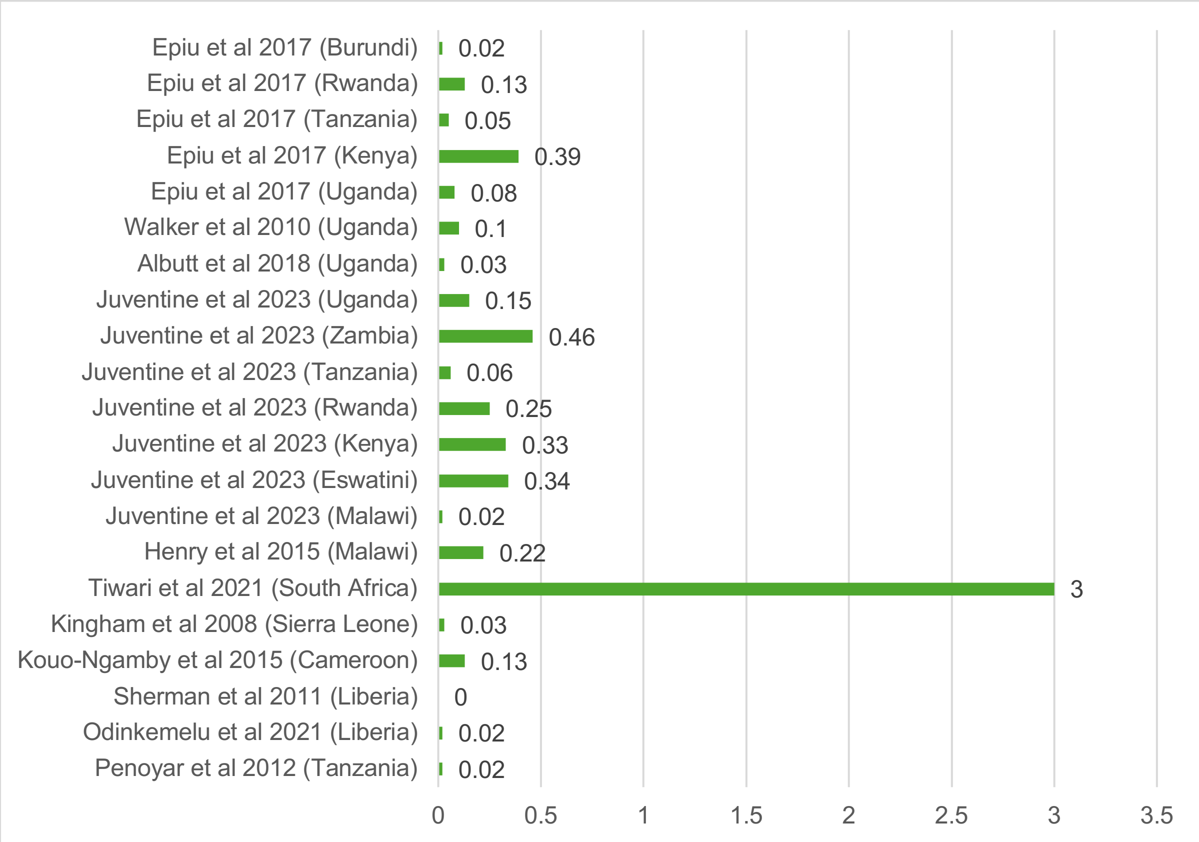
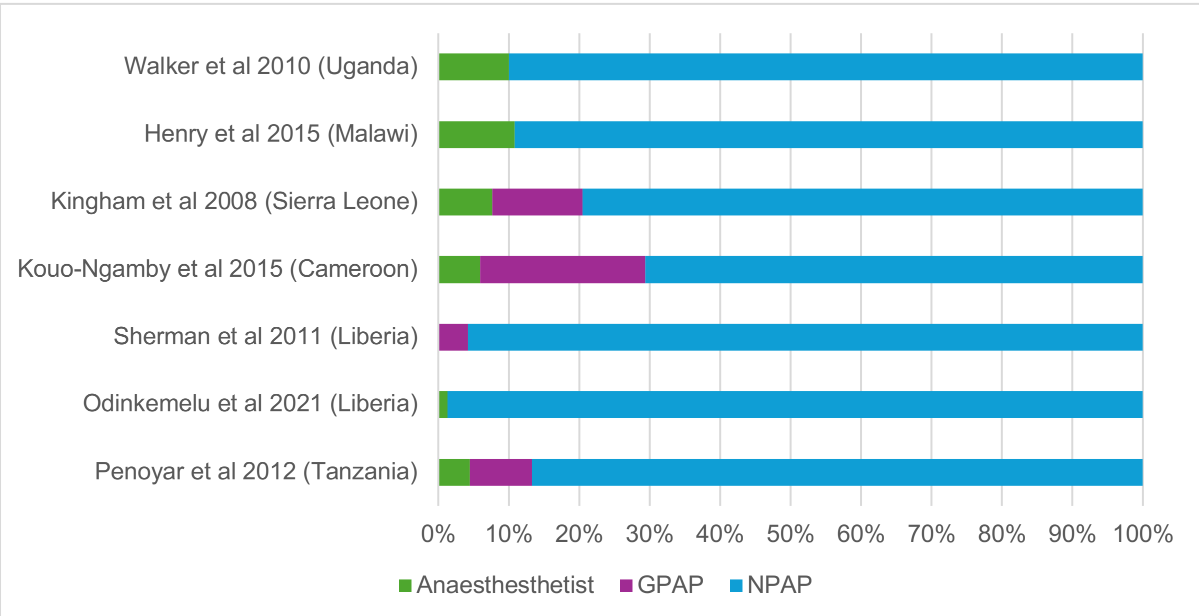
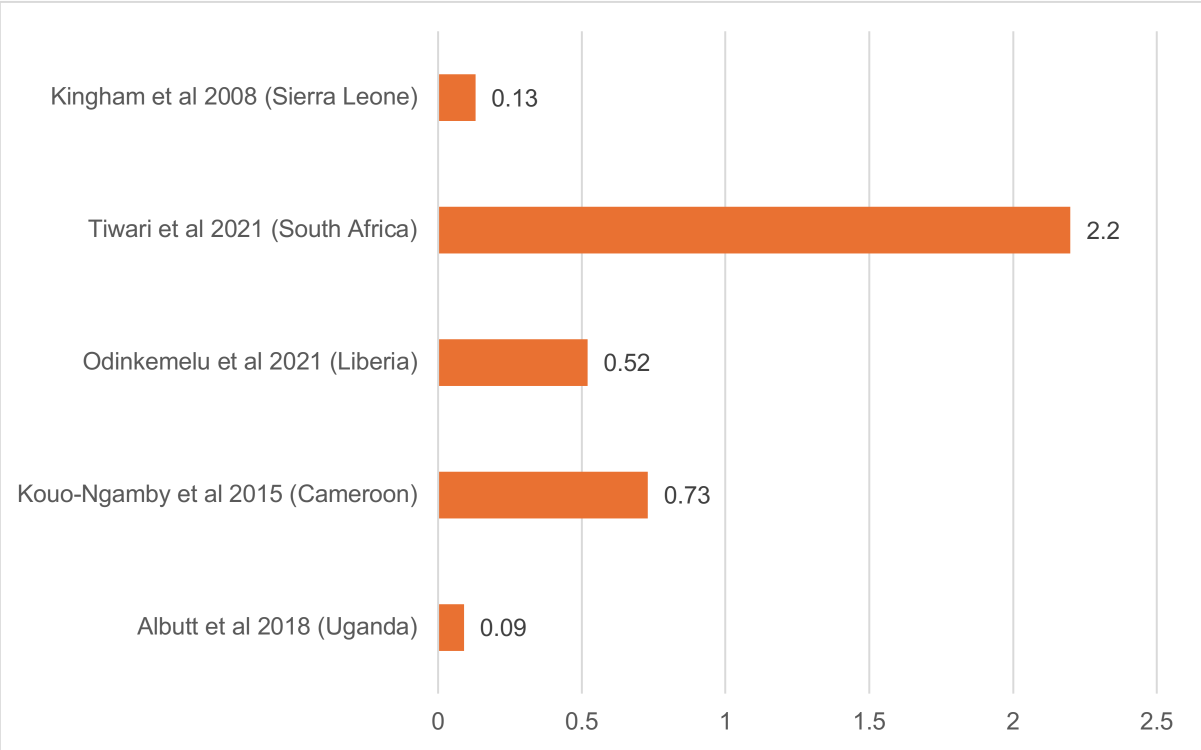


Figure 3-12. *Breakdown of anaesthesia providers by profession in the African region.*



There were ten studies included from the African region that reported data on OB/GYN specialists or midwives, of these, five reported the density of OB/GYN and six reported the density of midwives. South Africa was reported as having the highest density of OB'GYN specialists at 2.2/100,000 by Tiwari et al 2021 and Uganda was estimated to have the lowest at 0.09/100,000 by Albutt et al 2018 – see Figure

Figure 3-13. *Density of OB/GYN specialists, per 100,000 in the African region.*

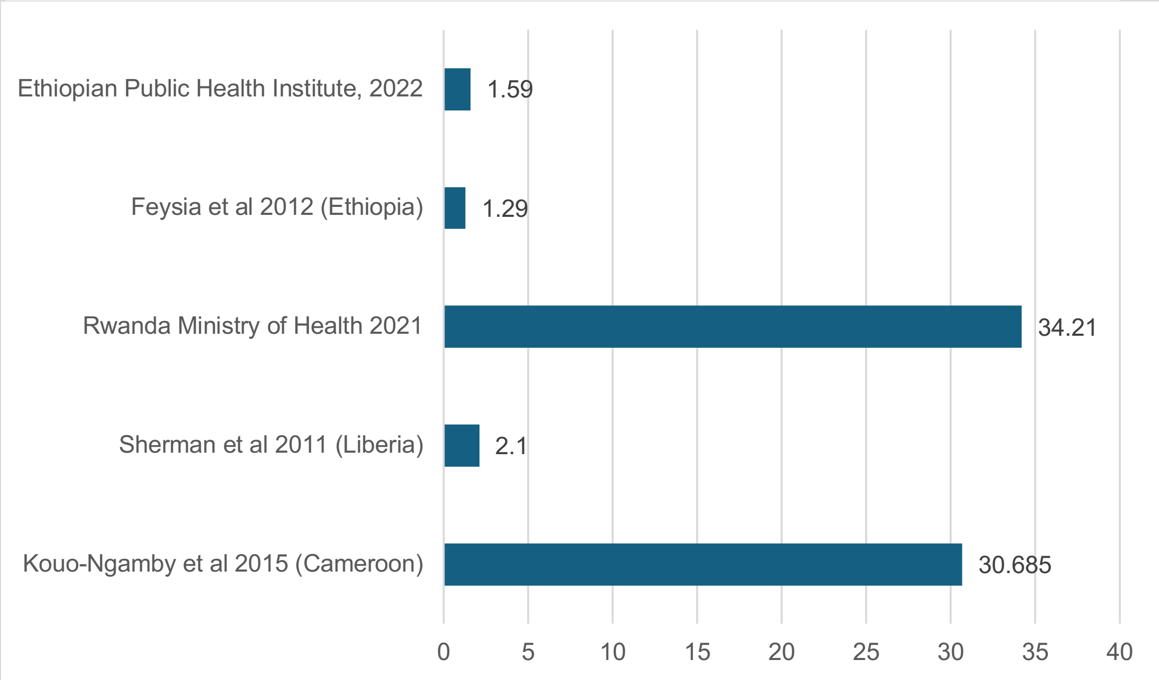


13.(228,233)

The highest density of midwives was reported to be in South Africa at 34.21/100,000 and the lowest in Ethiopia, at 1.29 by Feysia et al 2012, although this had increased to 1.59/100,000 based on the Ethiopian Public Health Institute report in 2022.(228,237,238) This data is shown in Figure 14.

Two studies reported the specialist physician density in Africa; this was estimated at 12/100,000 (including GPs) in Ethiopia in by the Ethiopian Public Health Institute in 2022 and the regional average was reported at 31/100,000 in 2018, rising from 20/100,000 in 2005 by the WHO Regional Office for Africa 2021.

Figure 3-14. *Density of midwives per 100,000 population in the African region.*



3.3.5 Eastern Mediterranean Region (EMRO)

There were two studies included from the EMRO region, both of these studies reported on Pakistan, one reported SAO providers, and one reported Anaesthetist density along with midwives.

Siddiqi et al 2020 used the WHO TSAAEESC survey to assess the density of SAO providers in the rural areas of Pakistan as 0.5/100,000, although this is likely to be an underestimate due the study not including urban areas where specialists are usually based.(239)

Ashraf et al 2022 performed a systematic review to report on the density of anaesthetists in Pakistan.(240) The authors estimated 0.15 consultant anaesthetists per 100,000, and 0.26/100,000 including trainees.

3.3.6 European Region (EURO)

There were five studies included from LMIC countries in the European region; two reported on Bulgaria, and one each on Serbia, Belarus and Kazakhstan, all were published by the authors from the European Observatory on Health Systems and Policies. There were no studies reporting GP surgical or anaesthetic providers or non-physician surgical or anaesthetic providers.

Four studies reported the density of surgeons, these are displayed in Figure 15. Kazakhstan was reported with the highest density at 44/100,000 by Katsaga et al 2012 using national MoH data.(241) The lowest density was found in Bulgaria (16/100,000) in 2012 by Dimova et al, this rose to 23/100,000 by the same authors in 2018, both using WHO Regional Office for Europe data.(242,243)

Dimova et al 2012 also reported the number of gynaecologists in Bulgaria at 18/100,000 using WHO Regional Office for Europe data.(242)

Five studies reported on the density of midwives within the European region. Belarus was estimated to have the highest density at 49.94/100,000 by Richardson 2013 and the lowest was found in Serbia with 36/100,000 by Bjegovic-Mikanovic et al 2019.(244,245) The density in Bulgaria was estimated to increase from 44/100,000 in 2012 to 46.6/100,000 in 2018, both by Dimova et al – see Figure 16.(242,243)

Two studies reported the density of specialist medical practitioners; Dimova et al 2018 reported 349.05/100,000 and Bjegovic-Mikanovic et al 2019 reported 210/100,000 in Serbia.(243,245)

Figure 3-15. *Density of surgeons per 100,000 in the European region.*

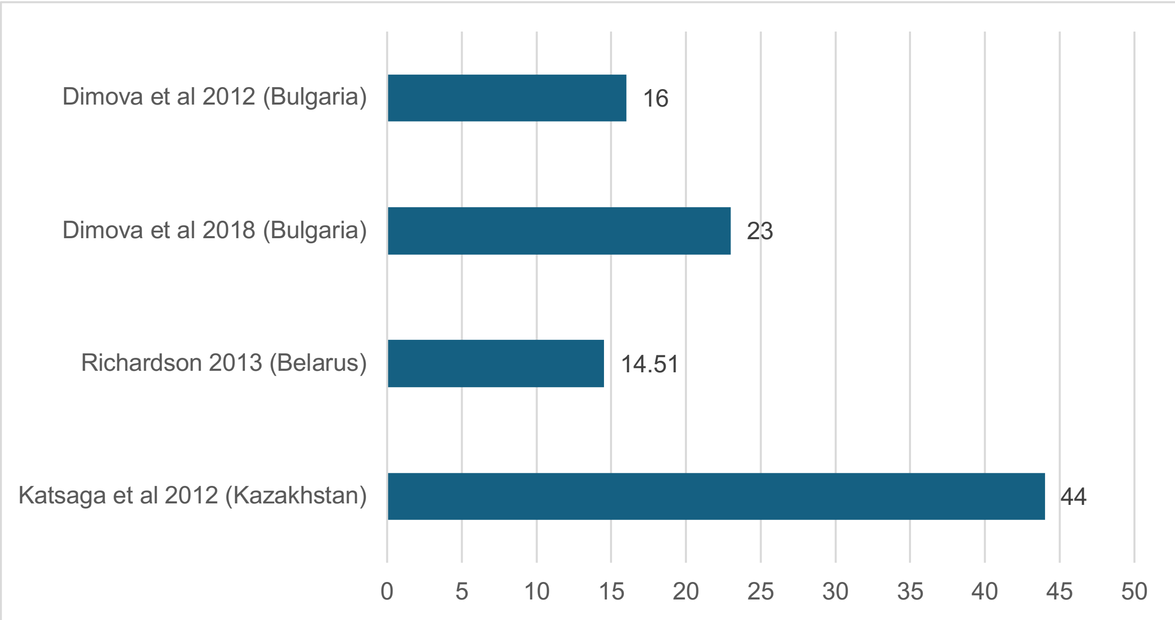
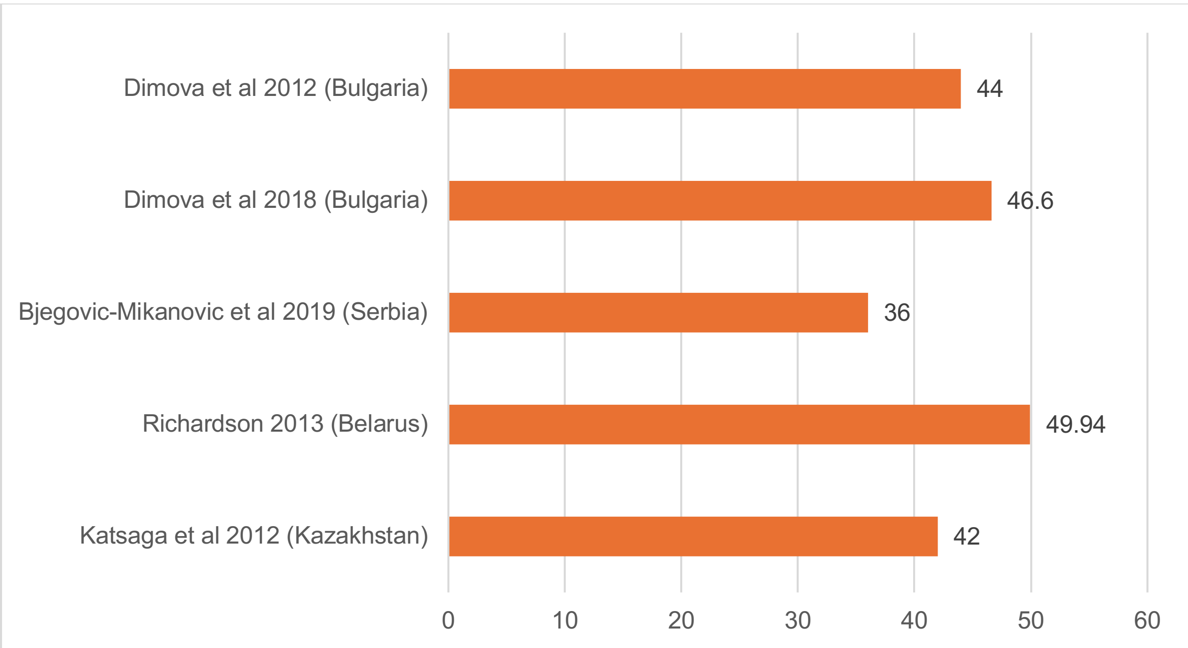


Figure 3-16. *Density of midwives per 100,000 population in European region.*

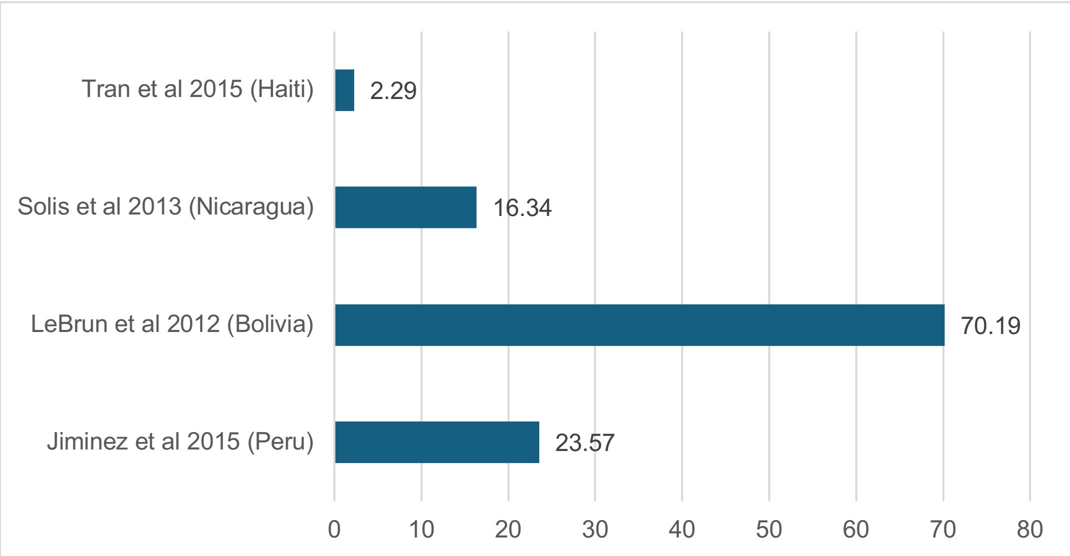


3.3.7 Americas Region (AMR)

There were five included studies form the Region of the Americas, one each from Peru, Bolivia, Nicaragua, Haiti and Guyana. Four used the WHO TSAAEESC survey and one used national MoH data. All five reported anaesthetist density and four reported surgeon and OB/GYN density.

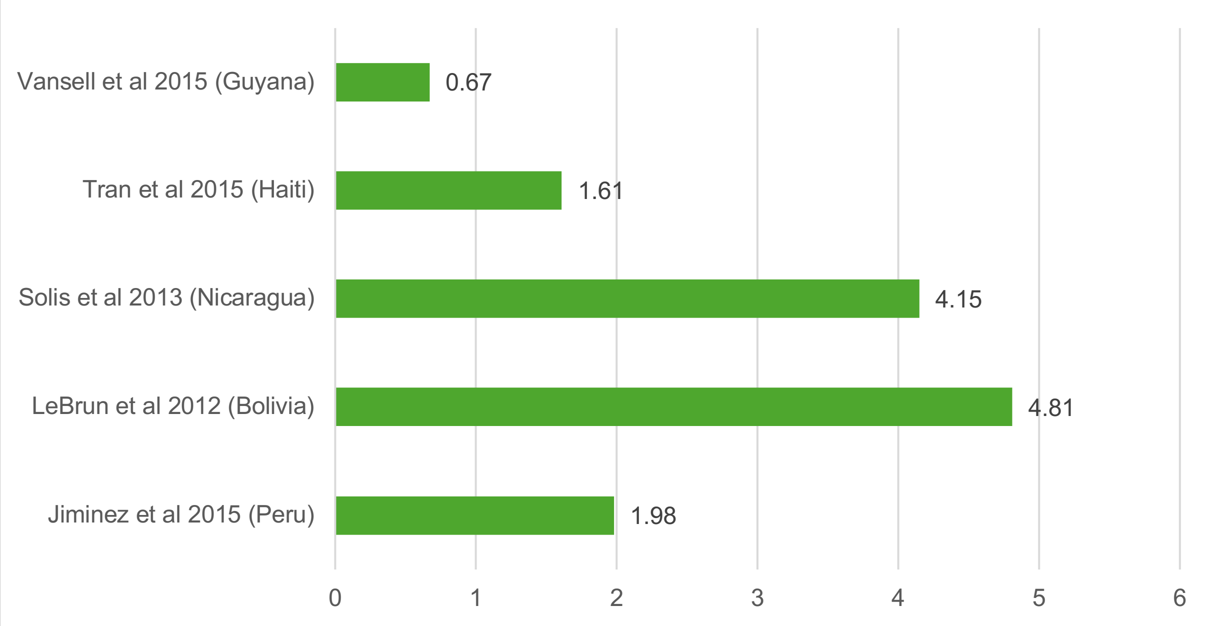
The four studies which reported surgeon density varied widely, with Bolivia reporting the highest density at 70.19/100,000 based on a WHO TSAAEESC survey by LeBrun et al 2012, and Haiti reported the lowest at 2.29/100,000 also using the WHO TSAAEESC survey conducted by Tran et al 2015.(246,247)

Figure 3-17. *Density of surgeons per 100,000 in the Region of the Americas.*



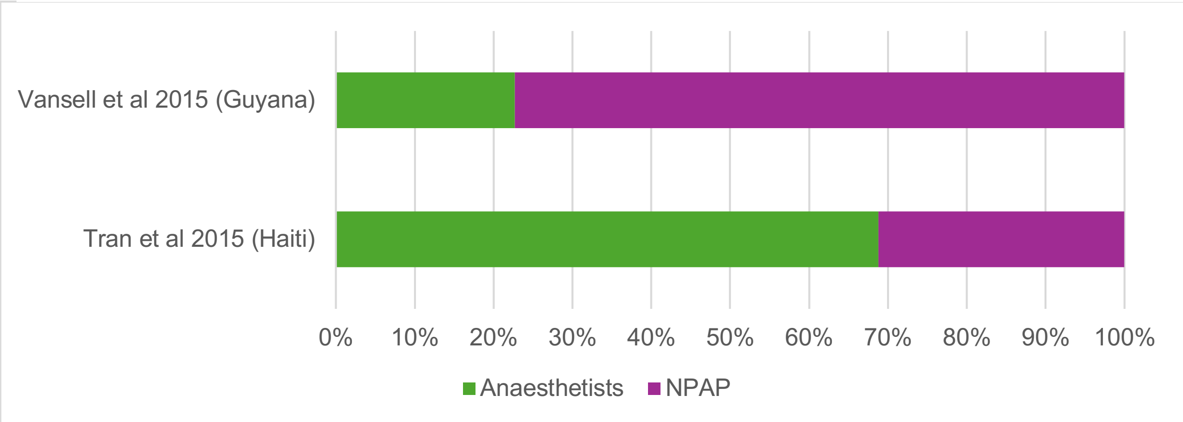
Of the five studies that reported density of anaesthetists, two also reported NPAPs. Bolivia was estimated as having the highest density of anaesthetists at 4.81/100,000 using a WHO TSAAEESC survey in 2011 by LeBrun et al 2012.(246) The lowest density was reported in Guyana at 0.67/100,000 by Vansell et al 2015, also using a WHO TSAAEESC survey – see Figure 18.(248)

Figure 3-18. *Density of anaesthetists per 100,000 population in the Region of the Americas.*



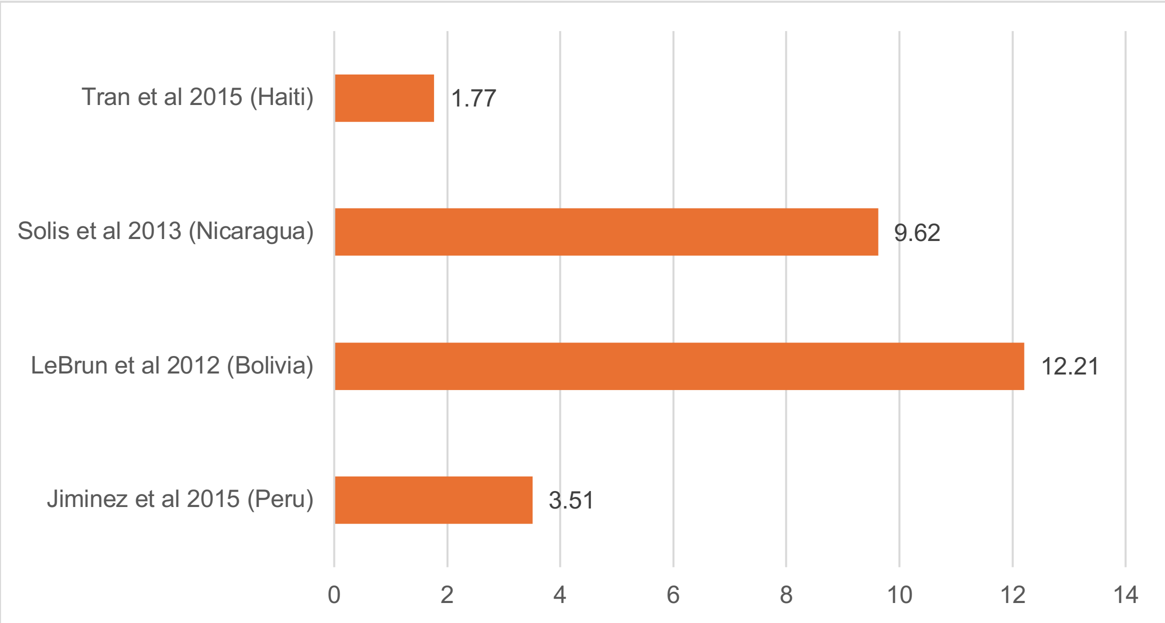
Guyana was estimated to have a much lower percentage of anaesthetists as part of the anaesthesia workforce - 22.72% compared to 68.83% in Haiti – see Figure 19.(247,248)

Figure 3-19*. Percentage of anaesthesia workforce by professional group within the Region of the Americas.*



The density of OB/GYN specialists was estimated by four studies. The highest density was reported by LeBrun et al 2012 in Bolivia at 12.21/100,000 and the lowest by Tran et al 2015 in Haiti at 1.77/100,000 – see Figure 20.(246,247)

Figure 3-20. *Density per 100,000 population of OB/GYN specialists in the Region of the Americas.*



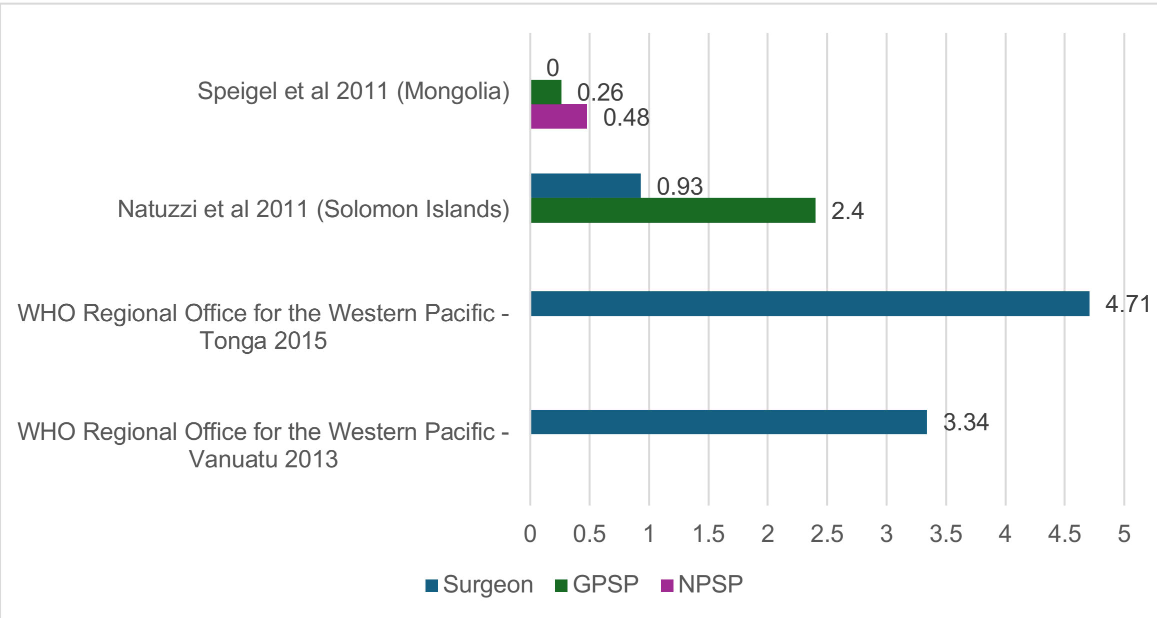
The density of midwives was reported by two included studies, Tran et al (Haiti) and Jiminez et al (Peru), both in 2015. The density in Peru was reported at 38/100,000 and 2.97/100,000 in Haiti.(247,249)

3.3.8 Western Pacific Region (WESTPAC)

There were 6 included studies from the Western Pacific Region. Of these, three were based on surveys, two on national MoH data and one using the WHO Global Health Observatory Data Repository.

Four studies reported surgical providers in the region. The WHO Regional Office for the Western Pacific published two studies, on Vanuatu in 2013 and Tonga in 2015.(250,251) These reported the density of surgeons at 3.34/100,000 in Vanuatu and 4.71/100,000 in Tonga.(250,251) Natuzzi et al 2011 conducted a WHO TSAAEESC survey of the Solomon Islands and reported a surgeon density of 0//93/100,000 and a density of GP surgical providers at 2.4/100,000.(252) Speigel et al 2011 also conducted a WHO TSAAEESC Survey of Mongolia and reported 0 surgeons, and a density of GPSP at 0.26/100,000 and NPSP at 0.48/100,000.(253) The density of surgical providers in the WESTPAC region is displayed in Figure 21.

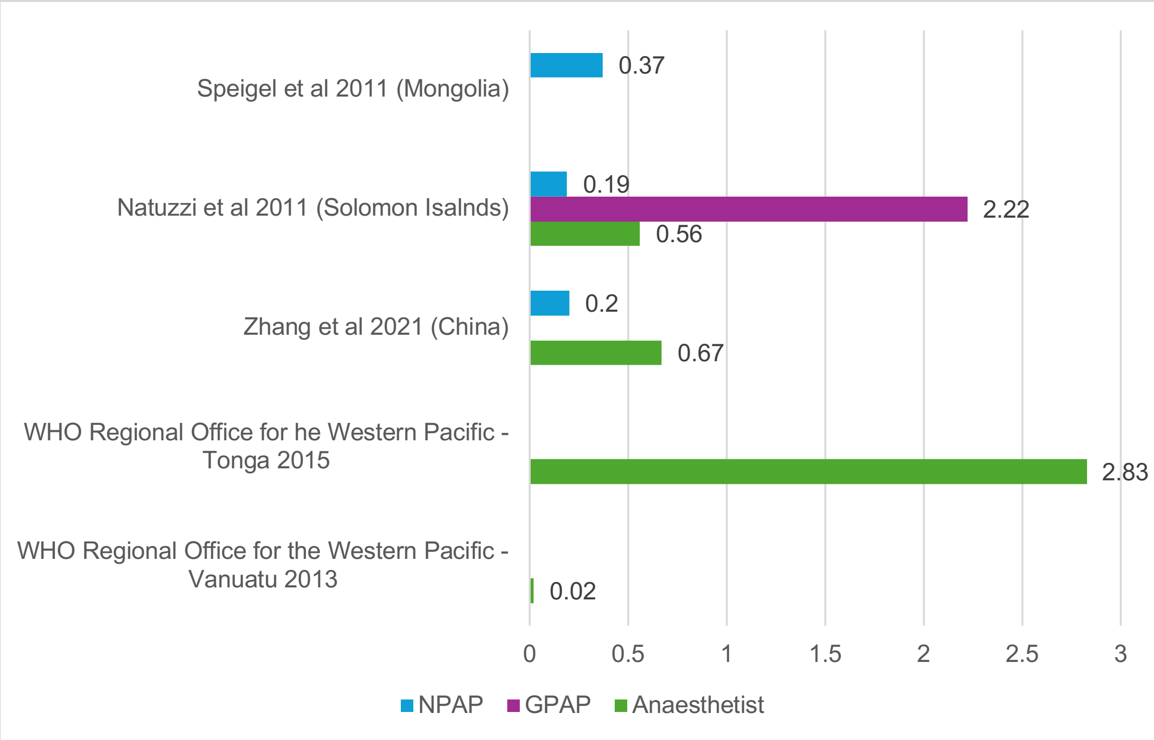
Figure 3-21. *Density of surgical providers in the WESTPAC region per 100,000 population.*



Five studies reported anaesthesia providers in the WESTPAC region. The WHO Regional Office for the Western Pacific estimated a density of anaesthetists as 0.02/100,000 for Vanuatu (2013) and 2.83 for Tonga (2015) using national MoH data for Vanuatu and the WHO Global Health Repository for Tonga.(250,251) Zhang et al 2021 used a cross sectional survey of anaesthesia departments to estimate a density of 0.67/100,000 for anaesthetists and 0.2/100,000 for NPAP in China.(254)

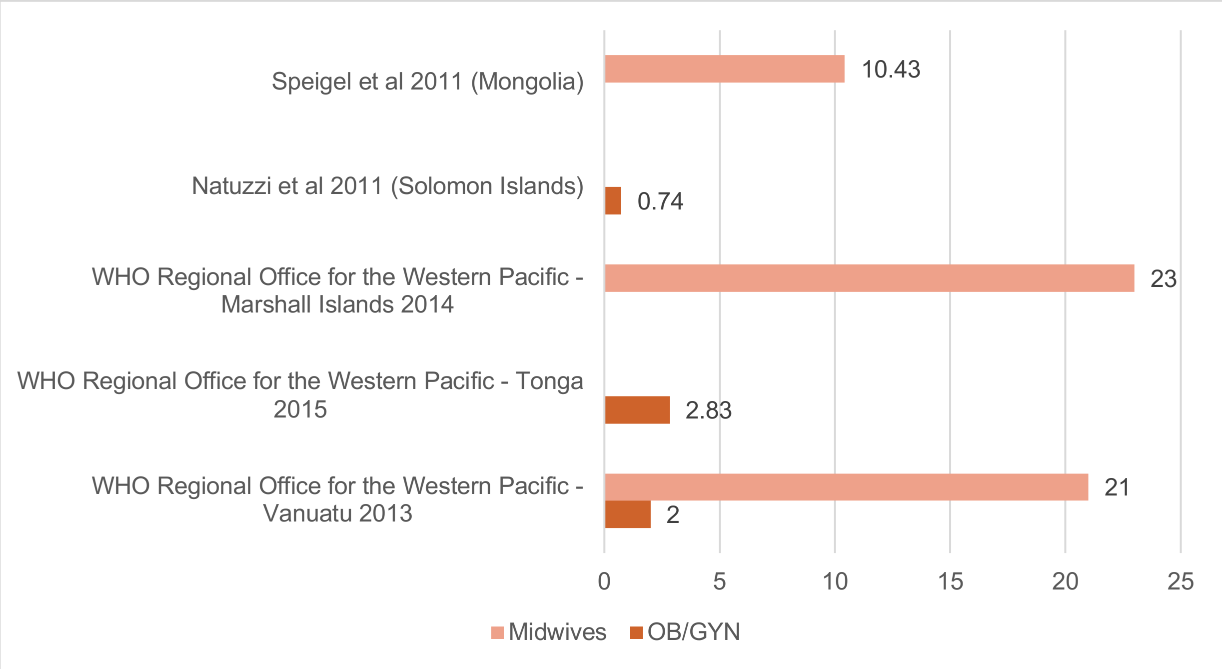
Natuzzi et al 2011 estimated 0.56/100,000 anaesthetists, 2.22/100,000 GPAP and 0.19 NPAP/100,00 in the Solomon Islands.(252) Speigel et al 2011 estimated that there were no anaesthetists, nor GPAP and just 0.37 NPAP/100,000 in Mongolia – see Figure 22.(253)

Figure 3-22. *Anaesthesia providers in the WESTPAC region per 100,000 population.*



Five studies reported OB/GYN specialists and midwives in the region. The WHO Regional Office for the Western Pacific estimated a density of 2/100,000 OG/GYN and 21/100,000 midwives in Vanuatu (2013), 23/100,000 midwives for the Marshal Islands and 2.83/100,000 OB/GYN in Tonga (2015).(250,251,255) Natuzzi et al 2011 estimated an OB/GYN density of 0.74/100,000 in the Solomon Islands, and Spiegel et al 2011 reported 0 OB/GYN and a midwife density of 10.43/100,000 in Mongolia – see Figure 24.(252,253)

Figure 3-23. *Density of OB/GYN and midwives in WESTPAC region per 100,000 population.*



One study reported specialist medical practitioners, WHO Regional Office for the Western Pacific used national MoH data to estimate 28/100,000 Specialist Medical for the Marshall Islands in 2014.(255)

3.3.9 South East Asian Region (SEAN)

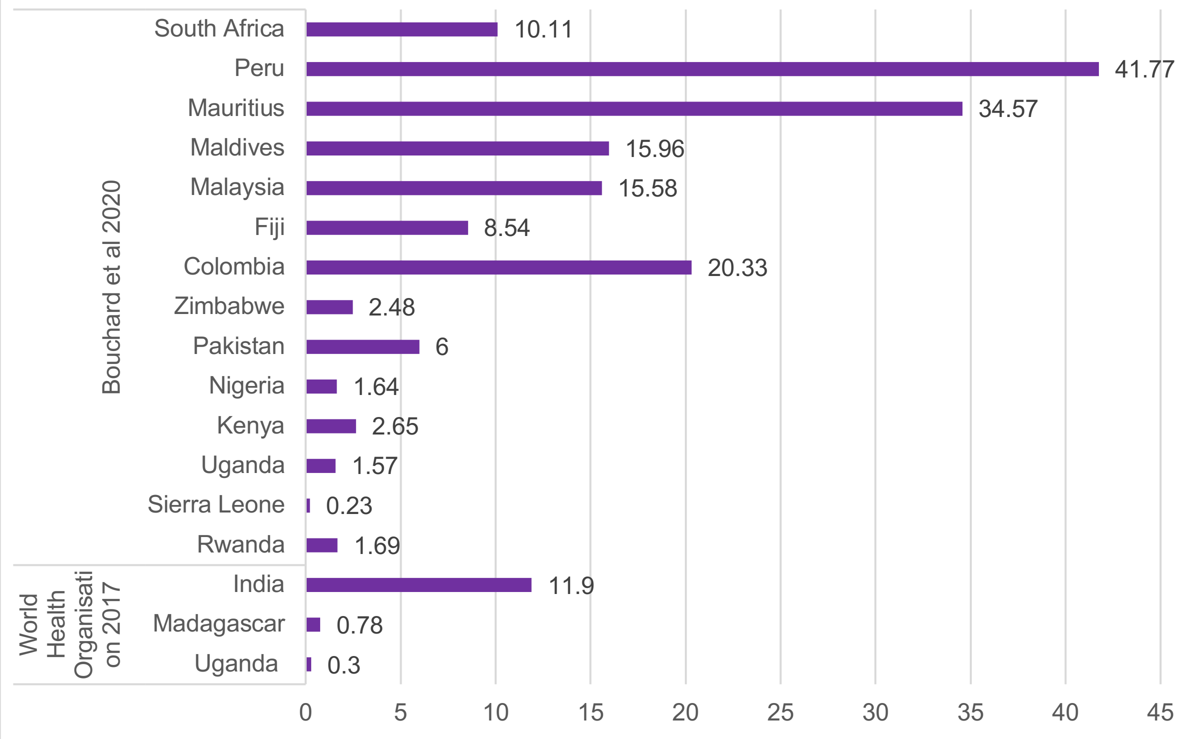
There were two included study from the SEAN region. Kolehmainen-Aitken & Srestha 2009 used national Nepal MoH data in combination with a field study and estimated a density of anaesthetists of 0.03/100,000 and OB/GYN specialists of 0.05/100,000.(256) Ross et al 2023 used the WHO-PGSSC Surgical Assessment Tool (SAT) survey to estimate the density of SAO providers at 0.4/100,000.(257)

3.3.10 Global

There were ten included studies that reported either multiple WHO regions or on the entire world. Of these studies, four used surveys, two used national MoH data, three used a combination of national MoH data with WHO data and a mixture of other sources and one was a systematic review.

Four of these studies reported SAO provider density. WHO 2017 used the WHO TSAAEESC survey to estimate the SAP density in Uganda, Madagascar and India. The authors reported a SAO density of 11.9/100,000 in India, 0.78/100,000 in Madagascar and 0.3/100,000 in Uganda.(258) These are shown in Figure 24. Bouchard et al 2020 used a combination of online medical licensing registries and the WHO Global Surgical Workforce Database to report on the SAO density in eleven countries across all six WHO World Regions.(259) These data are also displayed in Figure 24. Peru was estimated as having the highest density at 41.77/100,000 and Sierra Leone the lowest at 0.23/100,000.(259)

Figure 3-24. *SAO provider density per 100,000 in multiple countries from WHO 2017 and Bouchard et al 2017.*



Holmer et al 2015 used a combination of MoH, WHO country offices, professional societies and other publically available sources to evaluate the number and density of SAO providers in total and also by individual specialities.(207) The World Bank maintains a live, online database of Specialist Surgical Workorce reporting data collected by the Lancet Commission on Global Surgery (LCoGS), the WHO, national Ministries of Health, the OECD and the BMJ Global Health.(260) These combined data are presented in Figures 25 – 30 along with the LCoGS target of 20 SAO providers per 100,000 population.

. Both sources report the highest density in the African region as the Seychelles with an SAO density of 34.8/100,000 (Holmer) and 48.57/100,000 (World Bank), followed by Mauritius (18.9 and 17.58 respectively) and Cape Verde (16.2 and 16.4 respectively) – see Figure 25.(207,260) The lowest density was reported in Congo, Democratic Republic of the Congo and Sierra Leone. (207,260) The only country to meet the LCoGS target was the Seychelles – see Figure 25. (10,207,260)

Within the Americas region the highest density amongst the LMICs was found in Cuba (113.9 by Holmer and 100.89 by the World Bank) followed by Ecuador (61.1 and 59.39 respectively) and Brazil (59.2/100,000). (207,260) The lowest density within the region was found in Guatemala followed by Haiti and Guyana. When compared to the LCoGS target, 12 countries were above the required 20 and 12 countries were below the 20/100,000 target, and 3 countries reported no data – see Figure 26. (10,207,260)

Within the Eastern Mediterranean region, the highest density was found in Lebanon (85.5 by Holmer and87.4 by the World Bank), followed by Egypt (55.6 and 50.08 respectively) and Oman (28.5 by Holmer). (207,260) The lowest density was found in Afghanistan (0.03 by the World Bank) followed by Somalia (0.2 by Holmer and 0.16 by the World Bank) and Yemen (0.9 by Holmer and 0.82 by the World Bank). (207,260) Only four countries (Lebanon, Egypt, Oman and Jordan) met the LCoGS 20/100,000 target – see Figure 27. (10,207,260)

Within the South East Asia region, the highest density was found in Thailand (13.4 by Holmer and 13.09 by the World Bank), followed by India (6.5 and 6.82 respectively) and the Maldives (6.20 and 4.83 respectively). (207,260) The lowest density was in Timor-Leste (0.6 and 0.9 respectively), Sri Lanka (1.8 and 2.28

respectively) and Myanmar (2.4 and 2.42 respectively).(207,260) No countries within the region met the LCoGS target – see Figure 28.(10,207,260)

Within the Western Pacific region, the highest density was reported in Niue (200 by Holmer), followed by Mongolia (49.4 by Holmer and 45.03 by the World Bank) and China (38.9 and 40.13).(207,260) The lowest density was reported in Papua New Guinea (1.1 and 2.3), the Solomon Islands (2.2 and 2.5) and the Lao People's Democratic Republic (2.9 by Holmer).(207,260) Seven countries met the LCoGS target and 12 did not, with no data for 4 countries- see Figure 29.(10,207,260)

Within the European region, the highest density amongst LMICs was found in Belarus (122.1 by Holmer and 124.24 by the World Bank) followed by Serbia (54.3 and 86.72) and Ukraine (86.55 by the World Bank).(207,260) The lowest density was fond in Albania (6.5 and 11.63) followed by Bosnia and Herzegovina (11.6 by Holmer) and Turkey (24.1 by Holmer).(207,260) Only Armenia and Bosnia and Herzegovina did not meet the LCoGS target density – see Figure 30.(10,207,260)

The combined data for the entire world from Holmer et al 2015 and the World Bank has been displayed in a world map in Figure 31.(207,260) This is coloured based on the density of SAO providers, with any density less than the LCoGS recommended 20/100,000 coloured red and any density above coloured green, with a darker green representing a higher density.(10) This map shows that the countries that are below the LCoGS target of 20 SAO providers per 100,000 are based in the traditional 'Global South' of Africa, the Eastern Mediterranean, South East Asia and the Western Pacific.

Figure 3-25. *Density of SAO providers per 100,000 in the African region by Holmer et al 2015 and The World Bank with LCoGS target.*

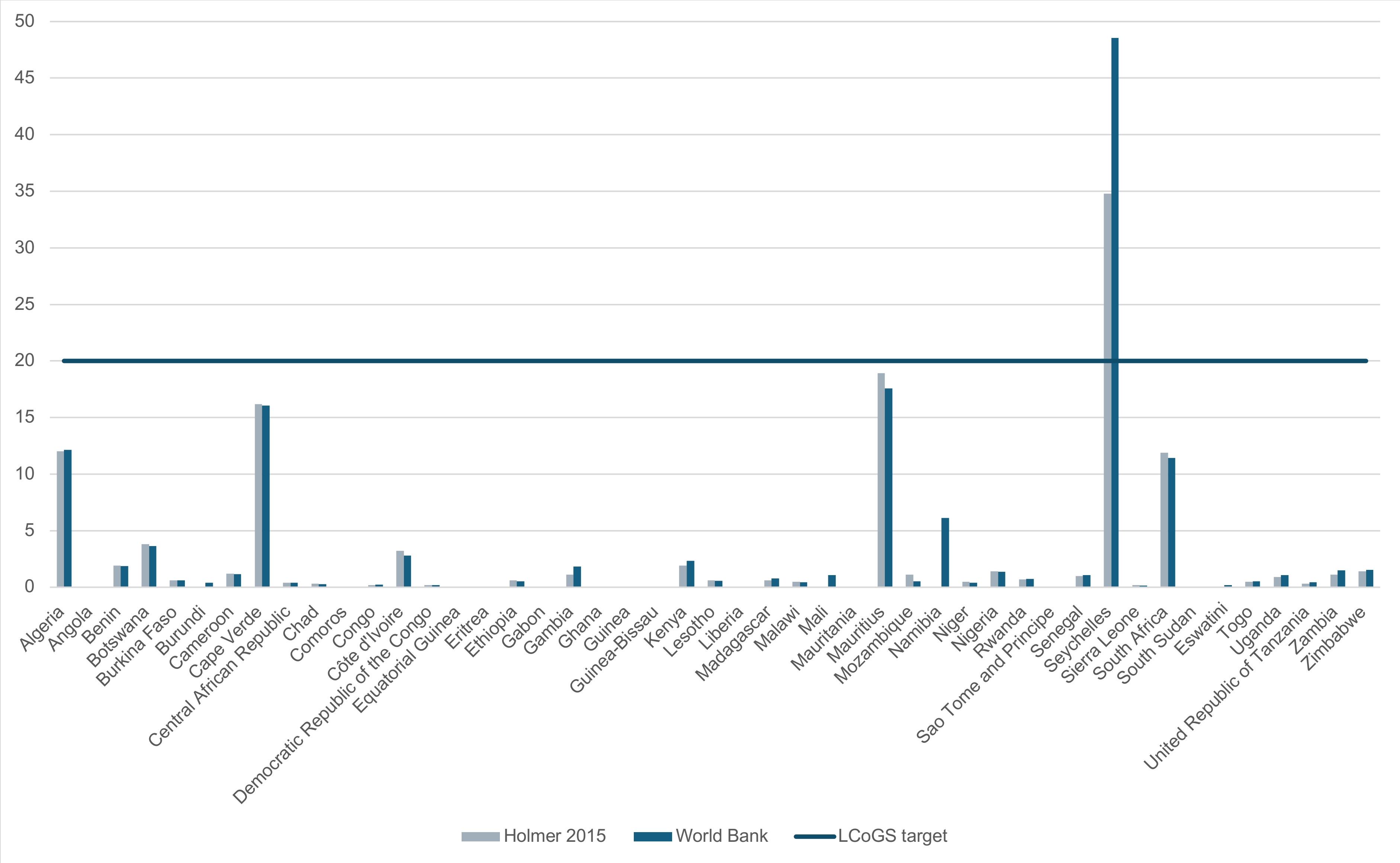


Figure 3-26. *Density of SAO providers per 100,000 in the region of the Americas by Holmer et al 2015 and The World Bank with LCoGS target.*

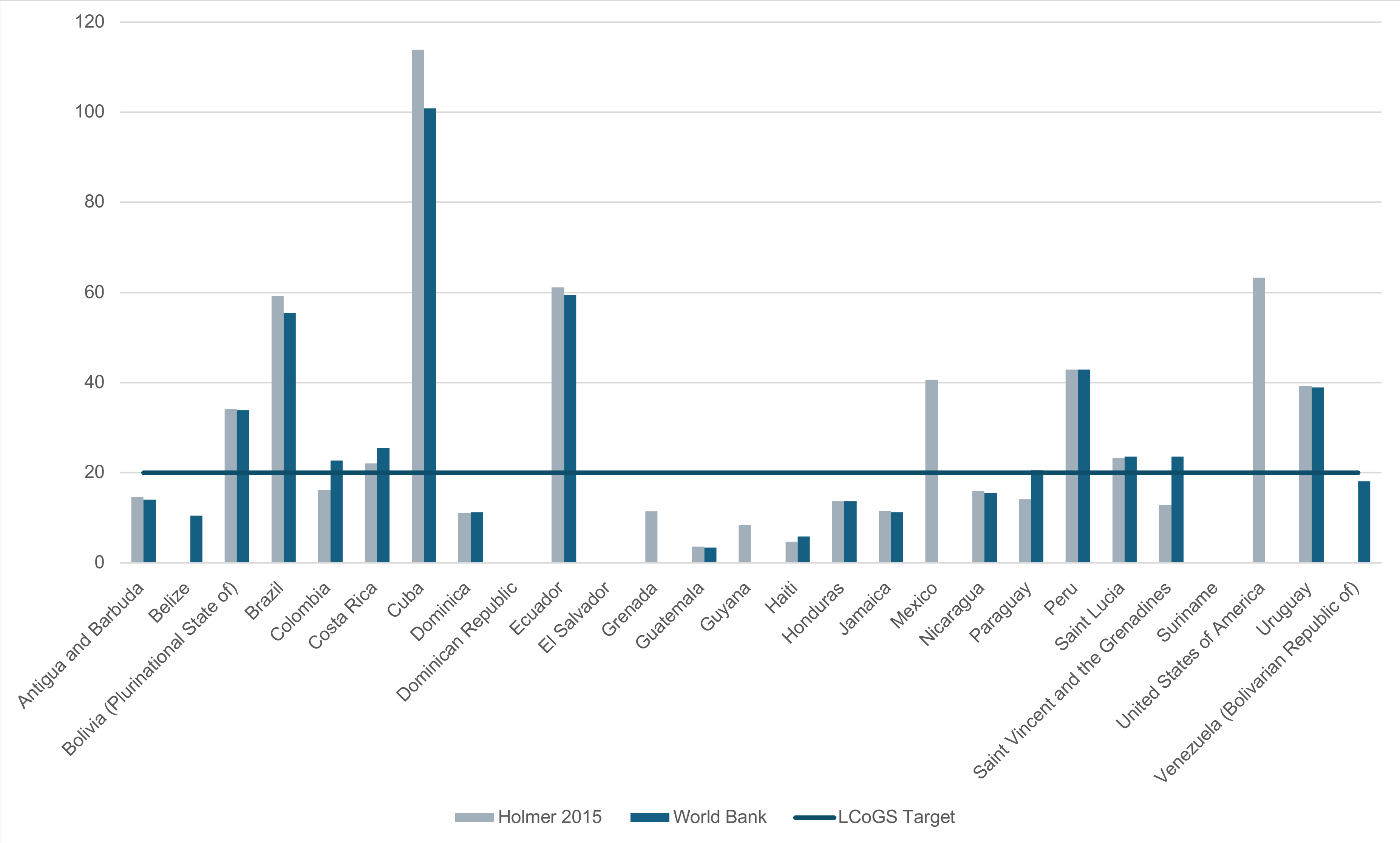


Figure 3-27. *Density of SAO providers per 100,000 in the Eastern Mediterranean region by Holmer et al 2015 and The World Bank with LCoGS target.*

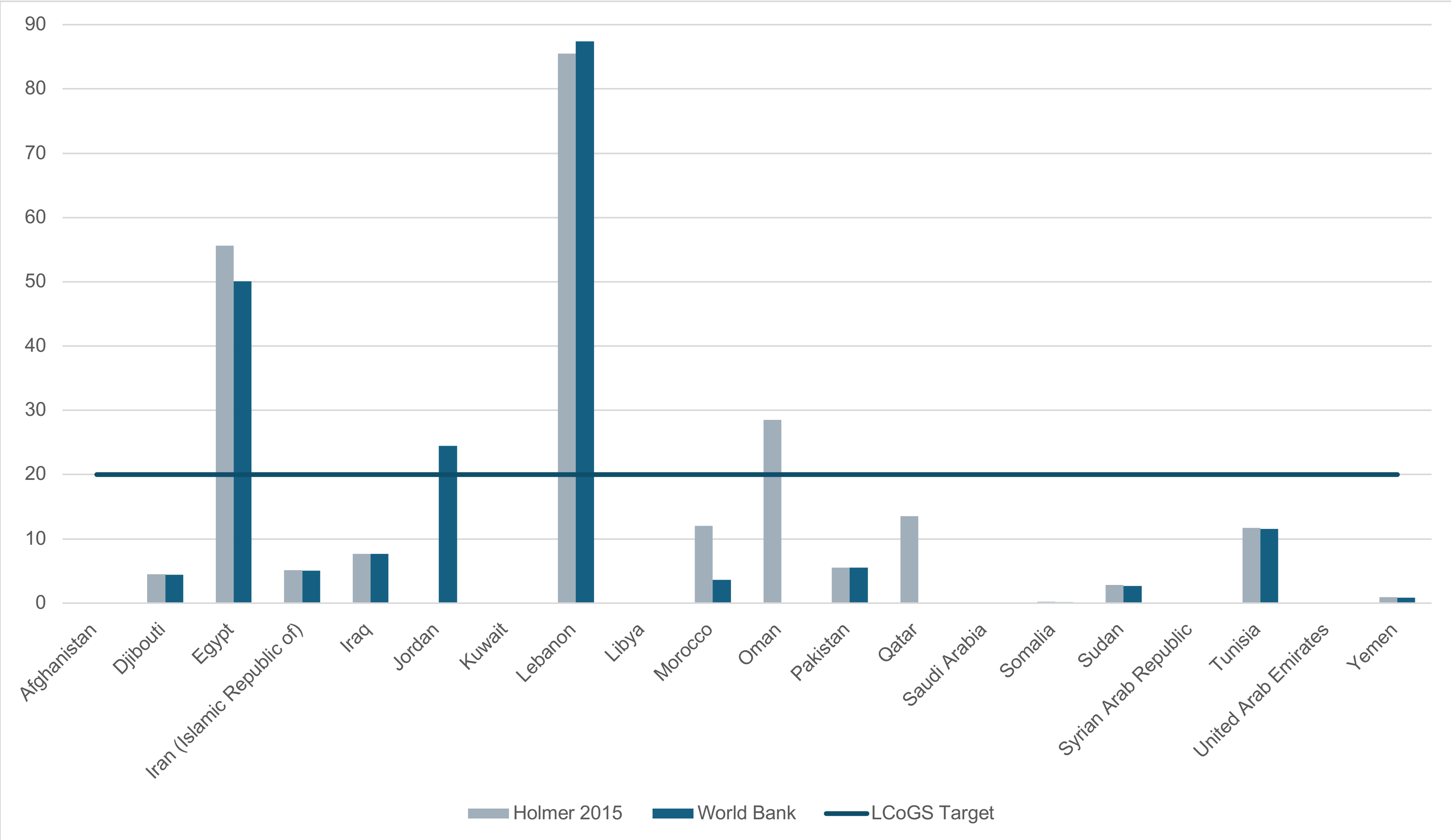


Figure 3-28. *Density of SAO providers per 100,000 in the South East Asian region by Holmer et al 2015 and The World Bank with LCoGS target.*

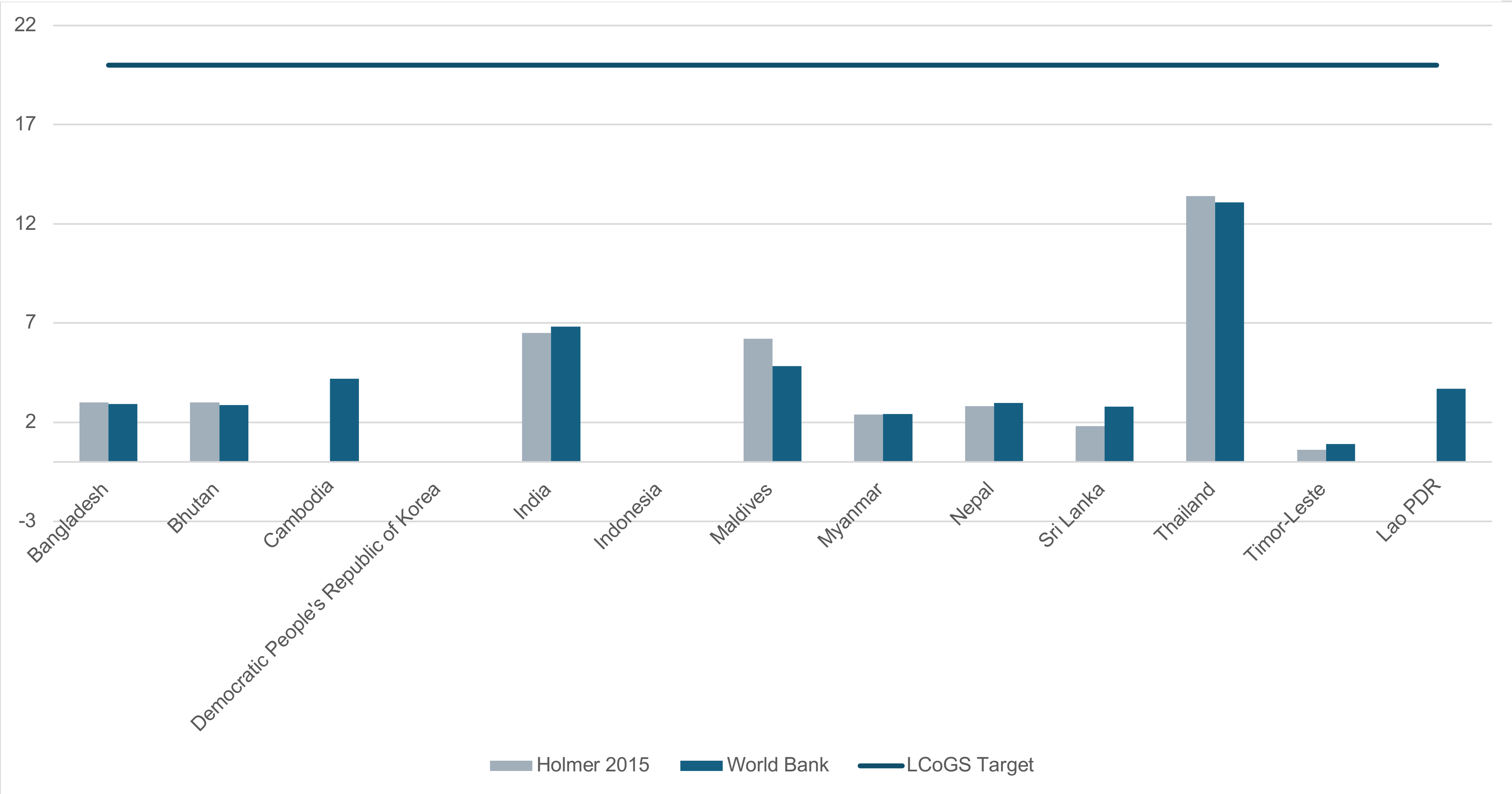


Figure 3-29. *Density of SAO providers per 100,000 in the Western Pacific region by Holmer et al 2015 and The World Bank with LCoGS target.*

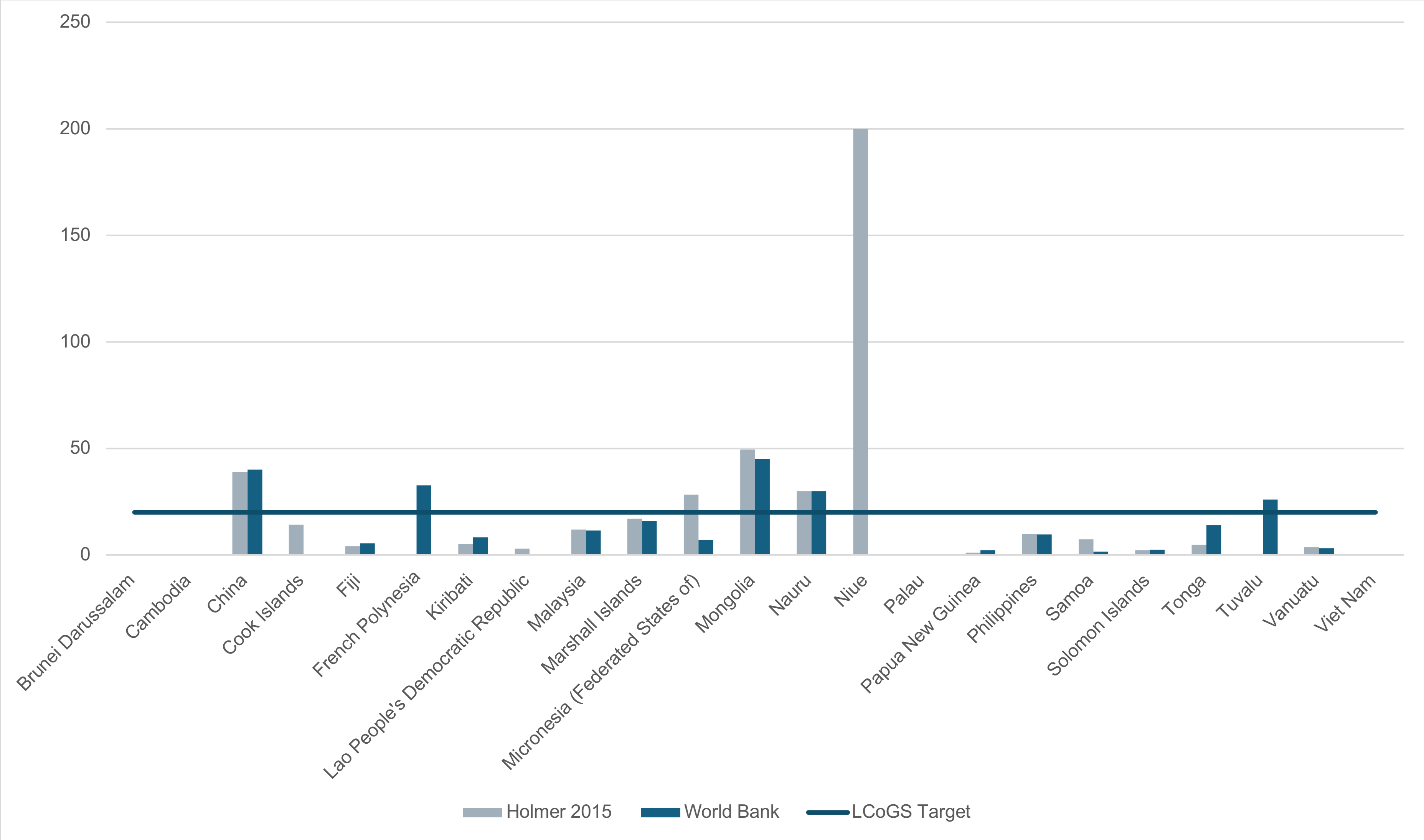


Figure 3-30. *Density of SAO providers per 100,000 population in the European region by Holmer et al 2015 and the World Bank with LCoGS target.*

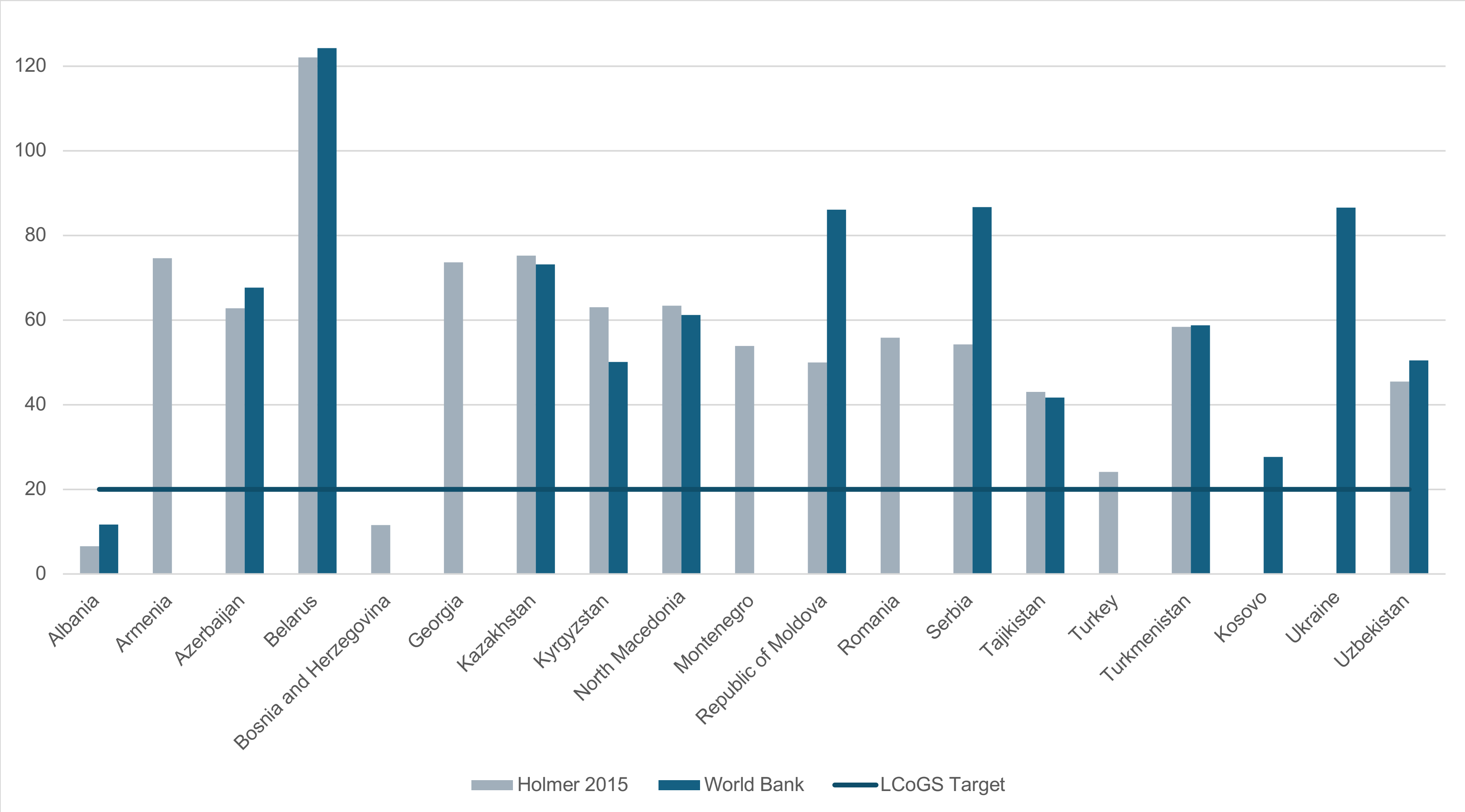
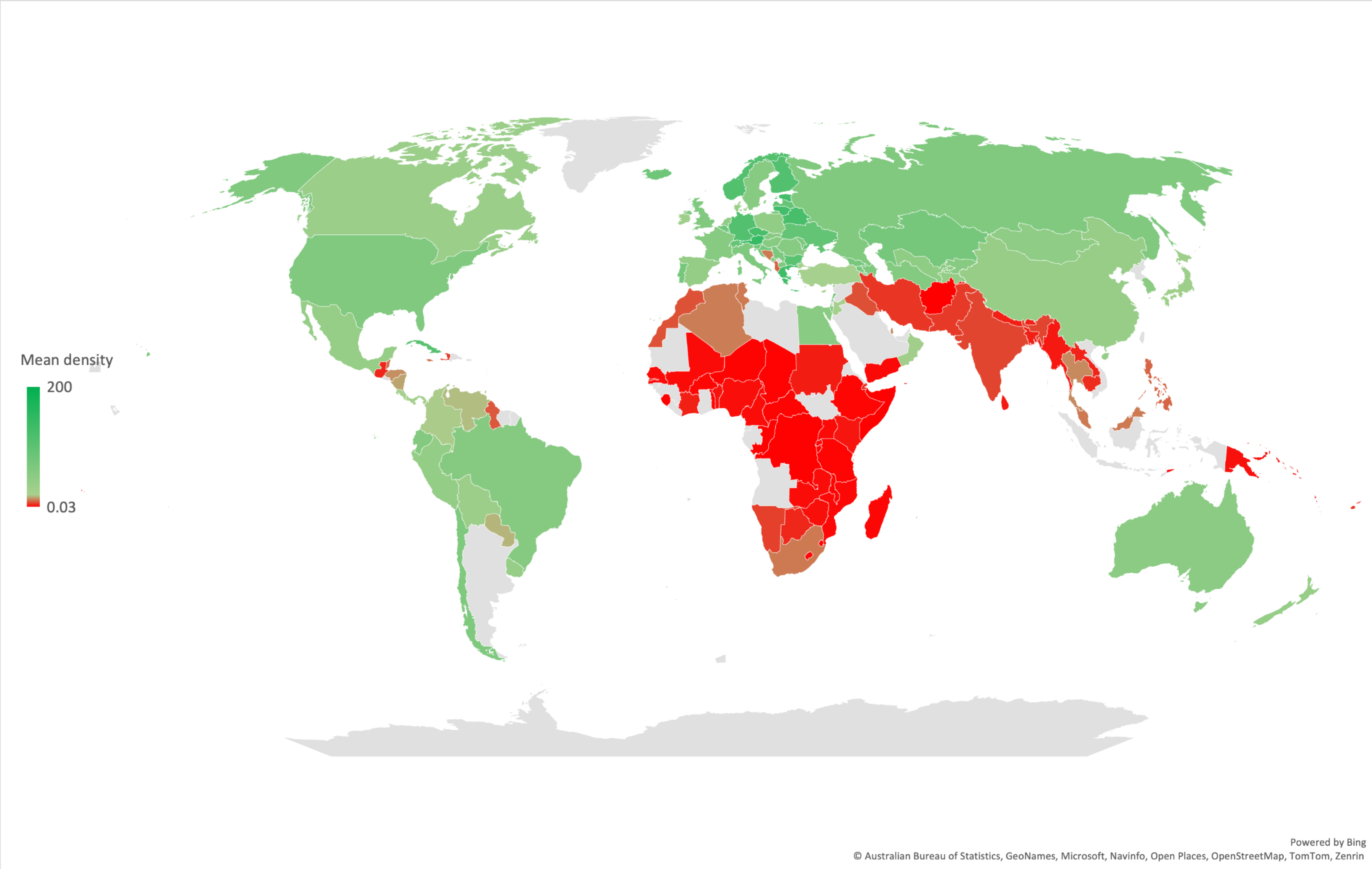


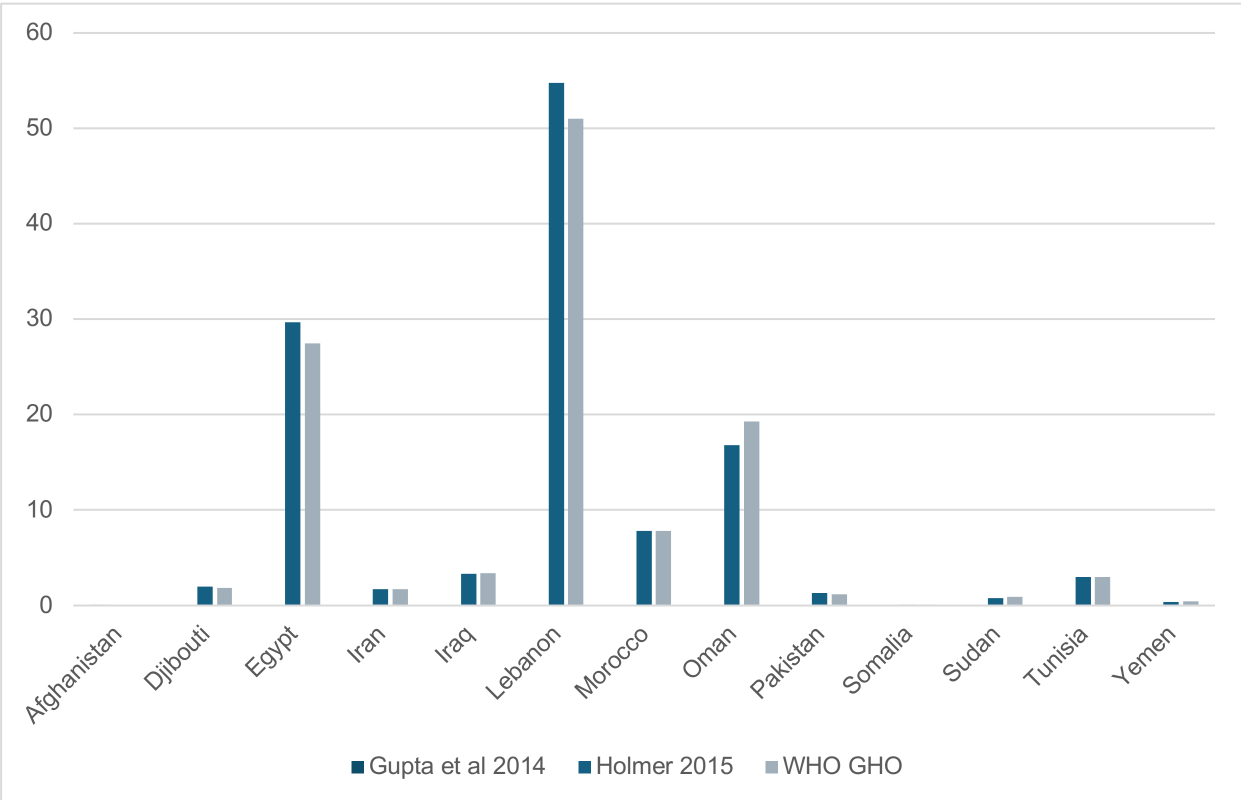
Figure 3-31. *Mean SAO density per 100,000 per country from Holmer et al 2015 and the World Bank.*



Five studies focussing on the global workforce report surgical providers. Gupta et al 2014 conducted a systematic review of studies using either the WHO TSAAEESC or PIPES surveys, with results from 13 countries.(261) The WHO Global Health Observatory (WHO GHO) collects data via national reporting directly to the WHO and provides estimates of the number and density of surgeons, anaesthetists and obstetricians in addition to the overall density of SAO providers.(262) Estimates from the WHO GHO can be from various years depending on the national reporting, therefore date have not been used in association with density estimates from this data. The other three studies (LeBrun et al 2014, Holmer et al 2015 and Bouchard et al 2020) have been described above.(207,259,263)

Within the Eastern Mediterranean region, the lowest surgeon density was reported in Afghanistan at 0.04 by Gupta et al 2014, followed by Somalia (0.1 by Holmer 2015, 0.12 by WHO GHO) and Yemen (0.4 by Holmer 2015 and 0.42 by WHO GHO) – see Figure 32(207,261,262). The highest density was found in

Figure 3-32. *Density of surgeons per 100,000 in the Eastern Mediterranean region.*

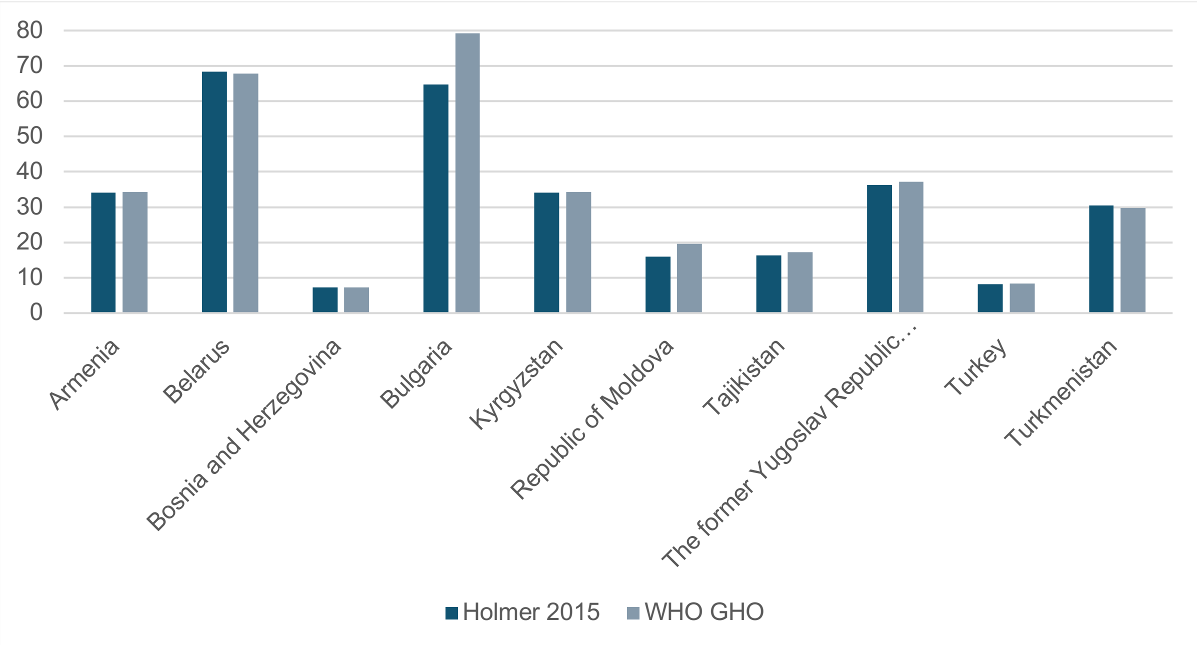


Lebanon at 54.8 by Holmer 2015 and 50.98 by WHO GHO.(207,262)

Within the African region, Chad and Sierra Leone were reported as having the lowest density of surgeon at 0.1/100,000, both by Holmer et al 2015 - see Figure 33.(207) The WHO GHO data set reported Chad with a higher surgeon density of 0.15 and Sierra Leone with a lower density of 0.08 per 100,000.(262) The highest density was reported in the Seychelles with 23.9 by Holmer 2015 and 24.51 by WHO GHO.(207,262)

The lowest surgeon density of LMICs in the European region was found in Bosnia and Herzegovinia at 7.2 (Holmer 2015) and 7.22 (WHO GHO), this was followed by Turkey (8.2 by Holmer 2015 and 8.34 by WHO GHO) and the Republic of Moldova (16 by Holmer 2015 and 19.67 by WHO GHO) – see Figure 34.(207,262) The highest surgeon density was found in Bulgaria (64.8 by Holmer 2015 and 79.22

Figure 3-33. *Density of surgeons per 100,000 population in the European region.*



by WHO GHO).(207,262)

The lowest surgeon density of LMICs in the Americas region was found in Haiti (1.1 by Holmer 2015 and 1.17 by WHO GHO) followed by Guatemala (1.3 by Holmer 2015 and 1.41 by WHO GHO) and Grenada (2.9 by Holmer 2015 and 2.63 by WHO GHO) – see figure 34.(207,262) The highest density was found in Cuba (71.20 by Holmer 2015 and 71.09 by WHO GHO).(207,262)

Figure 3-34. *Density of surgeons per 100,000 population in the Americas region.*

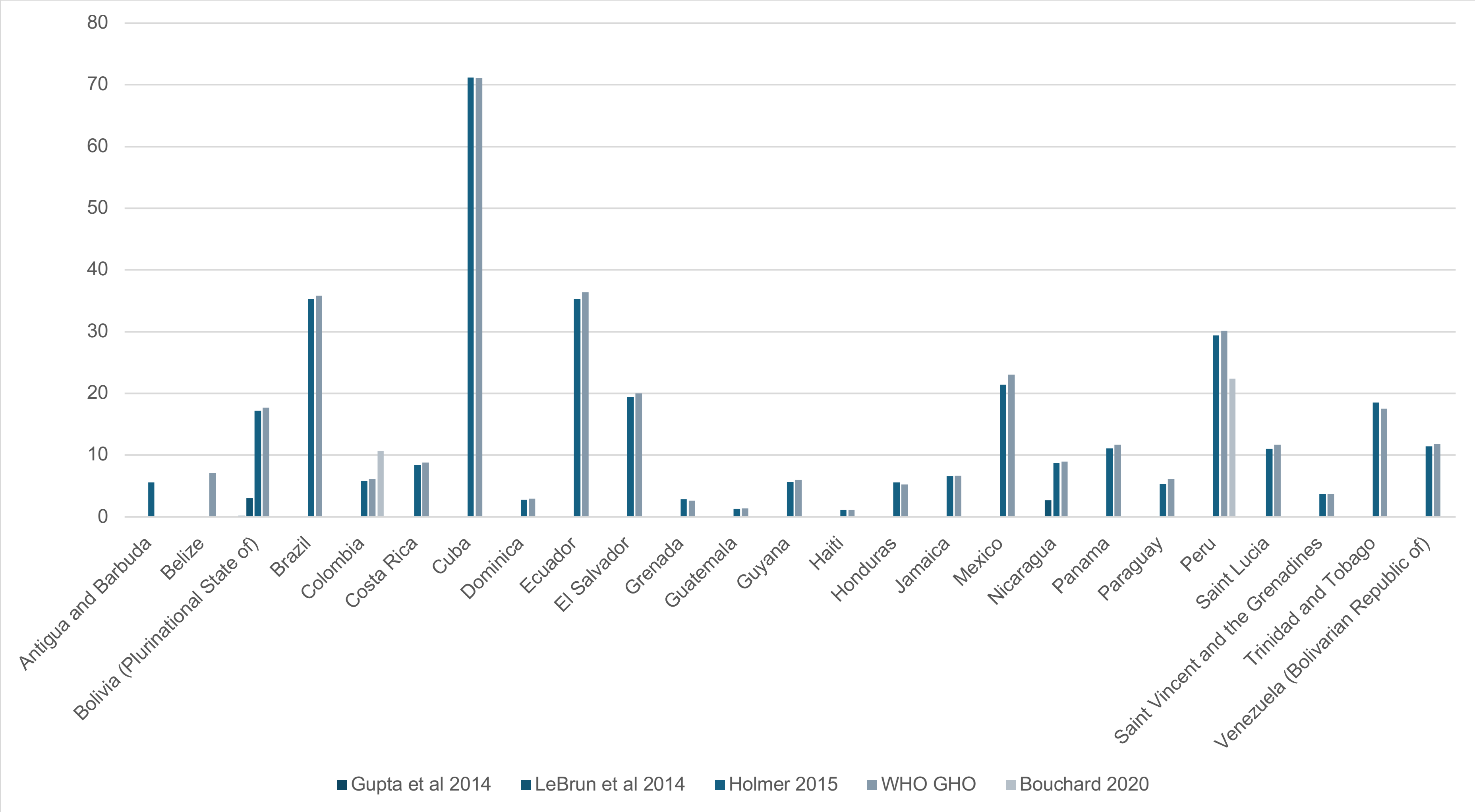
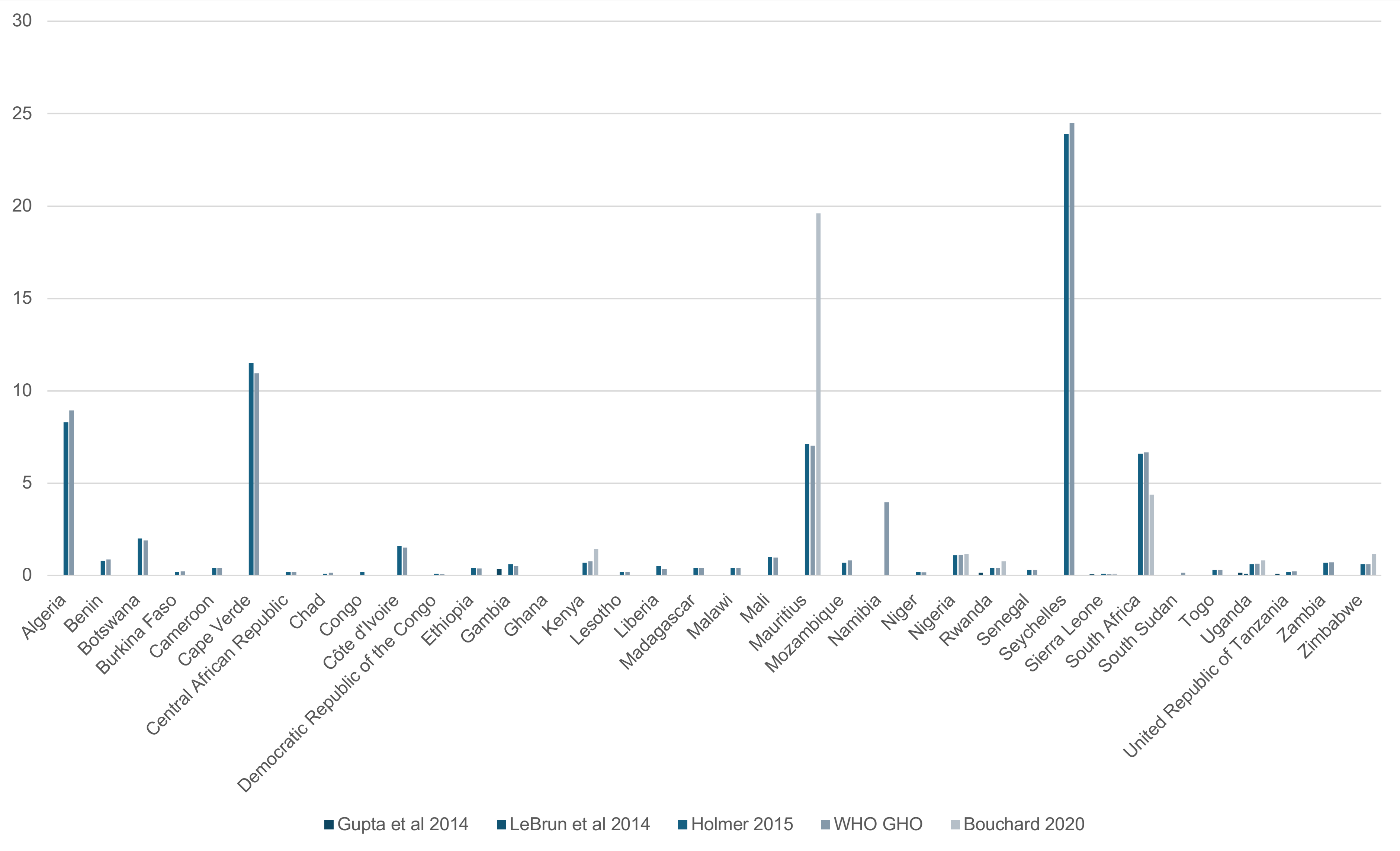
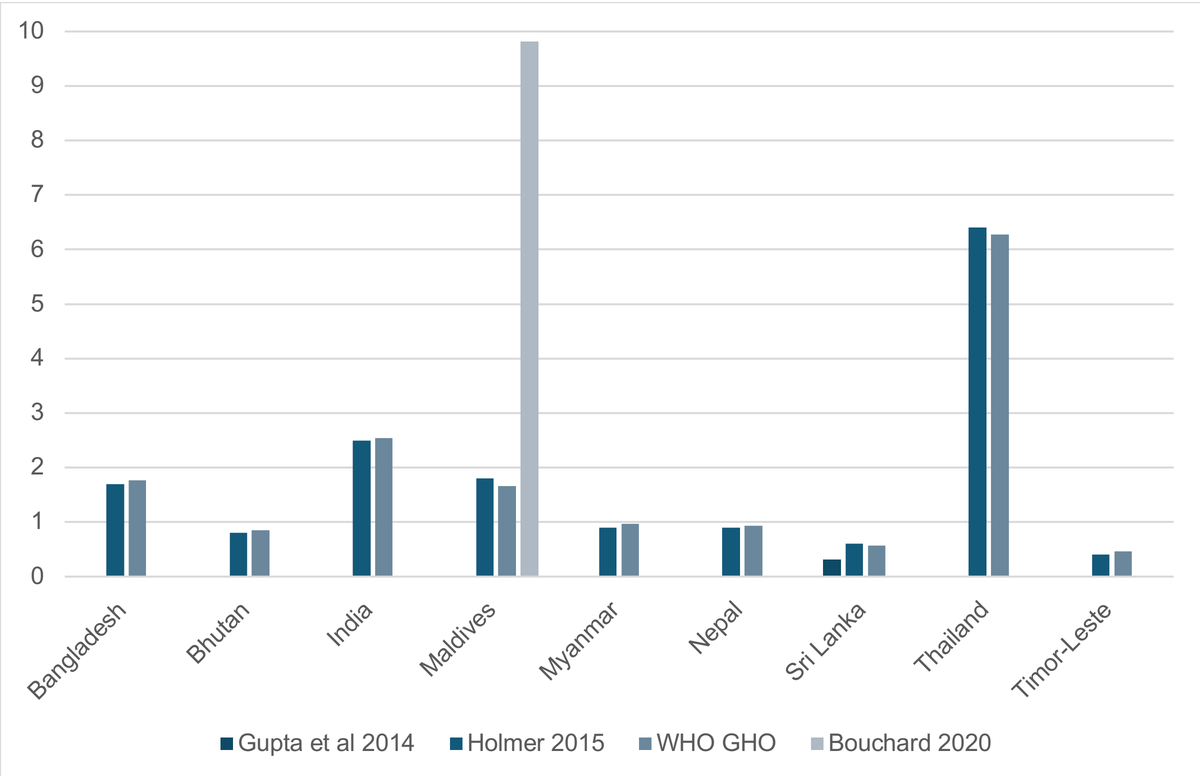


Figure 3-35. *Density of surgeons per 100,000 population in the African region.*



Within the South East Asian region, the lowest density of surgeons was found in Timor-Leste (0.4 by Holmer 2015 and 0.46 by WHO GHO) followed by Sri Lanka (0.31 by Gupta 2014, 0.6 by Holmer 2015 and 0.57 by WHO GHO) and Bhutan (0.8 by Holmer 2015 and 1.00 by WHO GHO) – see Figure 36.(207,262) The highest surgeon density was found in the Maldives at 9.81 by Bouchard 2020, however, much lower figures were reported by Holmer 2015 (1.8) and WHO GHO (2.0).(207,259,262)

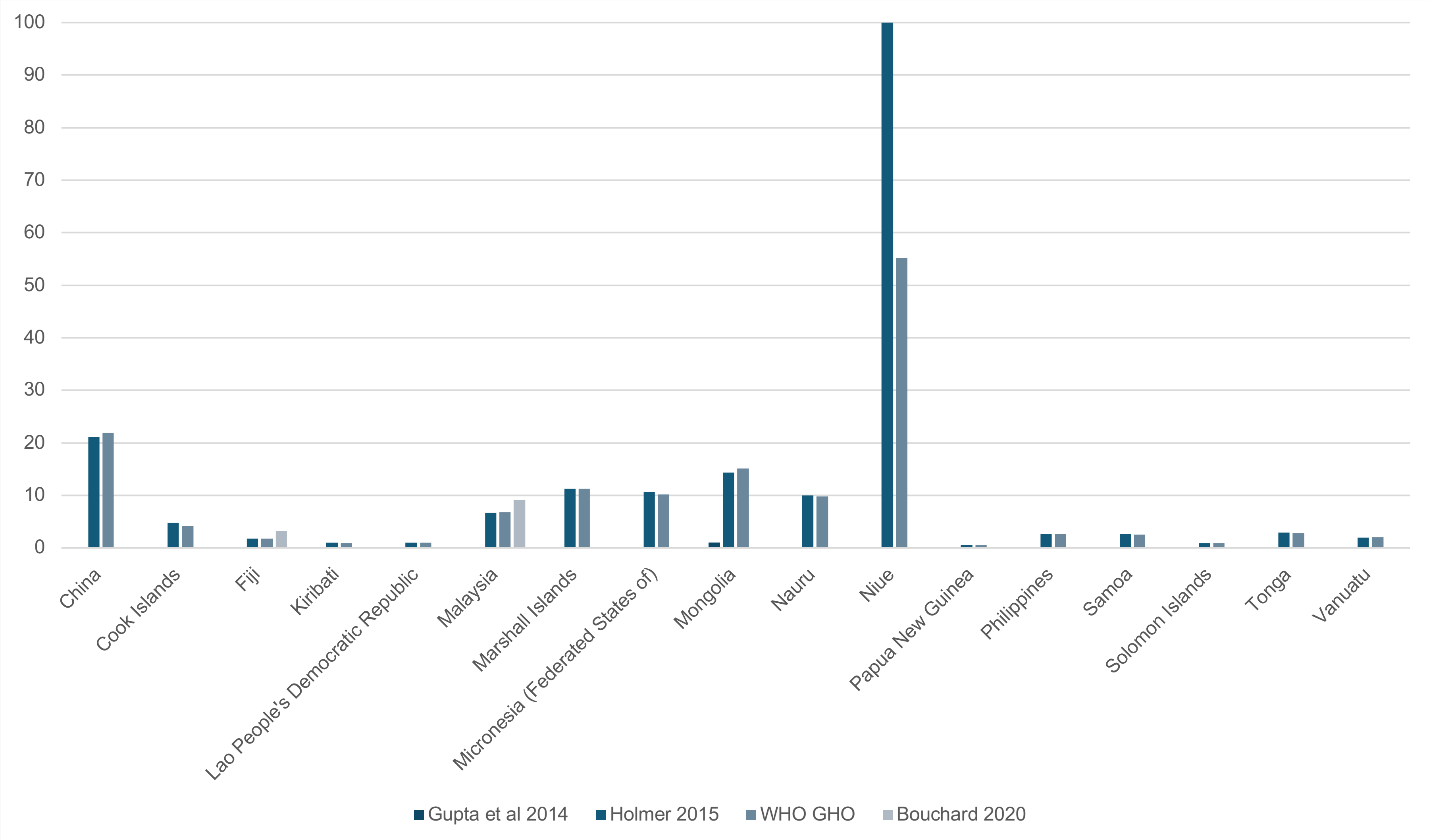
***Figure 3-36**. Density of surgeons per 100,000 in the South East Asian region.*



The lowest density of surgeons within the Western Pacific region was found in Papua New Guinea (0.50 by Holmer 2015 and 0.47 by WHO GHO) followed by Kiribati (0.1.00 by Homer 2015 and 0.93 by WHO GHO) and Lao People's Democratic Republic (1.00 by Holmer 2015 and 1.03 by WHO GHO).(207,262) The highest density was found in Nieu with 100 by Holmer 2014 and 44.19 by WHO GHO – see Figure 37.(207,262) Note that as a protectorate of New Zealand, Nieu also receives visiting specialists from New Zealand, it is unclear whether these visiting specialists are included in the estimates given.

Chapter 3 - The surgical workforce gap in low- and middle-income countries

Figure 3-37. *Density of surgeons per 100,000 in the Western Pacific region.*



There were seven included studies that reported on anaesthesia providers on a global basis. Gupta et al 2014 used estimates collected from a systematic review, Kempthorne et al 2017, LeBrun et al 2014 and Dubowitz et al 2009 used surveys.(218,261–264) The WHO Global Health Observatory data repository (WHO GHO) is based on national reporting to the WHO, Bouchard et al 2020 used national medical licensing agencies and Holmer et al 2015 used a combination of sources including national MoH and WHO Regional Offices.(207,259)

Within the African region, the lowest density of anaesthetists was found in Liberia at 0.02/100,000 by LeBrun et al 2014.(263) This was followed by Guinea-Bissau at 0.11 Physician Anaesthesia Providers (PAPs) and 0.11 Non-Physician Anaesthesia Providers (NPAPs) both by Kempthorne et al 2017.(218) The density of anaesthesia providers in Tanzania was third lowest with 0.1 total anaesthesia providers by Dubowitz et al 2009, 0.02 anaesthetists by Gupta et al 2014, and 0.01 anaesthetists by the WHO GHO.(261,262,264) The more recent study by Kempthorne et al 2017 estimated a higher density, with 0.09 PAPs and 0.43 NPAPs.(218) The highest density was found in Algeria with 2.1 anaesthetists by Holmer et al 2015, 2.30 anaesthetists by WHO GHO, rising to 3.91 PAPs and 12.73 NPAPs by Kempthorne et al 2017 – see Figure 38.(207,218,262)

The density of anaesthesia providers within the Americas Region was lowest in Haiti; 0.6 anaesthetists per 100,000 by Holmer 2015, 0.61 anaesthetists by WHO GHO, 0.88 PAPs and 1.44 NPAPs by Kempthorne et al 2017.(207,218) Second lowest was Jamaica; 1.4 anaesthetists by Holmer 2015 and 1.46 anaesthetists by WHO GHO. (207,218) Third lowest density was reported in Guatemala; 1 anaesthetists per 100,000 by Holmer 2015, 1.09 anaesthetists by WHO GHO and 1.9 PAPs and 1.9 NPAPs by Kempthorne et al 2017 – see Figure 39. (207,218) The highest density within the region was reported in El Salvador with 2.71 PAPs and 19.03 NPAPs, although the estimates from Holmer 2015 (1.9) and WHO GHO (1.93) were lower.(207,218)

Figure 3-38. *Density of anaesthesia providers per 100,000 population within the Africa region.*

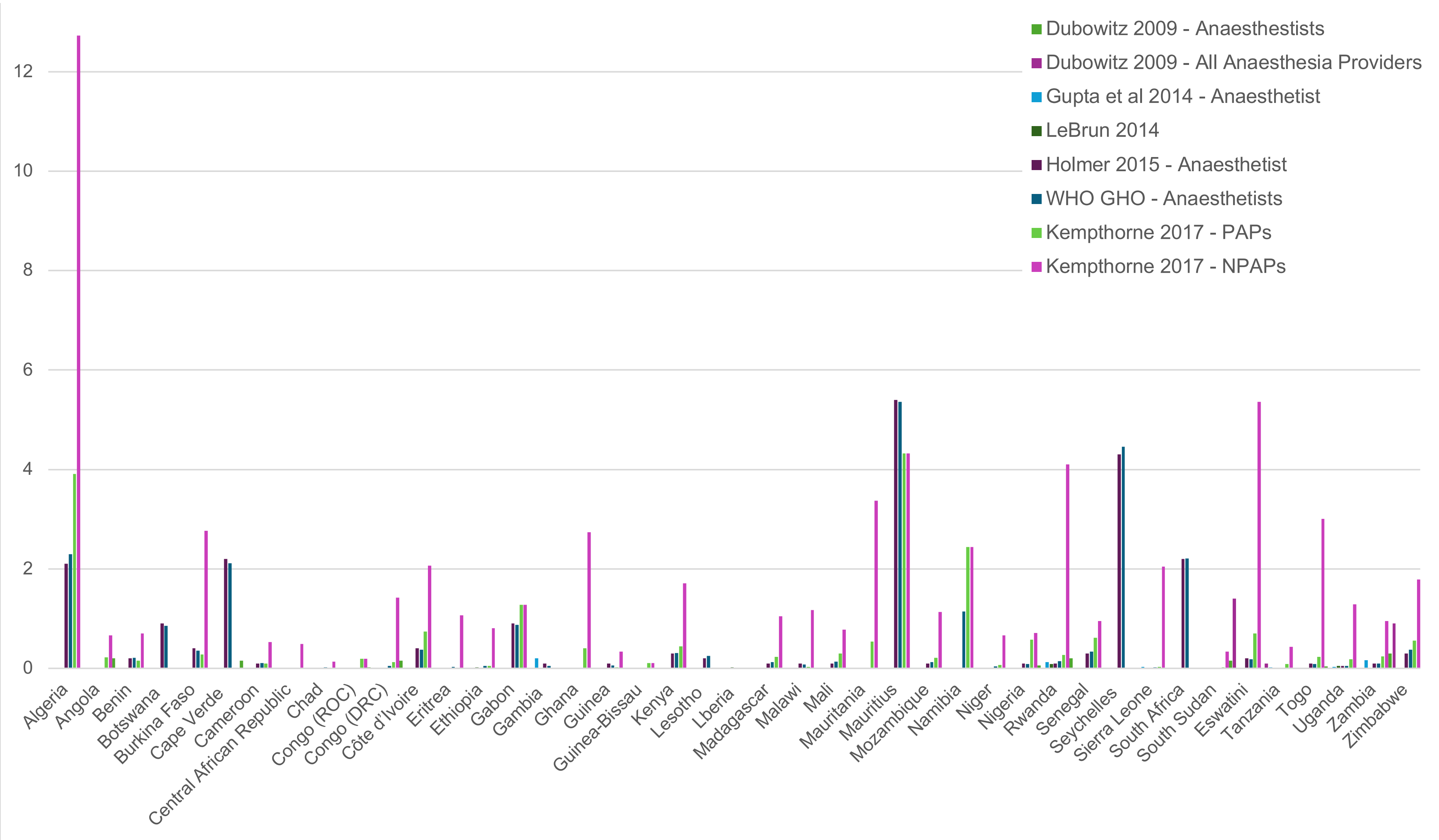
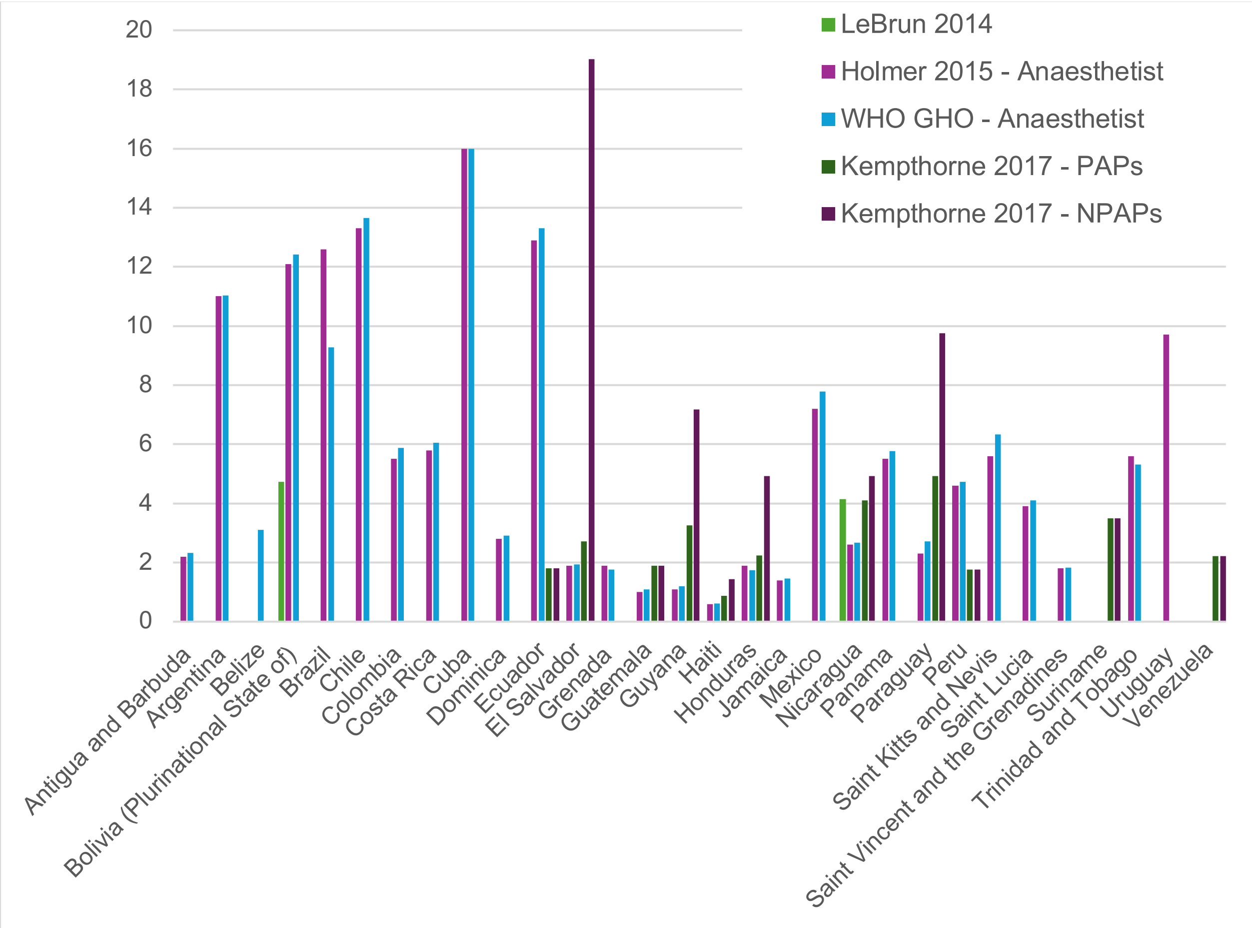


Figure 3-39. *Density of anaesthesia providers per 100,000 population within the Americas region.*



South Sudan was reported to have the lowest density of anaesthesia providers within the Eastern Mediterranean region with 0.01 anaesthetists/100,000 by WHO GHO. Yemen was reported to have the second lowest within the region, with 0.07 per 100,000 anaesthetists by Dubowitz 2009, 0.1 anaesthetists by Holmer 201 and 0.06 anaesthetists by WHO GHO. (207,218,264) Third lowest was Somalia with 0.001 anaesthetists by Holmer 2015, 0.01 anaesthetists by WHO GHO.(207,262). The more recent estimate by Kempthorne 2017 reported 0 PAPs but 0.29 NPAPs/100,000 in Somalia – see Figure 40.(218) The highest regional density was found in Lebanon with 10.5 anaesthetists by Holmer 2015 and 9.73 anaesthetists by WHO GHO.(262)

Figure 3-40. *Density of anaesthesia providers per 100,000 population in the Eastern Mediterranean region.*

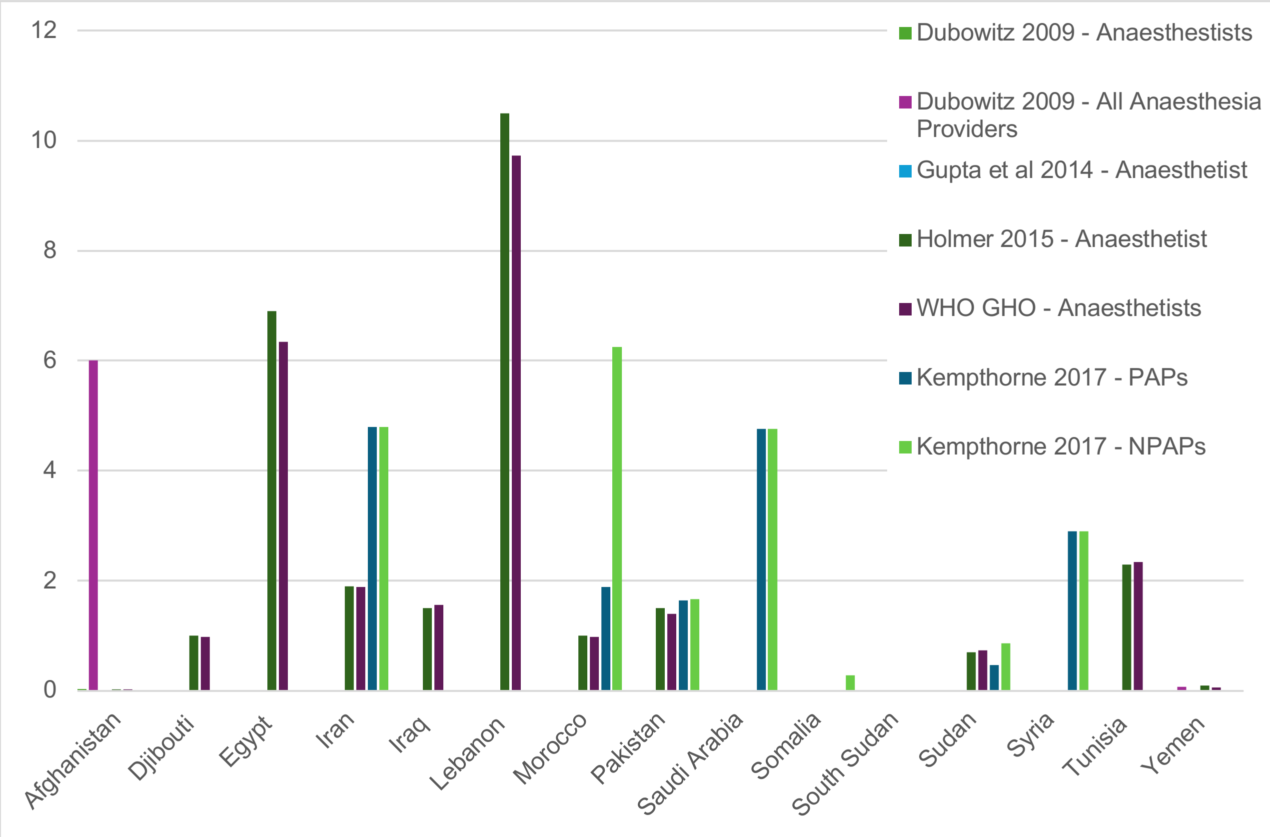
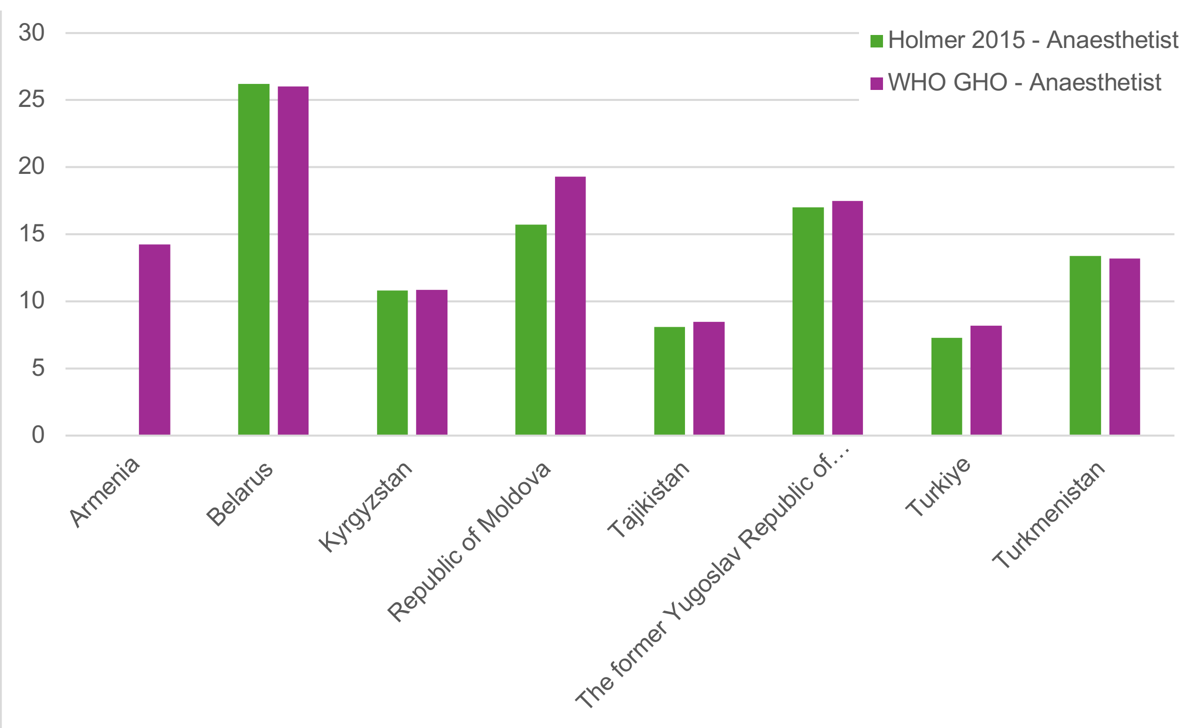


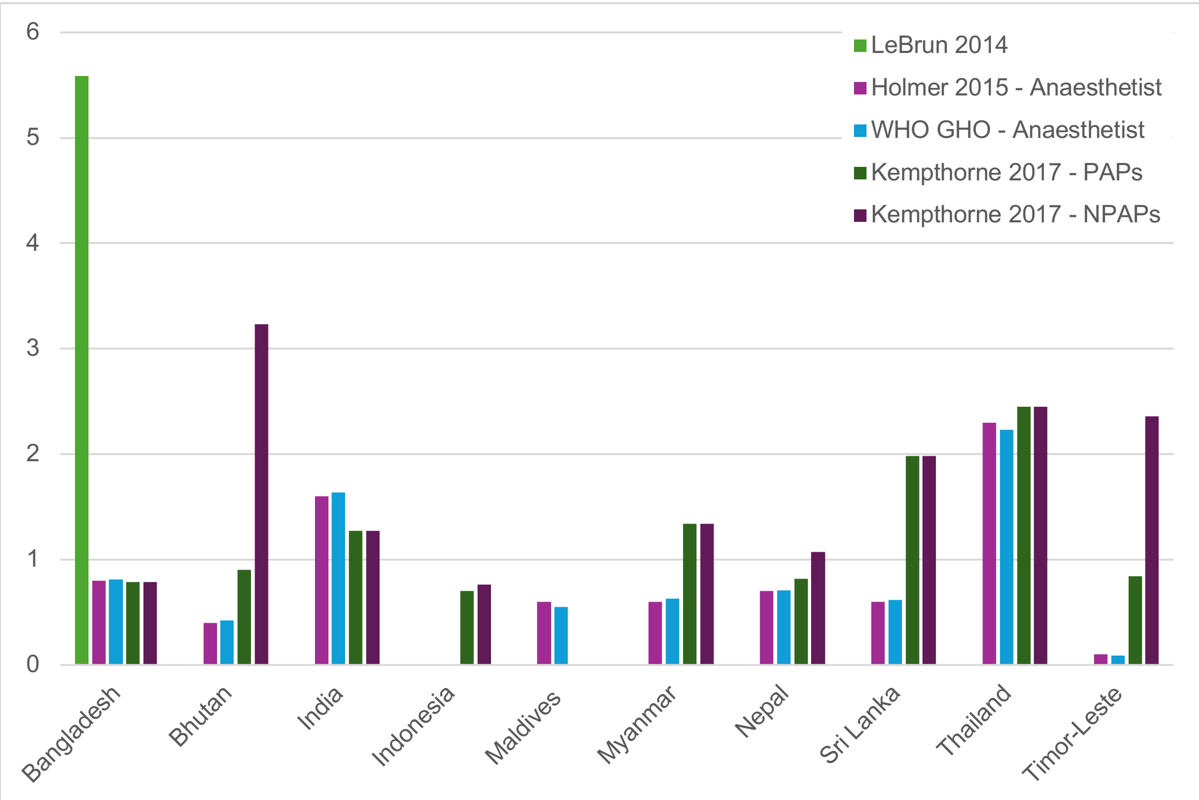
Figure 3-41. *Density of anaesthesia providers per 100,000 population within the European region.*



The lowest density within the European region was reported in Turkiye with 3.0 anaesthetists/100,000 by Holmer 2015 and 8.17 by WHO GHO – see Figure 41.(207,262) This was followed by Tajikistan with 8.1 anaesthetists per 100,000 by Holmer 2015 and 8.46 by WHO GHO and Krygyztstan with 10.8 and 10.87 anaesthetists per 100,000 by Holmer 2015 and WHO GHO respectively.(207,262)

Within the South East Asian region, the Maldives were found to have the lowest density with 0.6 and 0.55 anaesthetists per 100,000 by Holmer 2015 and WHO GHO respectively.(207,262) This was followed by Indonesia 0.7 PAPs and 0.76 NPAPs by Kempthorne 2017.(218) Third lowest anaesthesia provider density was found in SEA with 0.7 (Holmer 2015) and 0.71 (WHO GHO) anaesthetist and 0.83 PAPs and 1.07 NPAPs by Kempthorne 2017.(207,218,262) The highest density was found in Bangladesh at 5.59 anaesthetists by LeBrun 2014, although more recent estimates were much lower: 0.8 by Holmer 2015, 0.81 by WHO GHO and 0.79 PAPs and 0.79 NPAPs by Kempthorne 2017 – see Figure 42.(207,218,262,263)

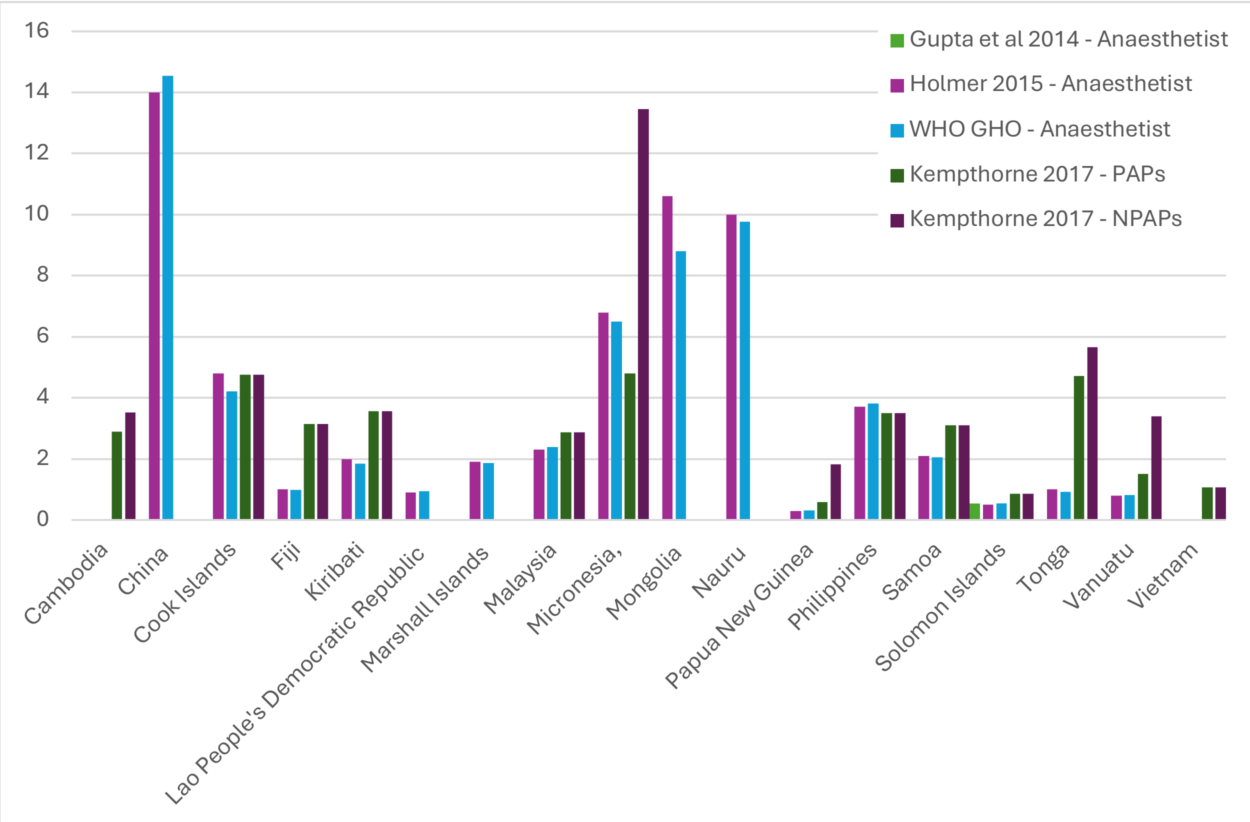
Figure 3-42. *Density of anaesthesia providers per 100,000 in the South East Asian region.*



The lowest density of anaesthesia workforce within the Western Pacific region was dound in Papua New Guinea with 0.3 and 0.32 anaesthetists by Holmer 2015 and WHO GHO respectively.(207,262) Kempthorne gave higher estimates with 0.59 PAPs and 1.82 NPAPs in 2017.(218) The Soloman Islands were reported to have the second lowest density with 0.52, 0.5 and 0.56 anaesthetists by Gupta 2014, Holmer 2015 and WHO GHO respectively.(207,261,262) Estimates from Kempthonre 2017

Figure 3-43. *Density of anaesthesia providers per 100,000 population in the Western Pacific region.*

were higher with 0.86 PAPs and 0.86 NPAPs.(218) Third lowest density was found in Lao People's Democratic Republic with 0.9 and 0.95 anaesthetists per 100,000 by Holmer 2014 and WHO GHO respectively – see Figure 43.(207,262) The highest anaesthesia workforce density was found in China with 14 and 14.55 anaesthetists per 100,000 by Holmer 2015 and WHO GHO respectively.(207,262)

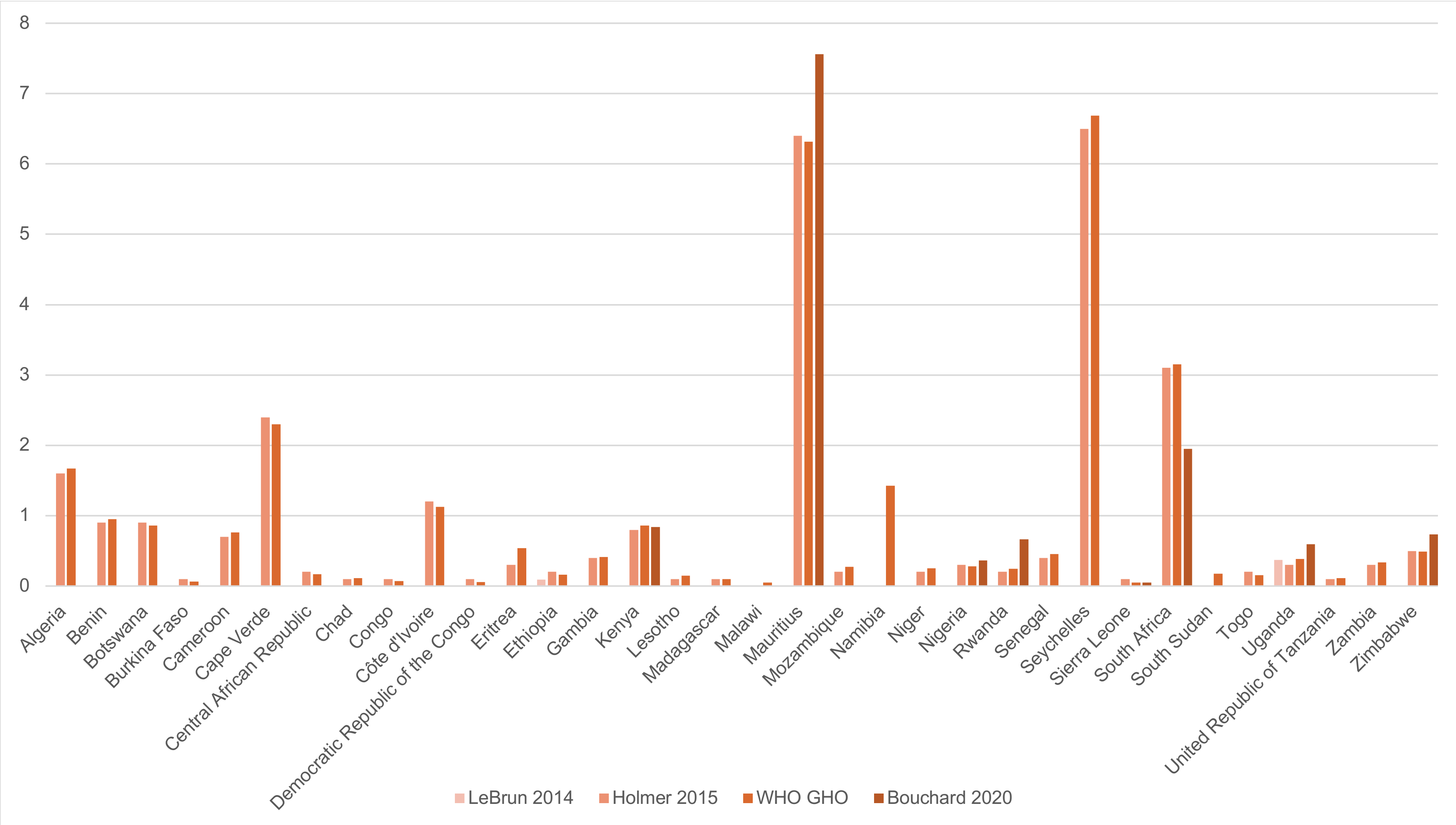


There were four included studies that reported the density of Obstetricians/Gynaecologists (OBGYN) globally; Le Brun 2014, WHO GHO, Holmer 2015 and Bouchard 2020, each of these have been described above.(207,259,262,263) The data from these four studies have been combined into charts and separated by WHO region in Figures 44 – 49.

Within the African region, the lowest density of OGBYN was found in Malawi with a workforce density of 0.05 OBGYN/100,000 by the WHO GHO – see Figure

44.(262) This was followed by Sierra Leone with 0.1 by Holmer 2015, 0.05 by the WHO GHO and Bouchard 2020.(207,259,262) Democratic Republic of Congo (DRC) was reported to have the 3rd lowest density with 0.1 by Holmer 2015 and 0.06 by WHO GHO.(207,262) The highest density was found in Mauritius at 6.4 by Holmer 2015, 6.32 by the WHO GHO and 7.56 by Bouchard 2020.(207,259,262)

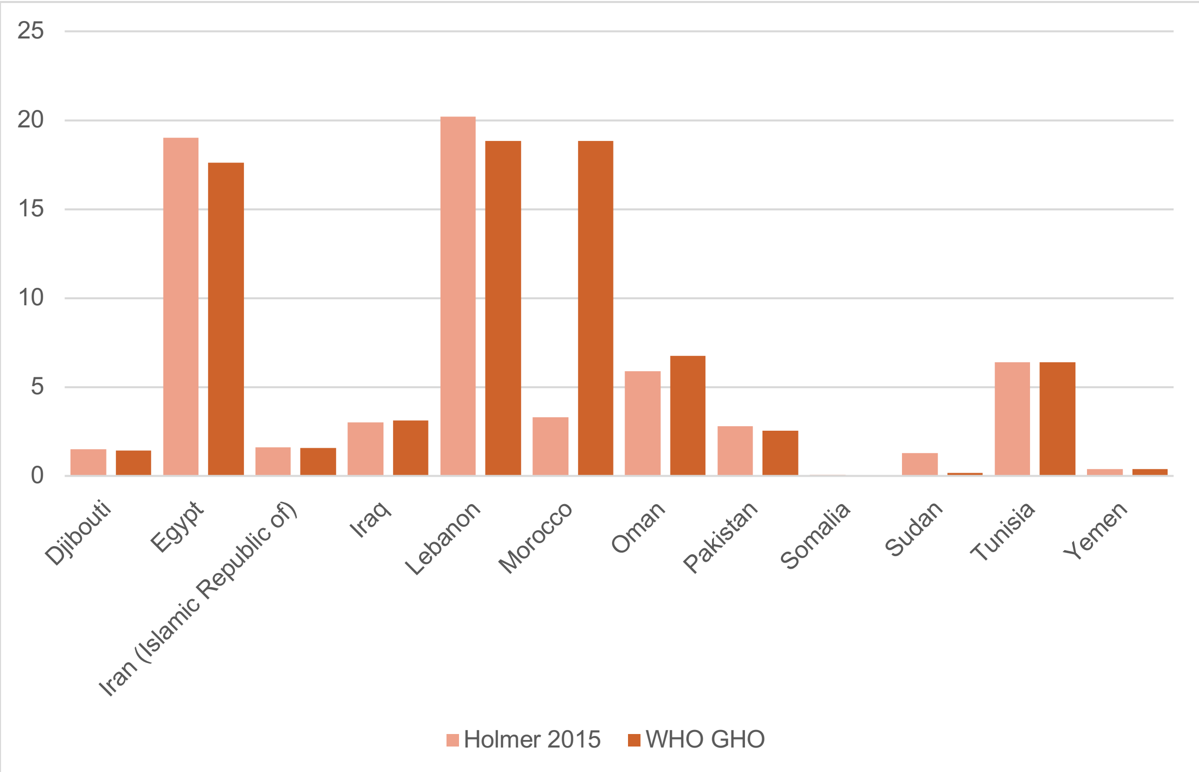
Figure 3-44. *Density of OBGYN specialists per 100,000 in the African region.*



The lowest OGBYN density within the Eastern Mediterranean region was found in Somalia, with 0.05 OBYN/100,000 by Holmer 2015 and 0.04 by the WHO GHO.(207,262) This was followed by Yemen with 0.4 by Holmer 2015 and 0.38 by the WHO GHO and Sudan with 1.3 by holmer 2015 and 0.17 by the WHO GHO – see Figure 45.(207,262) The highest density was found in Lebanon with 20.2 by

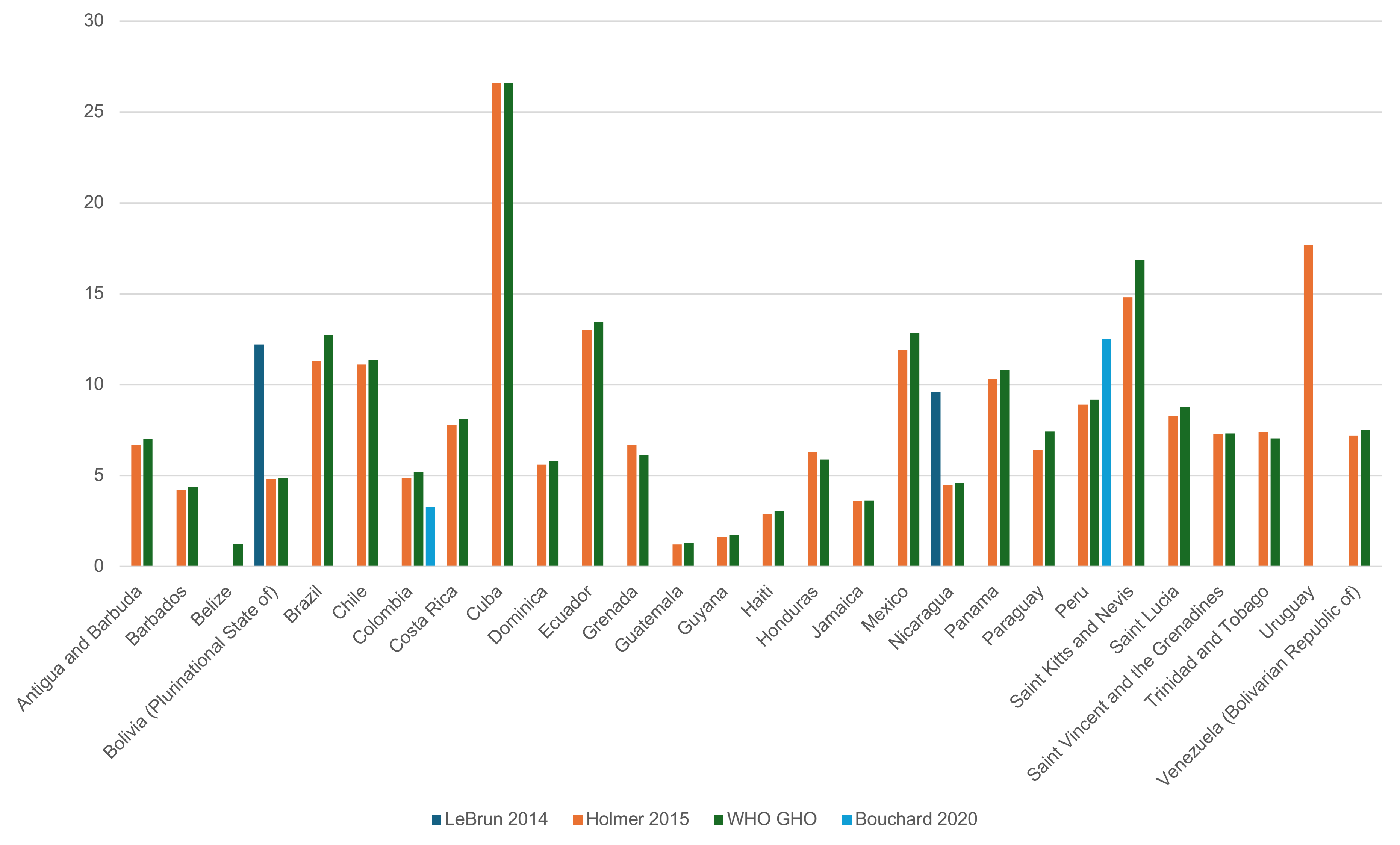
Figure 3-45. *Density of OGBYN specialists per 100,000 population within the Eastern Mediterranean*

Holmer 2015 and 18.84 by the WHO GHO.(207,262)



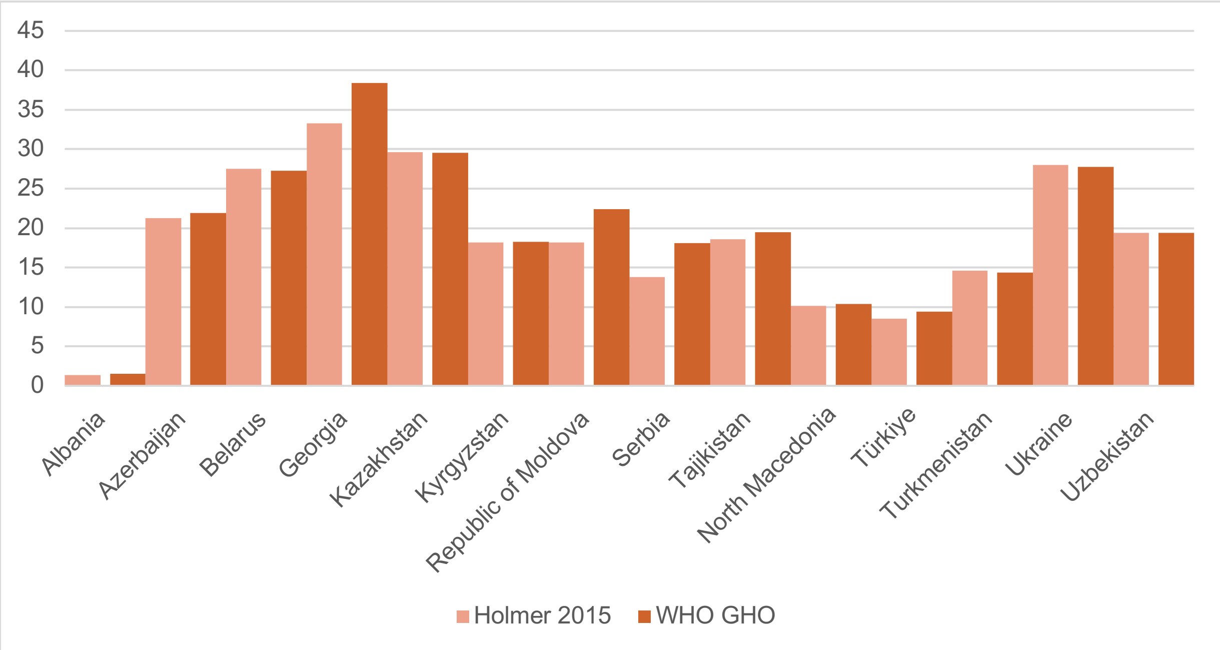
Within the Americas region, the lowest OGBYN density was found in Belize, with 1.24 by the WHO GHO – see Figure 46.(262) This was closely followed by Guatemala with 1.2 by Holmer 2015 and 1.32 by the WHO GHO.(207,262) Third lowest density was found in Guyana with 1.6 by Holmer 2015 and 1.74 by the WHO GHO.(207,262) The highest density was found in Cuba with 26.6 by Holmer 2015 and 26.58 by the WHO GHO.(207,262)

Figure 3-46. *Density of OGBYN specialists per 100,000 population in the Americas Region.*



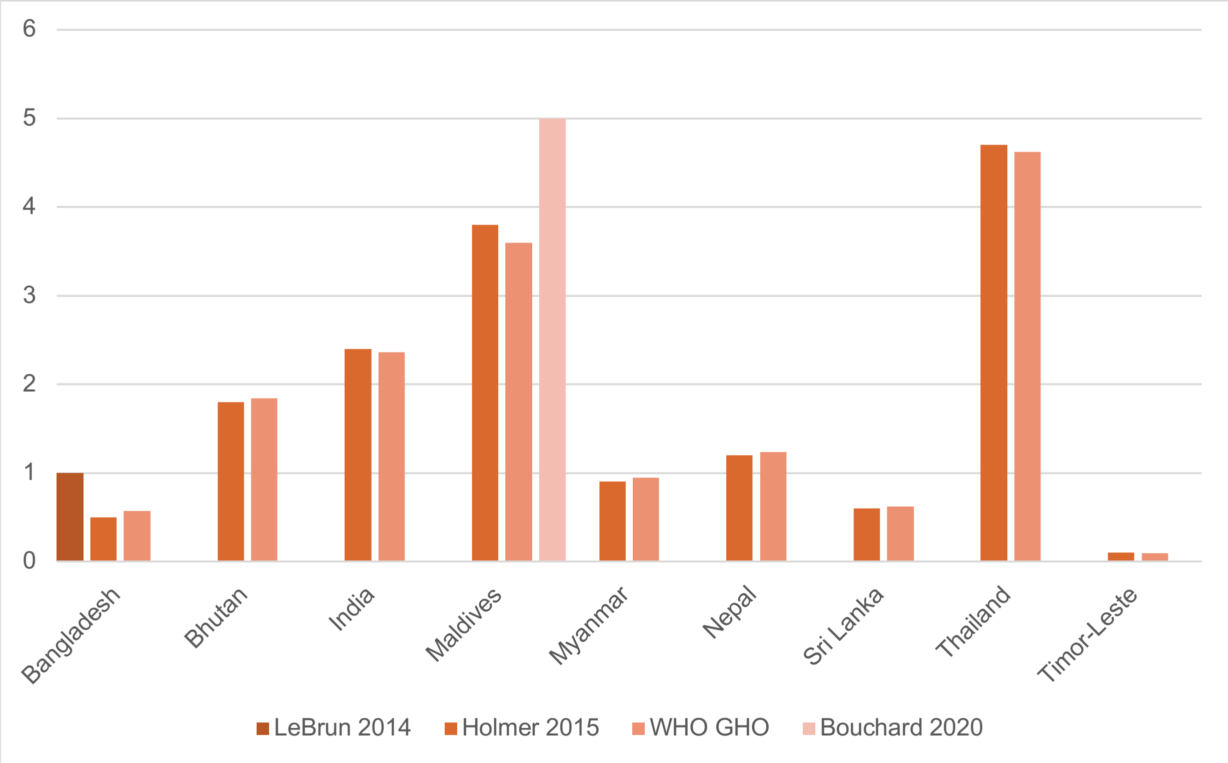
The lowest OBGYN density within the European region was found in Albania at 1.4 per 100,000 by Holmer 2015 and 1.54 by WHO GHO – see Figure 47.(207,262) Second lowest was in Türkiye with 8.5 by Holmer 2015 and 9.38 by the WHO GHO.(207,262) The Republic of North Macedonia was third lowest with a density of 10.1 by Holmer 2015 and 10.36 by the WHO GHO.(207,262) The highest OBGYN density amongst the LMIC countries of Europe was found in Georgia at 33.3 by Holmer 2015 and 38.37 by the WHO GHO.(207,262)

Figure 3-47. *Density of OBGYN specialists per 100,000 population in the European region.*



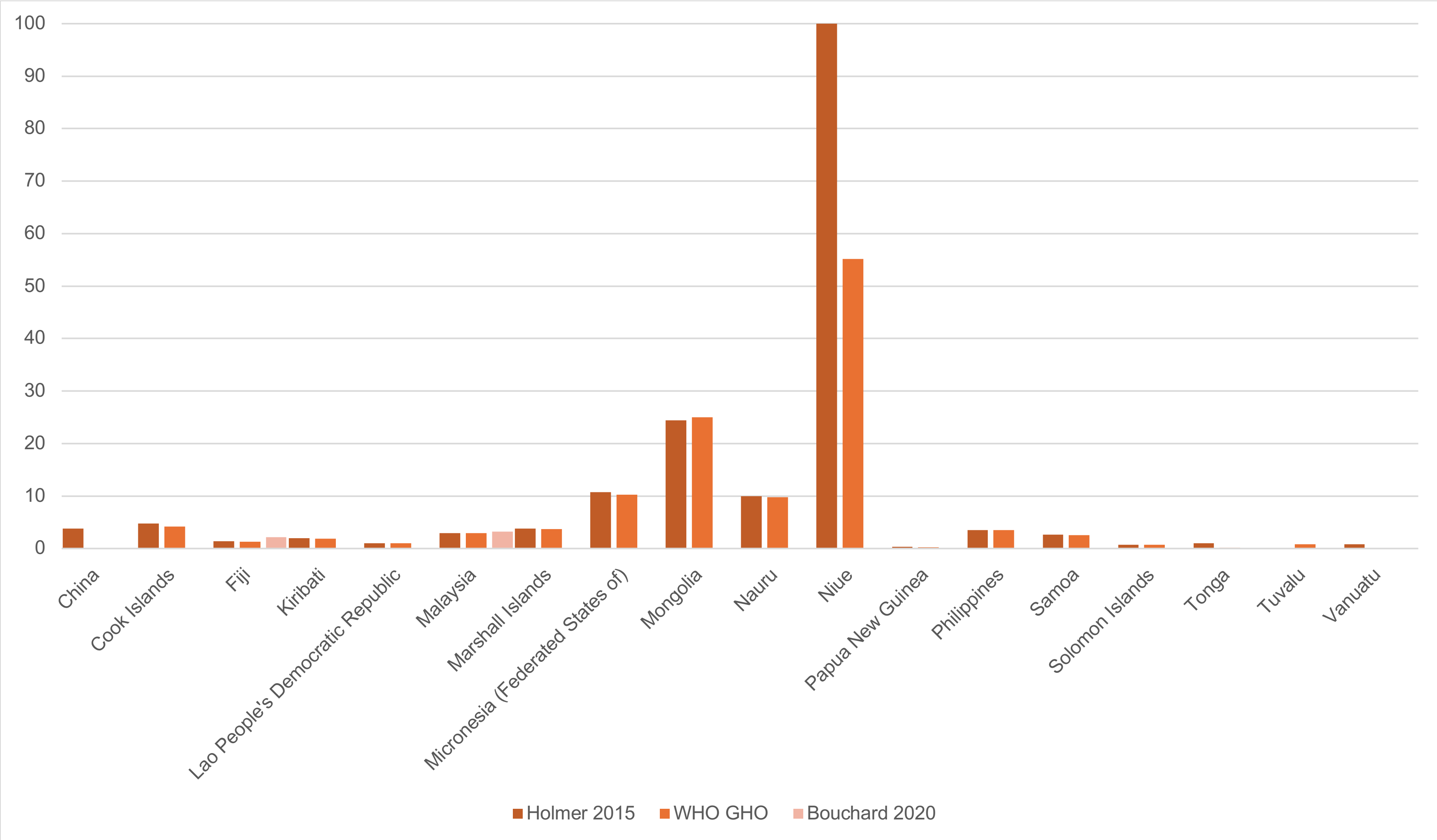
Within the South East Asian region, the lowest density was found in Timor-Leste with 0.1 OBGYN/100,000 by Holmer 2015 and 0.09 by the WHO GHO – see Figure 48.(207,262) This was followed by Bangladesh with 0.5 by Holmer 2015 and 0.57 by the WHO GHO, although LeBrun 2014 quoted a higher figure of 1/00,000.(207,262,263) The third lowest density was found in Sri Lanka with 0.6 by Holmer 2015 and 0.62 by the WHO GHO.(207,262) The highest density was found in the Maldives with 3.8 by Holmer 2015, 3.6 by the WHO GHO and 5 by Bouchard et al 2020.(207,262,263)

Figure 3-48. *Density of OGBYN specialists per 100,000 population in the South East Asia region.*



Within the Western Pacific region, the lowest density was reported in Tonga with 0.15/100,000 by the WHO GHO although Holmer 2015 reported a higher figure of 1/100,000 – see Figure 49.(207,262) Papua New Guinea was 2nd lowest with 0.3 by Holmer 2015 and 0.24 by the WHO GHO.(207,262) Third lowest was the Solomon Islands with 0.7 by Holmer 2015 and 0.74 by the WHO GHO.(207,262) The highest density was found in Niue, reported at 100 by Holmer 2015 and 55.19 by the WHO GHO.(207,262)

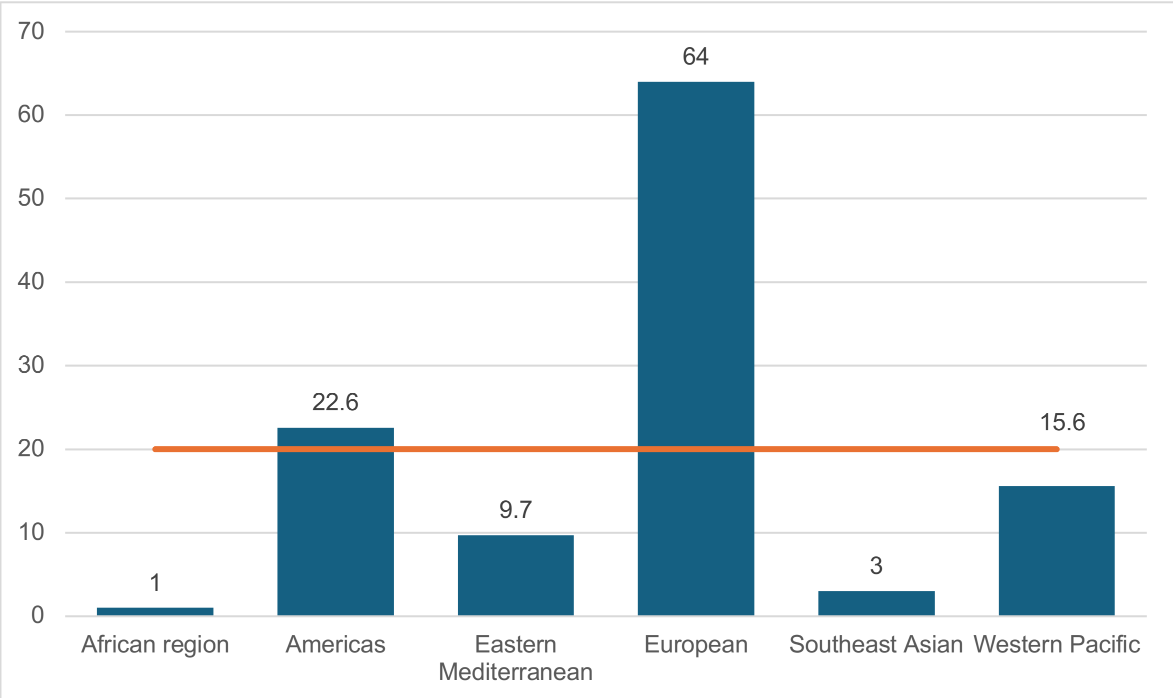
Figure 3-49. *Density of OBGYN specialists per 100,000 population in the Western Pacific region.*



3.3.4 Trends by income classification

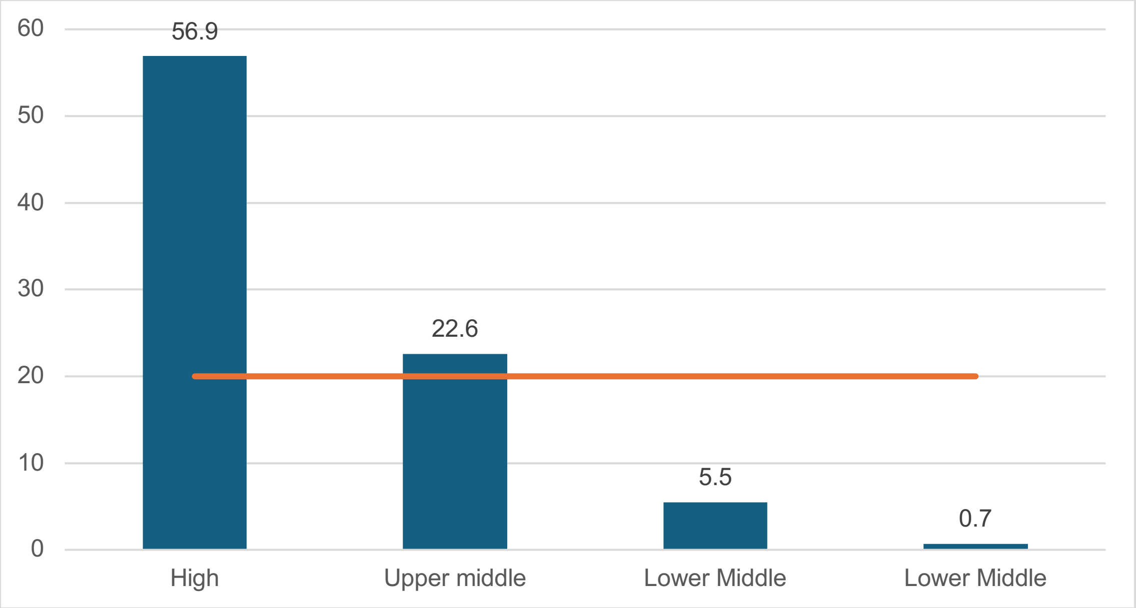
Holmer et al 2015 reported density by World Bank income classification as well as regional summaries. These have been displayed graphically in Figures 50 and 51. (207) Figure 50 shows that the mean density of SAO providers was above 20 only in the European and Americas region.(10,207)

Figure 3-50. *Mean density of SAO providers per 100,000 population by Holmer et al 2015 with the orange line representing the 20/100,000 minimum standard set by the LCoGS.*



A similar trend can be seen in Figure 51, that displays the mean SAO density from each World Bank income classification against the 20/100,000 LCoGS standard. (10,207) Only the High and High-Middle Income Countries were reported to have mean SAO densities above the 20/100,000 standard. (10,207)

***Figure 3-51**. Mean density of SAO providers per 100,000 population by World Bank Income classification with the orange line representing the 20/100,000 minimum standard set by the LCoGS.*



3.3.6 Risk of Bias

As no meta-analysis was performed, and most studies were either observational or based on observational data, no studies were removed due to the risk of bias (ROB). A formal ROB assessment was undertaken by one researcher following the JBI checklist for analytical cross-sectional studies or the ROBIS tool for systematic reviews as appropriate.(72,73) The full ROB assessments using the JBI checklist (for observational studies) can be found in Table 3 and the ROBIS tool (for systematic reviews) can be found in Tables 4 - 6. All three of the included systematic reviews were judged to be of high risk of bias.

3.3.7 Certainty of evidence

Each included study was assessed using the GRADE certainty of evidence and the results can be seen in Tables 3 – 7 and a summary in Figure 52. The majority of included studies (32, 60.38%) were rated low certainty, 19 studies (35.58%) were rated moderate and 2 (3.77%) were rated very low certainty of evidence.

Figure 3-52. *GRADE rating of included studies.*

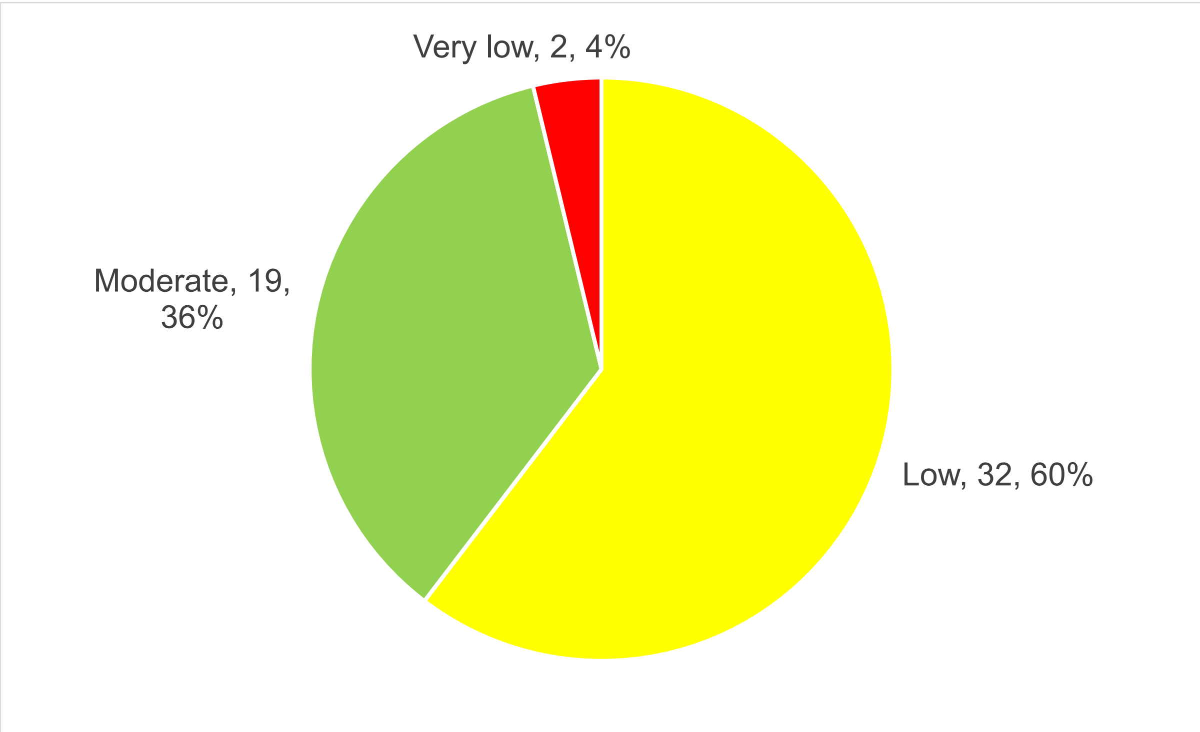


Table 3-3. *Risk of bias assessment and GRADE rating of evidence for each included study, excluding systematic reviews.*

Name of paper (Author, year)	1	2	3	4	5	6	7	8	9	Grade of evidence
Albutt et al 2018	Unclear	Yes	Unclear	Yes	Unclear	Yes	Yes	Yes	Yes	Low
Bjegovic-Mikanovic et al 2019	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Bouchard et al 2020	Unclear	Yes	Yes	No	Unclear	Yes	Yes	Yes	Yes	Moderate
Bruno et al 2017	Yes	Yes	Yes	No	Unclear	Yes	Yes	Yes	Unclear	Moderate
Carpio & Santiago	Unclear	N/A	Yes	Unclear	Unclear	Yes	Yes	No	N/A	Moderate
Chao et al 2012	Yes	Yes	Unclear	No	Unclear	Yes	Yes	Unclear	Unclear	Low
Dahir et al 2018	Yes	Yes	Yes	Unclear	Unclear	Yes	Yes	Yes	Yes	Moderate
Dimova et al 2012	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Dimova et al 2018 (European Observatory on Health)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Dubowitz et al 2009	Unclear	No	No	No	Unclear	Yes	Unclear	Yes	No	Very low
Epiu et al 20017	Yes	Yes	Unclear	Yes	Unclear	Yes	Unclear	Yes	Unclear	Low
Ethiopian Public Health Institute, 2022	Yes	Unclear	Unclear	No	Unclear	Yes	Yes	Unclear	Unclear	Moderate
European Observatory on Health 1999	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Feysia et al 2012	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Henry et al 2015	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
Herbst et al 2012	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Iddriss et al 2011	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Moderate

Jiminez et al 2015 (World Bank)	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Juventine et al 2023	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Unclear	Moderate
Katsaga et al 2012 (European Health Observatory)	Unclear	Yes	Unclear	No	Unclear	Unclear	Yes	Unclear	Unclear	Low
Kempthorne et al 2017	Yes	Yes	Yes	Yes	Unclear	Yes	Yes	Yes	Yes	Moderate
Kolehmainen-Aitken & Srestha 2009	Unclear	Unclear	Unclear	Unclear	Unclear	Yes	Yes	Unclear	Unclear	Low
Kouo-Ngamby et al 2015	Unclear	Unclear	Unclear	Yes	No	Yes	Yes	Yes	Yes	Low
LeBrun et al 2012	Unclear	Unclear	Unclear	Yes	Unclear	Yes	Yes	Yes	Yes	Low
LeBrun et al 2014	Yes	Unclear	Unclear	Yes	Unclear	Yes	Yes	Yes	Yes	Low
Liese & Dassault 2004	Unclear	Unclear	Unclear	No	Unclear	Yes	Yes	Yes	Unclear	Low
Meshesha, 2022	Yes	Yes	Yes	No	Yes	Yes	Yes	Yes	Unclear	Moderate
Odinkemelu et al 2021	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
Osebo et al 2024	Yes	Yes	Yes	No	Unclear	Yes	Yes	Unclear	Yes	Moderate
Richardson 2013	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Ross et al 2023	Unclear	Unclear	No	No	Unclear	Yes	Yes	Unclear	Yes	Very low
Rwanda Ministry of Health 2021	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Siddiqi et al 2020	Yes	Yes	Unclear	Yes	Unclear	Yes	Yes	Yes	Yes	Low
Solis et al 2013	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
The World Bank - Specialist Surgical Workforce	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
Tiwari et al 2021	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	N/A	Moderate
Tran et al 2015	Yes	Yes	Unclear	No	No	Unclear	Unclear	Yes	Yes	Low

Vansell et al 2015	Yes	Yes	Unclear	No	No	Yes	Yes	No	Unclear	Low
WHO Global Health Observatory data repository	Yes	Yes	Unclear	N/A	N/A	Yes	Yes	Yes	N/A	Moderate
WHO National Health Workforce Accounts Data Portal	Yes	Unclear	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
WHO Regional Office for Africa 2021	Unclear	Unclear	Unclear	No	Unclear	Yes	Yes	Unclear	Unclear	Low
WHO Regional Office for the Western Pacific - Marshall Islands 2014	Unclear	Unclear	Unclear	No	Unclear	Yes	Yes	Yes	Unclear	Low
WHO Regional Office for the Western Pacific - Tonga 2015	Unclear	Unclear	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	Low
WHO Regional Office for the Western Pacific - Vanuatu 2013	Unclear	Unclear	Unclear	Yes	Unclear	Yes	Yes	Yes	Unclear	Low
Wilson et al 2018	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Moderate
World Bank 2005	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
World Bank 2010	Unclear	Unclear	Unclear	No	Unclear	Unclear	Unclear	Unclear	Unclear	Low
World Health Organisation 2017 - Surgical care systems strengthening: developing NSOAPs	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Unclear	Low
Zhang et al 2021	Unclear	Unclear	Yes	No	Unclear	Yes	Yes	Yes	Yes	Moderate

Questions in the JBI checklist for analytical cross-sectional studies: 1. Was the sample frame appropriate to address the target population? 2. Were study participants recruited in an appropriate way? 3. Was the sample size adequate? 4. Were the study subjects and setting described in detail? 5. Was data analysis conducted with sufficient coverage of the identified sample? 6. Were valid methods used for the identification of the condition? 7. Was the condition measured in a standard, reliable way for all participants? 8. Was appropriate statistical analysis used? 9. Was the response rate adequate, and if not, was the low response rate managed appropriately?

Table 3-4. *Domains 1 and 2 of the ROBIS tool assessment of the included systematic reviews.*

Name of paper (Author, year)	1.1	1.2	1.3	1.4	4.5	Domain 1 - ROB	2.1	2.2	2.3	2.4	2.5	Domain 2 - ROB
Gupta et al 2014	Yes	Yes	Yes	Probably no	Probably yes	High concerns	No	Yes	Probably yes	Probably yes	Yes	High concerns
Ashraf et al 2022	Yes	Yes	Yes	Probably yes	Probably yes	Low concerns	Probably yes	Yes	Yes	Probably yes	Yes	Low concerns
Shirley & Wamai 2022	Probably yes	Probably yes	No	No information	No information	High concerns	No	Yes	Probably yes	No information	No information	High concerns
Osebo et al 2024	Yes	Yes	Probably no	Probably yes	No information	High concerns	Yes	No	Probably yes	No information	Yes	High concerns

Table 3-5*. Domain 3 of the ROBIS tool assessment of the included systematic reviews.*

Name of paper (Author, year)	3.1	3.2	3.3	3.4	3.5	Domain 3 - ROB
Gupta et al 2014	Yes	Probably yes	Probably yes	No	No information	High concerns
Ashraf et al 2022	Yes	No	Yes	No	No	High concerns
Shirley & Wamai 2022	No information	No	No information	No	No	High concerns
Osebo et al 2024	No information	Yes	No information	No	No	High concerns

Table 3-6. *Domain 4 of the ROBIS tool assessment of the included systematic reviews.*

Name of paper (Author, year)	A	B	C -	Phase 3 - Overall ROB	Overall Risk of Bias (ROB)	Grade of evidence
Gupta et al 2014	Probably yes	Yes	Yes	Low concerns	High risk of bias	Low
Ashraf et al 2022	Probably no	Probably yes	Yes	High concerns	High risk of bias	Low
Shirley & Wamai 2022	Probably yes	Probably yes	Yes	Low concerns	High risk of bias	Low
Osebo et al 2024	Probably yes	Probably yes	Yes	Low concerns	High risk of bias	Low

Table 3-7. Domain 5 of the ROBIS tool assessment of the included systematic reviews.

Name of paper (Author, year)	4.1	4.2	4.3	4.4	4.5	4.6	Domain 4 - ROB
Gupta et al 2014	Probably yes	Yes	Yes	Probably no	Probably yes	No information	High concerns
Ashraf et al 2022	Yes	Probably yes	Probably no	No	No	Probably no	High concerns
Shirley & Wamai 2022	No information	No information	Probably yes	No information	No	No information	High concerns
Osebo et al 2024	No information	No information	No information	No information	No information	No information	High concerns

Questions in the ROBIS assessment tool: 1.1 Did the review adhere to predefined objectives and eligibility criteria? 1.2 Were the eligibility criteria appropriate for the review question? 1.3 Were the eligibility criteria unambiguous? 1.4 Were restrictions in eligibility based on study characteristics appropriate? 1.5 Were restrictions in eligibility based on sources of information appropriate?
2.1 Did the search include an appropriate range of databases? 2.2 Were methods additional to database searching used to identify relevant reports? 2.3 Were the terms and structure of the search strategy likely to retrieve as many eligible studies as possible? 2.4 Were restrictions based on date, format or language appropriate? 2.5 Were efforts made to minimise error in selection of studies?
3.1 Were efforts made to minimise error data collection? 3.2 Were sufficient study characteristics available for both review authors and readers to be able to interpret the results? 3.3 Were all relevant study results collected for use in the synthesis? 3.4 Was risk of bias formally assessed using appropriate criteria? 3.5 Were efforts made to minimise error in risk of bias assessment?
4.1 Did synthesis include all studies that it should? 4.2 Were all pre-defined analyses reported or departures explained? 4.3 Was the synthesis appropriate given the nature and similarity in the research questions? 4.4 Was between-study variation minimal or addressed in the synthesis? 4.5 Were the findings robust, for example as demonstrated through funnel plot or sensitivity analyses? 4.6 Were biases in primary studies minimal or addressed in the synthesis?
A - Did the interpretation of findings address all of the concerns raised? B - Was the relevance of identified studies to the review's research question appropriately considered? C - Did the reviewers avoid emphasising results on the basis of their statistical significance?

3.4 Discussion

Despite the massive, and growing, burden of surgical disease identified in Chapter 2, this systematic review has highlighted the severe surgical workforce challenges faced by low- and middle-income countries across the world. To the authors knowledge it is the first attempt to measure the density of SAO providers using the synthesis without meta-analysis (SWiM) methodology.

3.4.1 Regional trends

The geographic imbalance of the surgical workforce is clearly highlighted by the World Bank and Holmer's 2015 study (Figure 31 above).(260,265) Data from these sources clearly shows the surgical workforce crisis is most acute in the African and South East Asian regions of the world. Within the African region, only one country (Seychelles) met the LCoGS minimum standard of 20 SAO providers per 100,000 population. This is in stark contrast to the European region, where only two countries (Albania and Bosnia) failed to meet this standard. In addition to the obvious disparity in the current workforce, has been reported that the countries with largest surgical workforce deficits also have the highest proportion of specialists working in high income countries – a concept know as 'brain-drain'. This highlights that retention of the workforce is a crucial, yet under-appreciated aspect of global surgical systems strengthening.(266) Rudolfson and colleagues have reported on the effect of migration of health care workers both to and from South Africa, and further studies examining the effect in other countries would be beneficial.(221)

Within the European region, there was noted to be a high density of SAO providers within the countries of the former Soviet Union which reflects the large volume of specialist physicians trained under communist rule.

The complex relationship between economic and health factors is also clearly identified by Holmer et al. The mean SAO provider density was 56.9 in High Income Countries and 22.6 in high-middle income countries, both above the LCoGS standard. However the mean density of low-middle (5.5) and low income (0.7) countries was well below the LCoGS standard – highlighting the need for a massive increase in the surgical workforce to achieve internationally acceptable mortality rates.

A similar trend of inequitable academic interest was seen in this study as was demonstrated in Chapter 2. South East Asia was the focus of 6% of studies, despite it's population making up nearly 25% of the total global population.

3.4.2 Data source

Surveys were the single most commonly used data source for studies included in this systematic review. This is understandable as they require very little resource and can give a helpful overview of a national surgical system in a relatively short period of time. Additionally there are a number of widely used, and well validated surveys in use.(235,239,267) They are however, limited by the inherent bias in survey methodology, this is discussed further in section 3.4.4 below.

One of the most comprehensive surveys was the World Federation of Societies of Anaesthesiologists (WFSA) global anaesthesia workforce survey published by Kempthorne and colleagues.(218) This survey collected data form 153 of 197 countries, representing over 97% of the world's population, and importantly targeted Non-Physician Anaesthesia Providers (NPAPs) in addition to Physician Anaesthesia Providers (PAPs). This study highlighted the crucial role that NPAPs have in providing the majority of anaesthetic care in a large number of LMICs. The data was collected in 2015 and 2016 so although currently out of date, is due to be updated with 2021 data, which will allow meaningful evaluation of efforts to improve the workforce crisis.

A number of large, international databases were included in this systematic review. These mostly reported estimates from national MoH data reported to international organisations such as the World Health Organisation (WHO) or the World Bank.(260,262) These databases are likely to be more accurate and more reliable than the surveys included, however, reporting from individual countries is often several years out of date. This makes comparison between countries more challenging and less reliable. Additionally, data reported by more resource challenged nations or countries affected by conflict or natural disasters are likely to be less accurate.

3.4.3 Professions

The professions studied and the names and roles used to describe these professions also varied across the included studies. Definitions of each of these professional groups, and how they are measured vary widely.(218,219) Some studies focussed exclusively on specialist physicians with post graduate training in surgery, obstetrics and anaesthesia.(207) Whereas others were more broadly focussed and general physician surgical or anaesthetic providers (GPSPs or GPAPs) as well as non-physician surgical or anaesthetic providers (NPSPs or NPAPs) were included.(218) Reporting SAO density by only reporting specialist physicians without including GP or non-physician providers will greatly under-report the SAO provider density providers in certain countries whilst making little difference in other, high-income countries with high proportion of specialist physicians. There were no included studies that reported NPAPs within the European region, making it impossible to draw meaningful comparisons across countries and regions with different World Bank income status. Davies and colleagues suggested an updated definition of the LCoGS indicator, including recommending that density of specialist physicians, non-specialist physicians and non-physicians practitioners be reported.(14) Following these recommendations would give a more holistic view of the health system, and avoid the under-reporting associated with only reporting specialist physician density.

Theatre nurses are an essential component of any surgical team.(205) However, this systematic review did not find a single study that reported theatre nurses as a separate entity. There are many studies reporting the density of nurses on a national basis, how many of these are suitably trained and experienced to work as theatre nurses is impossible to say. Further research into the surgical workforce should make efforts to measure this critical but neglected profession.(205) A similar issue was often found when looking at midwives. Many data sources report nurses and midwives together, making it difficult to accurately measure another essential profession within surgical care. Additionally, the definitions, scope of practice and training required of nurses and midwives were not reported in many studies. Further research should focus on the density of operating theatre nurses, midwives and pathology and laboratory medicine services in addition to SAO providers to provide more granular information and allow for real strengthening of the wider surgical system.(205,206)

3.4.4 Limitations

Given the heterogeneity of the data, a formal meta-analysis was not possible and unlikely to be helpful given that data sources were from various different years. A summarising effect estimates method would mask any trends across different timepoints.(62,69) Efforts to conduct a thorough and systematic analysis of the data were undertaken by following the SWiM guideline. Additionally, there will be an element of publication bias in these results, efforts to minimise this bias were undertaken through an extensive and thorough grey literature search outlined above.

There are also some limitations with the synthesis without meta-analysis method. Reporting the results either in a narrative review, bar chart or box and whisker plot does not account for the differences in the population size of each study.(69) This can make it difficult to interpret which study is estimating the more accurate result. The GRADE methodology for assessing certainty was used to give an overall assessment of the quality of each study in an effort to mitigate this.(71)

Focussing on national level data is also likely to mask inequalities within any given country. Those in rural areas are traditionally underserved by healthcare systems generally, and surgical care particularly.(10,268,269) However, national level data does allow for comparison on a national and regional level and sub-national analysis was beyond the scope of this study.

Most importantly, much of this data is based on estimates with low certainty of evidence and high risk of bias. This is due to the lack of high-quality primary data on surgical workforce density in some areas of the world. This can cause significant variations in the reported estimates, particularly at the national level, as displayed in the results section above. Surveys were the most common method of data collection for studies included in this systematic review, and the use of well validated surveys designed to collect data on global surgical systems is widely accepted.(218,234,270,271) However, although considered reliable for assessing structure and setting, there have also been concerns raised regarding the reliability of the WHO TSAAEESC when assessing processes of care.(272) Survey response rates can vary widely depending on the method used to collect the survey, the type of survey, and the country assessed.(273) Furthermore, they can be affected by response and non-response bias, selection bias the language used by the survey and the respondent.(274,275) Importantly, many of the studies using surveys did not report the study sample size in relation to the national surgical workforce, making it difficult to ascertain whether the sample size could be considered adequate to give an accurate picture of the surgical workforce.

3.5 Conclusion

This systematic review has clearly demonstrated the gap in the worldwide surgical workforce. Furthermore, it has highlighted that the workforce is inequitably distributed with significantly higher densities found in high-income countries when compared with middle- or low-income countries. Additionally, there is limited data available on the density of specialist professions such as operating theatre nurses, midwives and pathology and laboratory medicine specialists who play an essential role in any surgical care system. A further trend was noted – that of the unequal academic interest globally, with the regions with fewest healthcare workers being the subject of the fewest research studies.

An effective, well-trained, and sustainable surgical workforce is essential to addressing the massive, and growing, burden of surgical disease worldwide. The training needs of this workforce are yet to be identified. Having outlined the burden of disease in Chapter 2 and the workforce gap in Chapter 3, the next chapter will outline the methodology involved in conducting a thorough Training Needs Analysis of the surgical care team. Identifying and then addressing the training needs of the surgical workforce is a crucial step in improving the care for surgical patients worldwide.

Chapter 4 - Methodology of a Training Needs Analysis

"…the Hennessy-Hicks TNA survey is widely used as a clinical practice and educational quality improvement tool across continents. Furthermore, it facilitates prioritization and allocation of limited educational resources based on the identified training needs." (276)

4.1 Introduction

The previous two chapters have identified the large, and growing, burden of surgical disease and the lack, and unequal distribution, of the surgical workforce. Both factors highlight that training of the surgical workforce needs to be upscaled and the needs of the workforce need to be tailored to the local circumstance. Furthermore, given worldwide resource constraints in surgical training, those resources which are available must be targeted to the areas of greatest need. Epidemiological studies such as the Global Burden of Disease (GBD) studies give important evidence to target the needs of the local health system and the local population. (195,277) Whilst this data is imperfect, it does highlight important trends. When considering the training needs of the local surgical workforce, there is often no data available. This need is particularly acute in healthcare systems where there is limited or no existing post-graduate training, as the training received in undergraduate programs may be the only formal training a clinician receives in their career. It cannot be assumed that a healthcare system with a high incidence of a certain pathology will train their workforce to diagnose and manage this pathology to the best possible standards. Data from high income countries highlights that providing best possible care at the first instance not only improves patient outcomes, but also saves healthcare systems significant sums of money.(278)

Identifying the training needs of the surgical workforce will facilitate further improvements to undergraduate training programmes, and also build evidence base for targeted postgraduate training or continued professional education (CPD). This chapter will describe the methodology of designing, and robustly evaluating, a training needs analysis (TNA) questionnaire that can be delivered online, in low resource settings and collect pragmatic data.

4.1.3 Training needs analysis

A training needs analysis (TNA) has been defined, in personnel management, as “an ongoing process of gathering data to determine what training needs exist so that training can be developed to help the organization accomplish its objectives.” (279)

When considering how to conduct a TNA, there are a number of different conceptual models. The ‘Traditional Model’ focussed on three areas; organisation, task and person, hence is also known as the ’O-T-P’ model which refers to the analysis of those three areas.(279) Assessment of the organisation’s objectives and goals, along with the resource needs identifies where training is required. Analysis of the task seeks to establish a performance standard and the required knowledge and skills to meet this standard. Analysis of the person identifies who should receive the training.

There are a large number of alternative conceptual models including the ‘performance analysis model’, the ‘integrative model’ and the ‘Kirkpatrick model’.(280) The most established, and widely used of these models is Kirkpatrick’s model.(281) This framework sets out 4 levels for evaluation, as seen in Table 1.

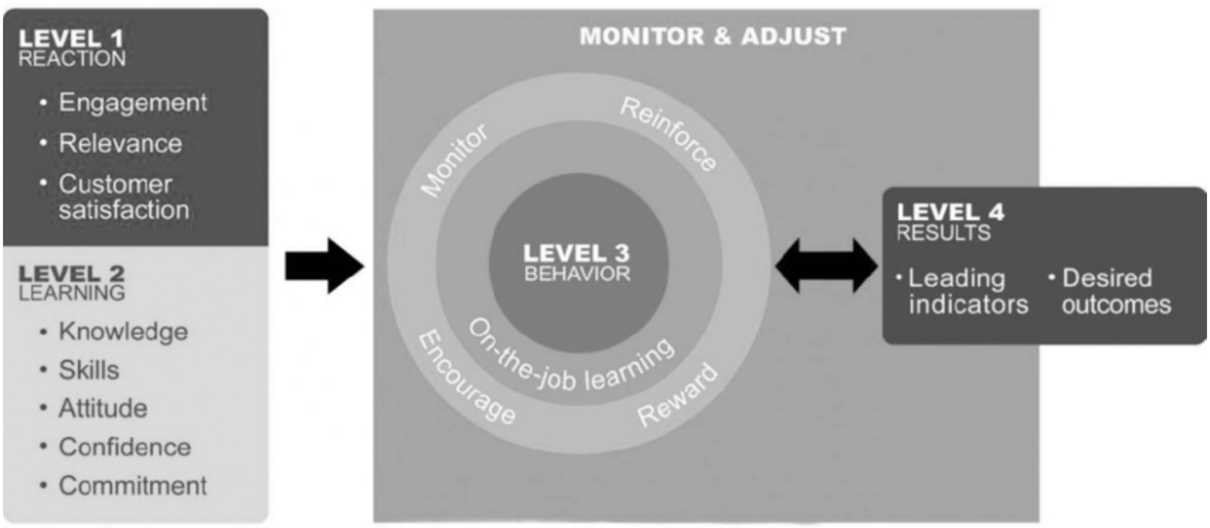
Table 4-1. *Kirkpatrick's original levels of evaluation with definitions*

Kirkpatrick level	Definition
1: Reaction	The degree to which participants find the training favourable, engaging, and relevant to their jobs.
2: Learning	The degree to which participants acquire the intended knowledge, skills, attitude, confidence, and commitment based on their participation in the training.
3: Behaviour	The degree to which participants apply what they earned during the training when they are back on the job.
4: Results	The degree to which targeted outcomes occur as a result of the training and the support and accountability package.

Since, the original publication of Kirkpatrick’s models in 1975, there have been a vast number of modification of the 4 levels, collectively known as ‘Kirkpatrick plus’, however, most of the changes to this model are relatively minor, such as Hamblin’s five level approach.(280) Ideally, any evaluation of training should assess all four of Kirkpatrick's levels simultaneously, however, it is notoriously difficult to evaluate training at the 'higher' levels (3: Behaviours and 4: Results) compared to Levels 1: Reaction and 2: Learning. Evaluating the higher Kirkpatrick levels requires objective metrics of behaviours and results which often do not exist. Where these metrics are available, collection of the data to support the evaluation is often difficult to achieve in many healthcare systems.

The original Kirkpatrick model was updated in 2016, to the 'New World Kirkpatrick Model' (NWKM) – Figure 2.(282) This model uses the same 4 levels described above but conceptually differs in that these are not suggested to be sequential, and that these can be evaluated non-sequentially, concurrently or in reverse. The authors also highlight that not all training programs require assessing at every level and evaluation should be performed in conjunction with key stakeholders to identify the levels that are most important, relevant, and useful to evaluate.

Figure 4-1. The New World Kirkpatrick Model (NWKM) four levels of evaluation.



This study aimed to evaluate training at levels 1 - 3 concurrently but did not have the resource or data available to evaluate level 4: Results, as this would require either measuring individual technical performance using validated measurements (such as OSATs) or clinical outcome data such as perioperative mortality.(283) Both of these possibilities are beyond the scope of this study. In keeping with the New World Kirkpatrick Model, this TNA was performed with close collaboration with key stakeholder organisations to ensure the TNA was focussed on the important and relevant areas of surgical practice within their healthcare system.

4.1.4 Hennessy-Hicks TNA

Although the TNA concept has been prevalent in business organisations for many decades, it was a more recently adopted by healthcare. Within healthcare, the majority of published literature on conducting a TNA has been in nursing, where it has been suggested that the concept should be considered similar to that of an audit; that it is a constant, cyclical process in order to improve systems and should not be considered a one-off event.(284) This cycle should start with a systematic TNA followed by a training intervention. An evaluation of this training should then take place in order to improve future iterations.(284)

The Hennessy-Hicks Training Needs Analysis questionnaire (HH TNA) is a tool developed to identify the training need for primary care nurses and health workers.(285,286) The questionnaire has been validated using psychometric principles amongst nurses in the UK.(287) Since its publication it has been used amongst healthcare professionals across the world, mainly in nurses, but also recently amongst physicians in Nigeria and India.(276,288–290) To date, it has not been applied to technical specialists such as surgeons and anaesthetists. The HH TNA remains one of the most widely used tools within the field and has been licensed to the World Health Organisation.(276) For these reasons it was been selected as the most appropriate validated tool available and was used as the basis of this training needs analysis.

4.2 Methods

The adaptions to the HH TNA questionnaire were designed as a mixed-methods, online survey following the tailored design method.(291) An online survey was chosen as it is low cost, collects data immediately and typically large numbers of responses can be collected in a short time period.(279,291) It was offered in smartphone format and desktop format, as well as there being an option for PDF copies of the survey to be downloaded and completed without an internet connection or to be printed onto paper and collected manually. The survey collected quantitative and qualitative data to aid meaningful comparison of the training need as well as allowing respondents to input their own suggestions on how to improve training in their health system. A mixed-methods approach involves a mixture of research methods and integration of these methods and can yield different but complementary insights to a research question.(292)

The questionnaire was purposely designed to collect data in low resource settings, and an existing partnership between the Royal College of Surgeons of England (RCS Eng) and the Somaliland Ministry of Health was used to conduct a pilot study. Following the pilot study, the survey was distributed to General Surgeons in South Africa.

4.2.1 Survey design

Surveys and questionnaires are not synonymous. A survey can be defined as a general methodology for gathering, describing and explaining information from a sample to describe a population.(293) Questionnaire refers to a specific tool for gathering information, consist of a series of questions and are often self-administered.(293) Questionnaires can also be called scales when the assessment creates a quantified score – s in the Hennessy-Hicks TNA.(293,294)

4.2.2 Survey error

Survey error can be described as the difference between an estimate generated from a survey and the true value.(291) In general there are four types of errors found in surveys:

1. Coverage error. This occurs when the sample population does not accurately represent the population of study. This can be minimised by ensuring that every member of the population of study has the same (non-zero) probability of being sampled.(291)
2. Sampling error. This is the difference between the estimate generated from surveying a sub-sample of the population and occurs whenever only a sample of the population complete a survey, as compared to the entire population.(291)
3. Nonresponse error. This is the difference between the estimate produced by a sample compared to the results when all of the population respond. Nonresponse error occurs when those who do not respond are different from those who do respond, in a way that changes the estimate.(291)
4. Measurement error. This is the difference between the estimate produced and the true value because respondents gave inaccurate responses. This can

occur when respondents are unable or unwilling to give accurate responses which can be due to poor survey design, interviewer or respondent behaviour, language differences or data collection mistakes.(291)

Coverage error has been minimised through collaboration with local professional organisations in each study location to ensure that the invitation to participate was sent electronically through the health system in question and was offered paper format. The results could then be uploaded to the same software used to collect the electronic surveys. In addition, snowball sampling was encouraged to ensure that any potential participants missed by the formal invitations could also complete the survey.

Sample error and nonresponse error were assessed through comparison of the demographics of the study sample with the available demographics for the relevant professional organisation in each study location. Measurement error was minimised through piloting of the survey to ensure it was practical and relatively quick to complete in addition to basing the survey on a validated questionnaire that has been used in multiple languages, cultures and locations across the world.(276,286,288,290) Data was collected via the same online software for all surveys to minimise any errors in data collection or transcription.

4.2.2 Reliability and validity

Although the HH TNA has been well validated in the UK primary care nursing population, using it in a very different context with significant structural changes required validation of the modified version. Therefore, an analysis of the validity of the survey was undertaken as a secondary outcome of the study. Validation of this modified version of the HH TNA may encourage other researchers to use this tool in future.

The two central concepts of psychometrics are that measuring instruments should be both valid and reliable.(287) Validity has several components, but the core concept is that a valid questionnaire ultimately measures what it sets out to measure.(287) There are four elements of validity that are relevant to questionnaire design:

1. Construct validity refers to the extent to which the questionnaire measures the theoretical ideas underpinning it.(287)

2. Content validity is the degree to which the test covers a balanced and representative sample of the behaviours in question, and specifically in this study refers to the sample of surgical and anaesthetic skills chosen to be included in the survey.(287)
3. Face validity refers to the extent to which the test appears to measures what it intends to measure.(287) This extends to the visual appearance of a survey and can be improved through ensuring the survey looks professional and looks as though it is directly related to the training needs of a surgical team.
4. Criterion validity is the test's ability to predict specific criterion behaviours from the responses to the questionnaire.(287) This is notoriously difficult to achieve and is tested retrospectively. This can be tested by assessing how involved in a specific area of practice a respondent is (e.g. by scoring years of experience) and comparing this against their score for importance in that area.

Construct validity was inherent in the survey by its basis on the validated HH TNA. The content of the modified TNA was informed by a thorough literature review, ensuring a high degree of content validity. Face validity was ensured by piloting the study multiple times amongst the research group and with members of the collaborating organisations in each study location. It was not possible to perform an assessment of criterion validity for the clinical skills included. This is due to the fact that it cannot be assumed that years practising correlates to clinical performance at any one skill. Therefore, comparing individual responses against their years of experience may not be reliable, and a suitable alternative 'gold standard' to assess confidence does not exist. Comparison against actual performance of any skill would be impractical and beyond the scope of this study. Furthermore, hypothesising that the most frequently performed procedures would be regarded as the most important does not fit logically with surgical or anaesthetic procedures, as infrequently performed but life-saving procedures may be regarded as just as, or more important than commonly used procedures. However, it is reasonable to expect that confidence would be related to how frequently any skill is performed.(295)

Reliability is defined as "the consistence or reproducibility of a measurement procedure".(296) It is also retrospectively tested and can also be thought of as the ability of the test to measure the same quality every time it is used.(287) An exploratory factor analysis was undertaken for each rating scale in the skills section of the survey using principal components extraction and Varimax rotation, following the psychometric validation methodology of the original Hennessy-Hicks TNA questionnaire.(287,297) An exploratory factor analysis (EFA) is a multivariate statistical method that is used to identify common factors that explain the order and structure found in the measured variables.(297) Brown defines a factor as an "unobservable variable that influences more than one observed measure".(298)

Following the original Hennessy-Hicks methodology, an analysis of reliability was undertaken using Cronbach's Alpha.(287,299) Cronbach's alpha is a measure of the internal consistency or reliability of a scale, and is expressed as a number between 0 and 1.(300) Although there is no agreed minimum alpha value, any item with an alpha value of 0.7 or more is considered acceptable reliability.(300) The standardised alpha was also calculated; this is the alpha value that would theoretically be obtained if all of the items are standardised to a variance of 1. Where items in a scale have comparable variance the difference between the actual alpha and the standardised alpha will be minimal.(287)

4.2.3 Software & data analysis

Jotform (Jotform Inc. San Francisco, USA) was chosen as the software to deliver the survey and collect data in conjunction with MedicineAfrica (Oxford, UK) – a non-profit organisation with extensive experience delivery technology for healthcare in low resource settings in Africa, particularly Somaliland. Data was downloaded from Jotform and analysed in both Microsoft Excel (Microsoft® Excel, Microsoft®, version 16.80). and SPSS (IBM® SPSS® Statistics, version 29). Quantitative and qualitative data were collected over the same time period using a convergent model and data was integrated at the analysis stage.(292) Quantitative data was analysed using descriptive statistics, each item scale was summarised using mean and standard deviation as this allows comparison between different groups as part of a sub-group analysis whilst using the same 7 point scale which facilitates direct comparison.(295) Means were compared using a paired T-test with two-sided significance set at 0.05.

Qualitative data were analysed through thematic analysis using a framework analysis, a style of thematic analysis within the codebook approach.(301,302) Thematic analysis refers to various forms of qualitative analysis that focus on identifying, organising and interpreting themes in textual data.(303) 'Themes' were defined as 'recurrent and distinctive features of participants' accounts, characterising particular perceptions and/or experiences, which the researcher sees as relevant to the research question'.(304) The framework thematic analysis approach was chosen of r a number of reasons; it is often used in health services and applied research to map a developing analysis; it provides transparent results; and is a pragmatic balance between the 'big Q' qualitative reflexive approaches and the 'small q' coding reliability approach.(303,305) It can also be undertaken by a team of researchers which can be useful when undertaking a study with potentially large volumes of responses. Additionally it can be used on separate, but linked, studies to identify cross-cutting themes which has particular relevance to this study.(302) NVivo 12 (NVivo© Lumivero, version 12.7.0) was used to conduct the framework analysis following the six steps set out by Braun and Clarke.(306)

4.2.4 Organisational analysis and study locations

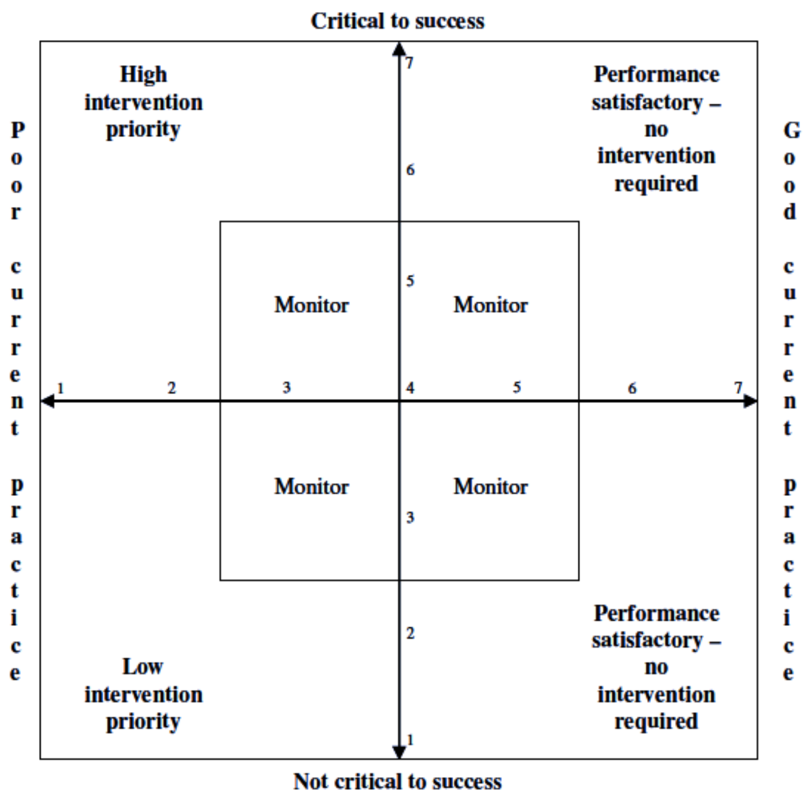
Due to a pre-existing collaboration between the RCS Eng, the LSE and the Somaliland Medical Association, Somaliland was chosen as the location for piloting of the survey. Somaliland is a low-income country in the eastern Africa and despite a population of 5.7 million people, has a small population of doctors at approximately 950 physicians with only 10 qualified surgeons and 80 nurse anaesthesia providers.(307,308). The density of surgeons, obstetricians and anaesthetists (SAO density) has been estimated at 0.8 per 100,000 of the population, well below the recommended 20/100,000 advised by the Lancet Commission on Global Surgery.(10,309) The Somaliland National Health policy published in 2011, outlined that the lack of trainings needs assessments was an ongoing weakness.(310) Due to the high surgical training needs and a small number of specialists, alongside the challenges of trailing an online based survey in a low-resource environment it was selected as a suitable location to pilot the modified HH TNA.

After piloting in Somaliland, the study was conducted in South Africa. Due to the much larger size, existing professional contacts, more developed health system and English being used as the primary language of medical education it was selected as a suitable study location. Furthermore, validating the modified HH TNA questionnaire in multiple African countries with different health needs and economic situations may encourage the wider use of this tool.

4.2.5 Task analysis

The most important aspect of the HH TNA asks respondents to rate the importance of a set of job specific skills. The respondents are then asked to rate how well those same set of skills is performed. The researcher can then identify any area where there is a mismatch between how important a skill is compared to how well it is performed. These skills are ranked on a Likert scale of 1-7 and the results can be plotted in a quadrant graph as seen in Figure 2. This allows the researcher to clearly identify which skills are the highest priority for intervention. Subsequently, respondents are asked to rate how important improving training would be and how important improving the work situation would be to improve the overall performance of a given skill. Again, this data can be displayed in a quadrant graph to identify whether resource should be focussed on training, or through improving the work situation.

Figure 4-2. *Hennessey-Hicks quadrant graph to display importance of a skill against how well it is performed.*(285)



Following discussion with collaborating partners in each of the study locations, it was decided to design specific modifications to the questionnaire for each professional group, using the HH TNA as a basis. Each of the surveys were designed following the tailored design method.(291) The surveys assessed the training need in critical skills within each profession. The exact set of skills included was agreed with the relevant professional organisation within each study location and using international tools or reference standards where available.

The surgical skills included were based on the ‘basket’ of surgical procedures proposed by Weiser *et al* as a more granular version of the ‘bellwether procedures’ proposed by the LCoGS.(10,311) These were modified in collaboration with the local surgical associations, to ensure they were relevant to the local healthcare system in each study location – see Appendix 4A for Somaliland and Appendix 4C for South Africa.

The anaesthesia skills assessed were based on the Safer Anaesthesia for Education (e-SAFE) modules designed by the Royal College of Anaesthetists (RCoA), the Association of Anaesthetists of Great Britain & Ireland (AAGBI), the World Federation of Societies of Anaesthesiologists (WFSA) and e-Learning for Healthcare.(312–315) Again, these were modified, where relevant, for the local health system – see Appendix 4B.

4.2.6 Personnel analysis

Although the completing the survey itself will not form an assessment or appraisal of any individual respondent, the needs identified can be used to improve training offered to individuals. The organisational and task analyses will also inform the analysis of the person as how well each task is completed, and the organisational barriers identified will affect the ability of the individual to perform their job. Additionally, the questionnaire will identify the areas where training could be strengthened and the respondent’s favoured method of addressing these training needs.

4.2.7 Ethical approval

Ethical approval for the pilot study was granted by both the LSE Health Policy Department (Reference – 96088) and by the Somaliland Ministry of Health Development (Reference – MOHD/DG:2/571/2022). Ethical approval for the full study in South Africa was granted by the LSE Health Policy Department (Reference – 221598) and endorsed by the Association of Surgeons of South Africa (ASSA) and the South African Association of Surgeons in Training (SAASiT). Study oversight was undertaken by the Global Surgery Policy Unit (GSPU) – a collaboration between the RCS Eng and the LSE. An introductory page was present at the start of the survey explaining the background to the project and the rationale. Respondents were asked to tick a box to indicate that they had read this information and consented to being part of the study. In study locations where English was not the first language, a video explanation was also uploaded in the local language. Participants were pseudo-anonymised in the data collection process and fully anonymised in the research output.

4.2.8 Proposing improvements

The needs identified have been collated and will be provided to the collaborating organisations to stimulate further discussion on how to improve training of surgical teams in their countries. It is imperative that any recommendation is guided not only by the needs identified but is also sensitive to the resource constraints of the health system. By conducting a thorough TNA on an organisational level, the data generated will be able to help target resources towards the areas of greatest need and maximum possible benefit to both healthcare workers and patients alike.

4.3 Conclusion

This chapter has given an overview of what a training needs analysis (TNA) is, why it is important and how it has been applied to healthcare. The Hennessy-Hicks TNA questionnaire was chosen as it is a well validated tool that has been licensed to the World Health Organization (WHO) and is the most widely used TNA in healthcare worldwide.(286,316,317) The same psychometric principles underlying the HH TNA have been used to guide the changes required to ensure the modified TNA tool is relevant to the study population and will generate meaningful data for the collaborating organisations whilst retaining the academic rigor of the original.(317) The questionnaires developed for the pilot study can be seen in Appendix 4A (Somaliland Surgery & Obstetric skills), Appendix 4B (Somaliland Anaesthesia skills), the results of which were used to develop and refine the survey used in South Africa (Appendix 4C). A pragmatic and robust pilot study informed the improvements to the questionnaire and demonstrated that useful data could be generated even in low resource settings with good response rate. The following chapter will describe the results of the pilot study using the modified HH TNA amongst the surgical care team in Somaliland.

Chapter 5 - Results of a pilot Training Needs Analysis of surgical teams in Somaliland

"The surgical system in Somaliland did not reach any of the target indicator goals as defined by LCoGS, with each indicator lagging behind its target by 76% or more …" (309)

5.1 Introduction

Having outlined the methodology of how to develop a training needs analysis (TNA) questionnaire and ensure the results are valid and reliable, this chapter will report the results of a TNA of surgical teams in Somaliland. This study acted as a pilot study for a study of the training needs of General Surgeons in South Africa.

Somaliland is a low-income country in the Horn of Africa that emerged from the Somali civil war in 1991 and is yet to be formally recognised by the international community. Despite the lack of international recognition, it has undergone the process of building the systems of state in a peaceful environment.(310) It has a population of approximately 4 million people, of which, 40% live in the capital city Hargeisa and 55% are estimated to be nomads.(309,310) It is the fourth poorest nation in the world and with constant drought and famine has significant challenges with delivering health services.(309,310) Health services have been targeted towards the Millennium Development Goals and focussed on reducing poverty, targeting communicable diseases and reducing child and maternal mortality.(310,318)

The health system includes primary care units, health centres, referral health centres, regional hospitals and one national referral hospital.(309) Additionally, there are a number of specialist hospitals including 7 tuberculosis hospitals, 1 obstetric fistula hospital, 1 children's hospital and 1 mental health hospital.(309) Approximately 60% of health services are provided through the private sector, including non-governmental organisations (NGOs), individual private health practitioners and traditional medicine practitioners.(310) There are 2 medical schools, 5 nursing schools and 2 midwifery schools, however there is minimal oversight or co-ordination of these schools at a national level and the country suffers from a persistent exodus of healthcare professionals abroad.(310) The Somaliland National Health Policy, published in 2011, also identified the lack of training needs assessments as an ongoing weakness of the healthcare system.(310)

The surgical system includes 16 hospitals capable of providing surgery (defined as a hospital with at least one dedicated operating room) and requires strengthening in almost every facet, including the training and continued development of the workforce.(309) One recent analysis by Dahir et al, using the World Health Organization's (WHO) Surgical Assessment Tool, identified that Somaliland did not meet the Lancet Commission on Global Surgery (LCoGS) minimum standard in any of the 6 indicators – see Table 1 below.(10,309) This study highlighted that the density of surgeons, anaesthetists and obstetricians (SAO density) was 0.8/100,000 and the procedure volume was 368.8 procedures/100,000, well short of the LCoGS benchmarks of 20 SAO providers and 5,000 procedures per 100,000 population.(10,309) The same study identified 15 surgeons, 3 anaesthetists and 14 obstetricians working across the country, each defined as physicians with specialist postgraduate training in their area.

Table 5-1. *LCoGS indicators in Somaliland reported by Dahir et al 2020.*(319)

Indicator		LCoGS Target	Somaliland
Preparedness	1 - Access to timely essential surgery	80% of population within 2 hours	18.8%
	2 - Specialist surgical workforce density	20 SAO physicians /100,000 population	0.8/100,000
Delivery	3 - Surgical volume	5,000 procedures/100,000 population	368.8/100,000
	4 - Perioperative mortality	Tracking perioperative mortality	Not routinely collected
Impact	5 - Protection against impoverishing expenditure	100% of households protected against impoverishing expenditure	18% protected
	6 - Protection against catastrophic expenditure	100% of households protected against catastrophic expenditure	1% protected

One important limitation of the LCoGS methodology, is that the SAO density focusses strictly on specialist surgeons, anaesthetists and obstetricians and excludes non physicians as well as physicians without formal postgraduate training.

This can significantly under-report the surgical and anaesthetic workforce, and for this reason the broader definition of surgical providers (SPs) and anaesthetic providers (APs) was chosen for this study.

Dahir's study highlights the need for significant strengthening of the surgical care system within Somaliland. The SAO density of 0.8/100,000 demonstrates there is a significant need to upscale training of these clinicians. However, the training needs of the current surgical workforce and the role that technology could play in both improving the quality capacity of training programmes are currently unknown. The primary aims of this study were:

- Identify the training needs of APs and SPs in Somaliland.
- Identify how technology can improve training.

The secondary aims were:

- Validate a novel surgical TNA survey.
- Demonstrate the utility of a pragmatic TNA in a low-income country.

5.1.2 Collaborating partners

Collaborating with multiple organisations is essential in any attempt to strengthen a surgical system, this is especially true when working across international boundaries. This study was conducted as a collaboration between two main groups:

- The Global Surgery Policy Unit (GSPU), a collaboration between the Royal College of Surgeons of England (RCS Eng) and the London School of Economics and Political Science (LSE).
- Partnerships for Surgical Systems Strengthening Somaliland (PaSSS Somaliland) – a collaboration between InciSioN Somaliland, Somaliland Medical Association, Somaliland Nursing Anaesthesia Network (SNAN), Somaliland Nursing & Midwifery Association (SNMA), Somaliland Medical Laboratory Association (SOMLA), Hargeisa Group Hospital (HGH), Burco Regional Hospital (BRH), Medicine Africa and RCS Eng.

5.2 Methods

The questionnaire was designed as a mixed-methods, online survey to allow capture of quantitative and qualitative data to aid meaningful comparison of training need as well as allowing respondents to input their own suggestions on how to improve training. Integration of these methods can yield different but complementary insights to a research question.(292) The Good Reporting of a Mixed Methods Study (GRAMMS) guideline has been followed for reporting of results - see Appendix .(320) The full methodology has been covered in in detail in Chapter 4, in summary an online, mixed methods survey was designed, based on the Hennessy- Hicks Training Needs Analysis questionnaire and sent to members of the collaborating organisations.(285)

Participant recruitment was led by the Somaliland Medical Association (SMLA) and the Somaliland Nursing Anaesthesia Network (SNAN) who engaged local members to encourage participation. Jotform (Jotform Inc. San Francisco, USA) was chosen as the software to deliver the survey and collect data in conjunction with MedicineAfrica (Oxford, UK) – a non-profit organisation with extensive experience delivery technology for healthcare in Somaliland. Inclusion criteria were anaesthesia provider (AP) or surgical provider (SP) currently practicing in Somaliland. APs and SPs were defined as any healthcare professional (with dedicated undergraduate training) providing anaesthetic or surgical care respectively. Both those with specialist post-graduate training and those without any formal postgraduate training were included.

Data was downloaded from Jotform and analysed in both Microsoft Excel (Microsoft® Excel, Microsoft®, Version 16.80). and SPSS (IBM® SPSS® Statistics, Version 29). Quantitative and qualitative data were collected over the same time period using a convergent model and data was integrated at the analysis stage.(292) Quantitative data was analysed using descriptive statistics, and qualitative data analysed using a framework thematic analysis approach – as outlined in Chapter 4.

A separate survey was designed for each of the professional groups:

1. Surgical Providers (doctors, surgeons and obstetricians)
2. Anaesthesia Providers

Participants were identified by the relevant partner organisations in Somaliland and targeted through emails, social media and in person approach at their place of work. Incentives were offered to the partner organisations to encourage participation as part of the wider PaSSS Somaliland project. In total, $1500 USD was offered to each organisation, 50% of the total given on initiation of the project and a further 50% half if at least 25% of their membership completed the survey.

5.2.2 Ethical approval

Ethical approval was granted by both the London School of Economics and Political Science Health Policy Department (Reference – 96088) and by the Somaliland Ministry of Health Development (Reference – MOHD/DG:2/571/2022). Project oversight was undertaken by the GSPU. An introductory page was present at the start of the survey explaining the background to the project and the rationale with a video in Somali and English language. Respondents were asked to tick a box to indicate they read this information and consented to being part of the study. Participants were pseudo-anonymised in the data collection process and fully anonymised in the research output.

5.2.3 Survey design

The full methodology and the rationale for choosing the Hennessy-Hicks TNA questionnaire and the steps taken to modify this have been outlined in Chapter 4. The surveys assessed the training need in critical skills within each profession. The exact set of skills included was influenced by a literature review using peer reviewed data or reference standards where available. The surveys were each tailored to the local requirement in Somaliland in agreement with the collaborating organisations.

The surgical skills included were based on the 'basket' of surgical procedures proposed by Odland *et al* as a more granular version of the 'bellwether procedures' proposed by the LCoGS.(10,311) These were modified in collaboration with the Somaliland Medical Association, to ensure they were relevant to the local healthcare system.

The anaesthesia skills assessed were based on the Safer Anaesthesia for Education (e-SAFE) modules designed by the Royal College of Anaesthetists (RCoA), the Association of Anaesthetists of Great Britain & Ireland (AAGBI), the World Federation of Societies of Anaesthesiologists (WFSA) and e-Learning for Healthcare.(312–315) Again, modification were made after discussion with local physicians and APs from the Somaliland Nursing Anaesthesia Network. Additionally, all APs were asked if they have access to accurate and reliable oxygen saturation monitors, as this is an area that was locally identified as a concern and cost-effective solutions are currently available such as the Lifebox-Smile Train Pulse Oximeter.(50)

All respondents were asked if they used the World Health Organization (WHO) Surgical Safety Checklist, as adherence to this checklist has been demonstrated to reduce mortality and morbidity from surgery across the world.(321) The final part of the survey assessed the current use of technology in training and in clinical practice and the appetite for the use of technology in the workplace in future. Open space questions were asked, with no character restriction, to encourage fuller responses that could offer nuance and detail that can be missed by only collecting quantitative data.

The survey was trialled in English amongst a cohort of Somaliland healthcare professionals from each of the professional organisations to ensure that it was straightforward to complete, the format was easy to follow and that it was relatively short. Minor amendments were made at this stage to improve clarity and to ensure it was relevant to the needs of the collaborating organisations. This initial pilot ensured that the survey showed good face validity and was practical within the local context.

5.3 Anaesthesia Providers

Responses were received from 41 Anaesthesia Providers (APs), giving a response rate of approximately 59% of APs in Somaliland. One of the responses was from an anaesthetist, giving a response rate of 33.33% of anaesthetists.

5.3.1 Demographics

Of the 41 responses, 41% (17) were female and 59% (24) were male – see Table 2. The cohort was relatively young, the majority (80.49%, 33) were aged between 25-34, and there were no respondents over age 44. There was 1 (2.44%) doctor, all other respondents were nurses (2,4.88%) or Anaesthesia Providers (38, 92.68%). The majority of respondents (80.49%, 33) were qualified healthcare professionals, 14.63% (6) were students and 4.88% (2) were specialists with formal postgraduate training in anaesthesia. No respondent had more than 10 years of experience and 56.09% had been qualified less than 3 years.

All respondents were trained (or in training) in Somaliland. The highest number of responses (56.09%, 23) came from Marodi Jeh region, which is the most populous region and contains the national capital, Hargeisa, and 65.85% (27) of all responses came from urban settings. A majority (60.98%, (25) of respondents worked in publicly funded hospitals, with 29.27% (12) working in the private setting and 9.76% (4) working in a hospital funded by a non-governmental organisation (NGO) or charity. Just under a quarter (24.39%, 10) worked in a WHO level 1 setting (primary care or community facility), 41.46% (17) worked in a WHO level 1 hospital (district general hospital) and 34.15 (14) worked in a WHO level 2 or 3 setting (tertiary hospital). The majority (63.41%, 26) of respondents did not hold a National Health Professions Commission (NHPC) license. These results are detailed in Table 2.

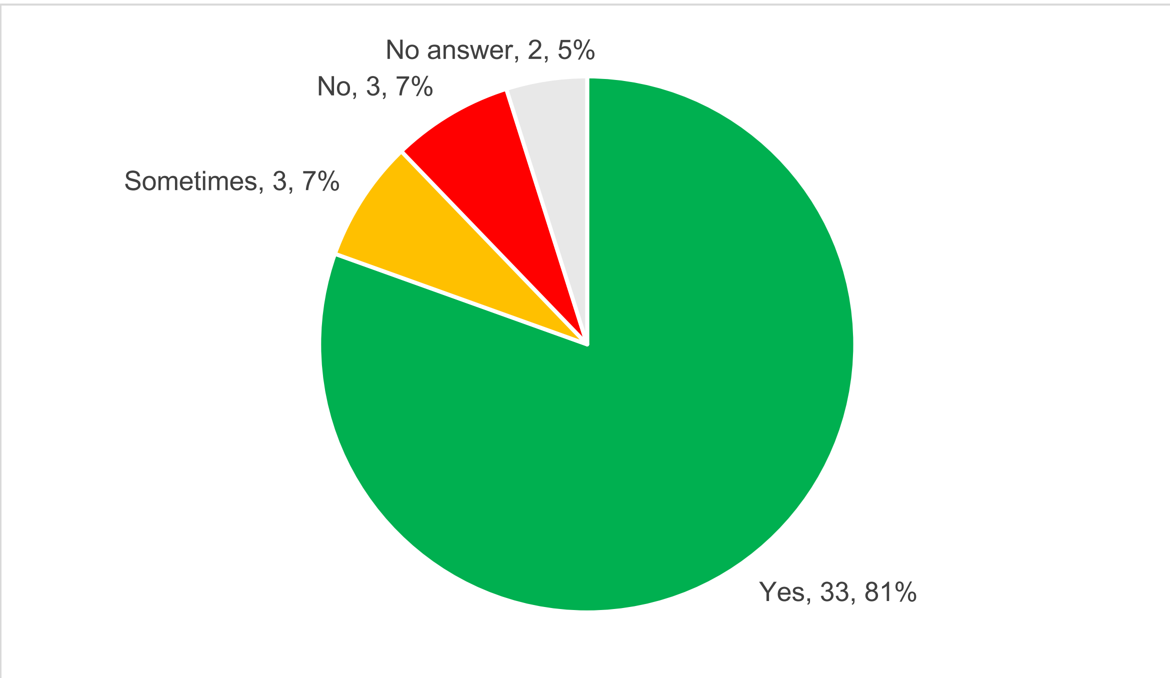
***Table 5-2**. Demographics of Anaesthesia Provider respondents.*

Demographic	**Number**	**Percentage**
Age		
18 – 24	2	4.88%
25 – 34	33	80.49%
35 - 44	6	16.63%
45 - 54	0	-
55 - 64	0	-
65 or above	0	-
Gender		
Male	24	58.54%
Female	17	41.46%
Profession		
Anaesthesia Provider	38	92.68%
Nurse	2	4.88%
Doctor	1	2.44%
Level of training		
Student	6	14.63%
Qualified health worker	33	80.49%
Specialist (with postgraduate training)	2	4.88%
Experience		
Less than 3 years	23	56.09%
3 – 5 years	9	21.95%
6 – 10 years	7	17.07%
11 – 15 years	2	4.88%
16 – 20 years	0	-
More than 20 years	0	-
Location of training		
Somaliland	41	100%
Other	0	-
Region of work		
Marodi Jeh	23	56.09%
Awdal	8	19.51%
Togdheer	5	12.19%
Sanaag	2	4.88%
Gabiley	2	4.88%
Sahil	1	2.44%
Sool	0	-

Workplace setting		
Urban	27	65.85%
Rural	14	34.15%
Workplace finance		
Public/government facility	25	60.98%
Private facility	12	29.27%
Non-governmental organisation (NGO) or charity	4	9.76%
WHO level		
Primary care/community facility	10	24.39%
Secondary care/WHO Level 1 hospital	17	41.46
Tertiary care/WHO Level 2 or 3 hospital	14	34.15%
NHPC Licence		
No	26	63.41%
Yes	13	31.71%
Don't know	2	4.88%

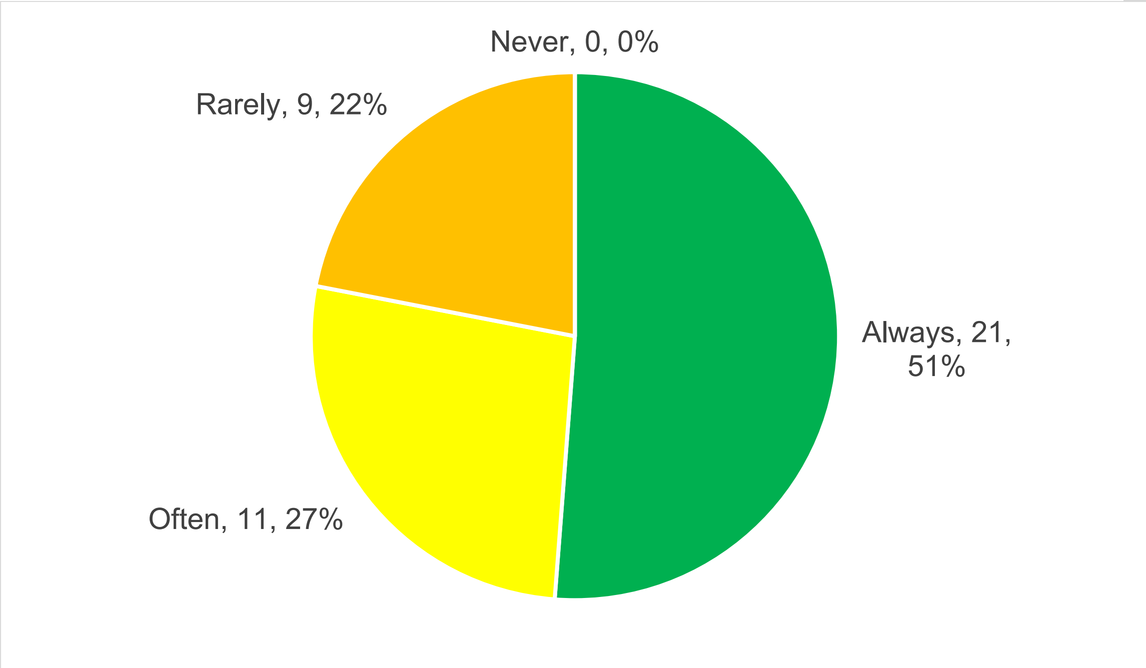
Figure 1 below, demonstrates that 80.48% (33) of respondents have regular access to a reliable oxygen saturation monitor intra-operatively. However, 7.32% (3) reported 'sometimes' having access and the same number (7.32%, 3) answering 'no'. Two respondents (4.88%) did not answer the question.

Figure 5-1*. Responses to the question: Do you have regular access to a reliable oxygen saturation monitor or probe for use intra-operatively? N = 41*



The WHO checklist was ‘always’ used by 21 (51.29%) of respondents, ‘often’ by 11 (26.83%), ‘rarely’ by 9 (21.95%) – see Figure 2. No respondents reported ‘never’ using it.

Figure 5-2. *Use of WHO Surgical Safety Checklist by respondents, N=41.*



5.3.2 Importance & performance

The mean ratings for importance and performance of each skill can be seen in Table 3. Highest mean importance was reported in administration of general anaesthesia (6.60), followed by perioperative assessment of a patient undergoing surgery (6.51) and spinal anaesthesia (6.50). The lowest mean importance was found in emergency front of neck access (FONA or cricothyroidotomy) at 4.69, followed by medical management of medical co-morbidities (5.50) and anaesthesia in the geriatric population (5.62).

The highest mean rating of performance was for perioperative assessment of a patient undergoing surgery (6.06) followed by regional anaesthesia (5.91) and spinal anaesthesia (5.91). The lowest mean rating of performance was found in FONA (2.68) followed by medical management of medical co-morbidities (4.53) and anaesthesia for geriatric patients (4.61).

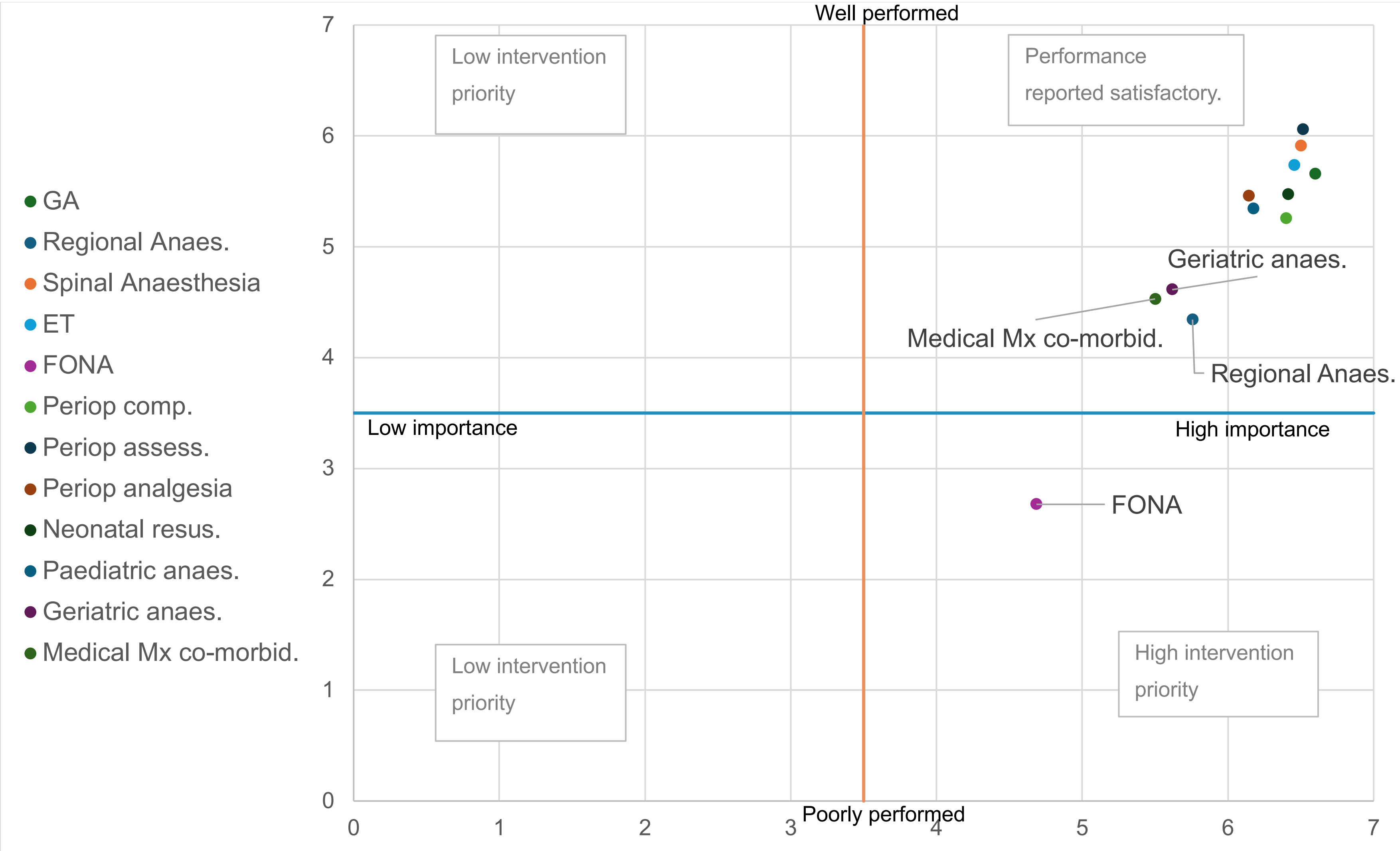
The largest difference between importance and performance was found in FONA (2.01) and the smallest in the perioperative assessment of a patient undergoing surgery (0.46).

Table 5-3. *Mean rating, standard deviation and significance of importance and performance of each skill with standard deviation. N= 41*

Skill	Mean importance (SD)	Mean performance (SD)	Difference	Significance (Two-sided)
General anaesthesia	6.60 (0.83)	5.66 (1.05)	0.94	<0.001
Regional anaesthesia	5.76 (1.64)	4.34 (2.00)	1.41	<0.001
Spinal anaesthesia	6.50 (1.00)	5.91 (1.11)	0.59	0.056
Endotracheal intubation	6.45 (1.06)	5.74 (1.21)	0.72	0.08
Emergency front of neck access (FONA or cricothyroidotomy)	4.69 (2.31)	2.68 (2.05)	2.01	<0.001
Management of perioperative complications	6.40 (1.11)	5.26 (1.30)	1.14	<0.001
Perioperative assessment of a patient undergoing surgery	6.51 (1.09)	6.06 (0.92)	0.46	0.085
Perioperative analgesia	6.14 (1.18)	5.46 (1.35)	0.69	0.006
Neonatal resuscitation	6.41 (1.30)	5.47 (1.35)	0.94	0.002
Paediatric anaesthesia	6.18 (1.27)	5.34 (1.23)	0.83	<0.001
Geriatric anaesthesia	5.62 (1.68)	4.61 (1.63)	1.00	<0.001
Medical management of co-morbidities	5.50 (1.73)	4.53 (1.62)	0.97	<0.001

These same data are displayed in a quadrant graph format in Figure 3, which demonstrates that emergency FONA was reported as a high intervention priority according to the Hennessy-Hicks methodology, as the mean performance was below 3.5 and the mean importance was above 3.5. All other skills were reported as satisfactory.

Figure 5-3. *Quadrant graph showing mean importance versus mean performance scores for each anaesthetic skill.*



5.3.3 Training & situation

Table 4 displays the mean ratings of importance for improving training alone and improving the work situation. The highest mean rating of importance for improving training alone was found in the management of perioperative complications (5.80) followed by paediatric anaesthesia (5.74) and FONA (5.63). The lowest mean rating was found in neonatal resuscitation (52.3), followed by the medical management of medical co-morbidities (5.29) and spinal anaesthesia (5.32).

Table 5-4 Mean rating, standard deviation and significance of importance of improving training and improving the work situation for each skill. N = 41

Skill	Mean training (SD)	Mean situation (SD)	Mean difference	Significance (Two-sided)
General anaesthesia	5.50 (1.77)	5.59 (1.61)	-0.09	0.993
Regional anaesthesia	5.35 (1.98)	5.76 (1.60)	-0.41	0.57
Spinal anaesthesia	5.32 (1.45)	5.64 (1.27)	-0.31	0.416
Endotracheal intubation	5.60 (1.81)	5.71 (1.67)	-0.11	0.158
FONA	5.63 (2.14)	5.38 (2.20)	0.25	0.60
Perioperative complications	5.80 (1.27)	5.50 (1.19)	0.30	0.028
Perioperative assessment	5.51 (1.57)	5.33 (1.71)	0.18	0.077
Perioperative analgesia	5.34 (1.57)	5.39 (1.57)	-0.05	0.697
Neonatal resuscitation	5.23 (1.88)	5.28 (1.89)	-0.05	0.334
Paediatric anaesthesia	5.74 (1.24)	5.81 (1.32)	-0.07	0.787
Geriatric anaesthesia	5.56 (1.38)	5.68 (1.30)	-0.12	0.854
Medical management of co-morbidities	5.29 (1.16)	5.61 (1.48)	-0.32	0.170

The highest mean rating of importance for improving the work situation was found in paediatric anaesthesia (5.81), followed by regional anaesthesia (5.76) and endotracheal intubation (5.71). The lowest mean rating of importance for improving the work situation was found in neonatal resuscitation (5.28), followed by perioperative assessment (5.33) and FONA (5.38).

The largest difference between mean rating for improving training versus improving the work situation (favouring improving training) was found in the management of perioperative complications (0.30), followed by FONA (0.25) and perioperative assessment (0.18). The lowest difference (favouring improving the work situation) was found in regional anaesthesia (-0.41), followed by the medical management of co-morbidities (-0.32) and spinal anaesthesia (-0.32).

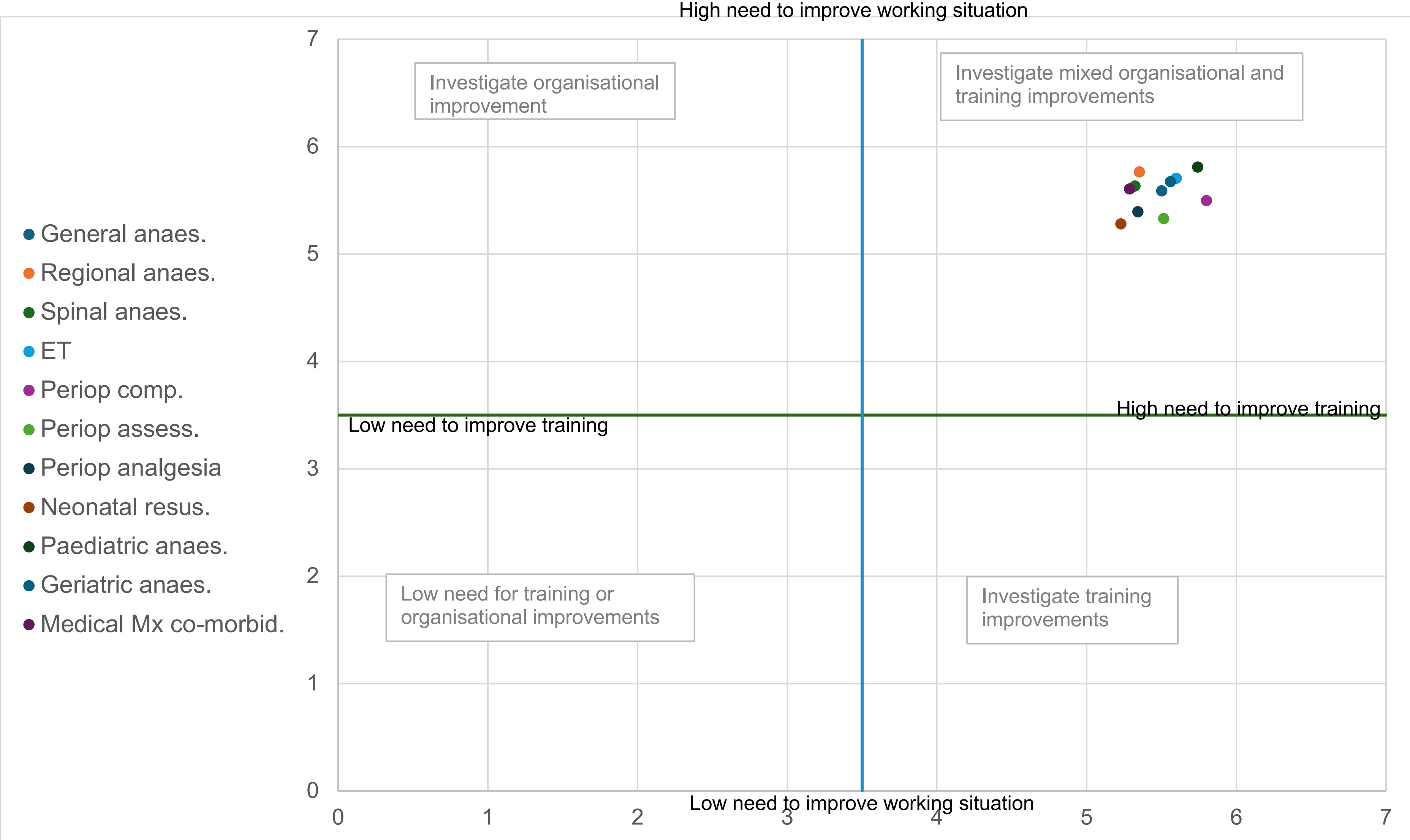
These data are displayed in a quadrant graph in Figure 4, below, which demonstrates that mixed organisational and training improvements were desired for all assessed skills.

Table 5, below highlights the modal answer for the majority of skills was ‘daily’. However, the modal answer was ‘never’ for emergency front of neck access (cricothyroidotomy), ‘monthly’ for paediatric and geriatric anaesthesia and both ‘monthly’ and ‘annually’ were equal for medical management of co-morbidities.

Table 5-5. *Modal responses to the question "how often do you use this skill?' N=41.*

Skill	**Modal answer**
General anaesthesia	Daily
Regional anaesthesia	Daily
Spinal anaesthesia	Daily
Endotracheal intubation	Daily
Emergency front of neck access	Never
Management of perioperative complications	Daily
Perioperative assessment of a patient	Daily
Perioperative analgesia	Daily
Neonatal resuscitation	Daily
Paediatric anaesthesia	Monthly
Geriatric anaesthesia	Monthly
Medical management of co-morbidities	Monthly/Annually

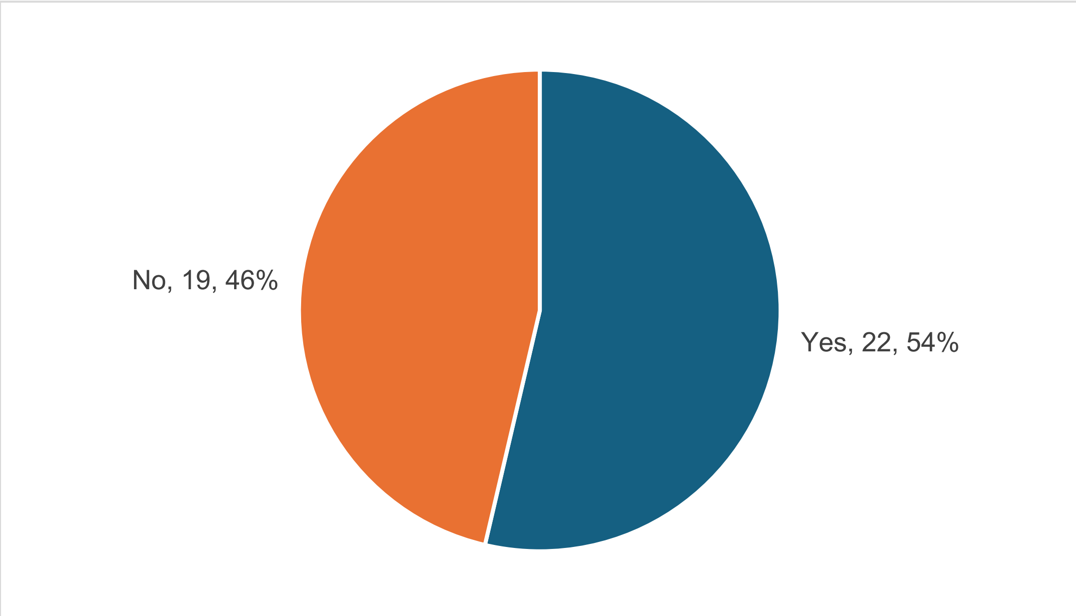
Figure 5-4. *Quadrant graph showing mean scores for need to improve training vs need to improve work situation.*



5.3.4 Use of technology

A slim majority of respondents (53.66%, 22) used some form of technology in training or in clinical practice – see Figure 5 below.

Figure 5-5. *Technology in use in either training or clinical practice amongst APs in Somaliland (N=41).*



Answers to the question *"what technology is currently used?"* are displayed in Figure 6 in green alongside answers to the questions *"What technology would you like to see introduced in future?"* in blue. This shows that *'Online lectures'* and *'Watching video recording of an operation or procedure'* were the joint most popular responses, selected by 51.22 (21) of respondents. This was followed by '*Sending clinical photographs or videos'* and various websites by 46.34% (19) of respondents. *'Video calls to patients'* was the least frequently reported use of technology, with 19.52% (8) respondents.

Desire for future use of *'online lectures'* was the most frequently reported, by 68.29% (28) of respondents. This was followed by *'Online conferences'* by 65.85% (27) and '*Videoconferences*' by 63.41% (26) of respondents.

Figure 5-6. *Current use of technology and desire for future use amongst APs in Somaliland (N=41).*

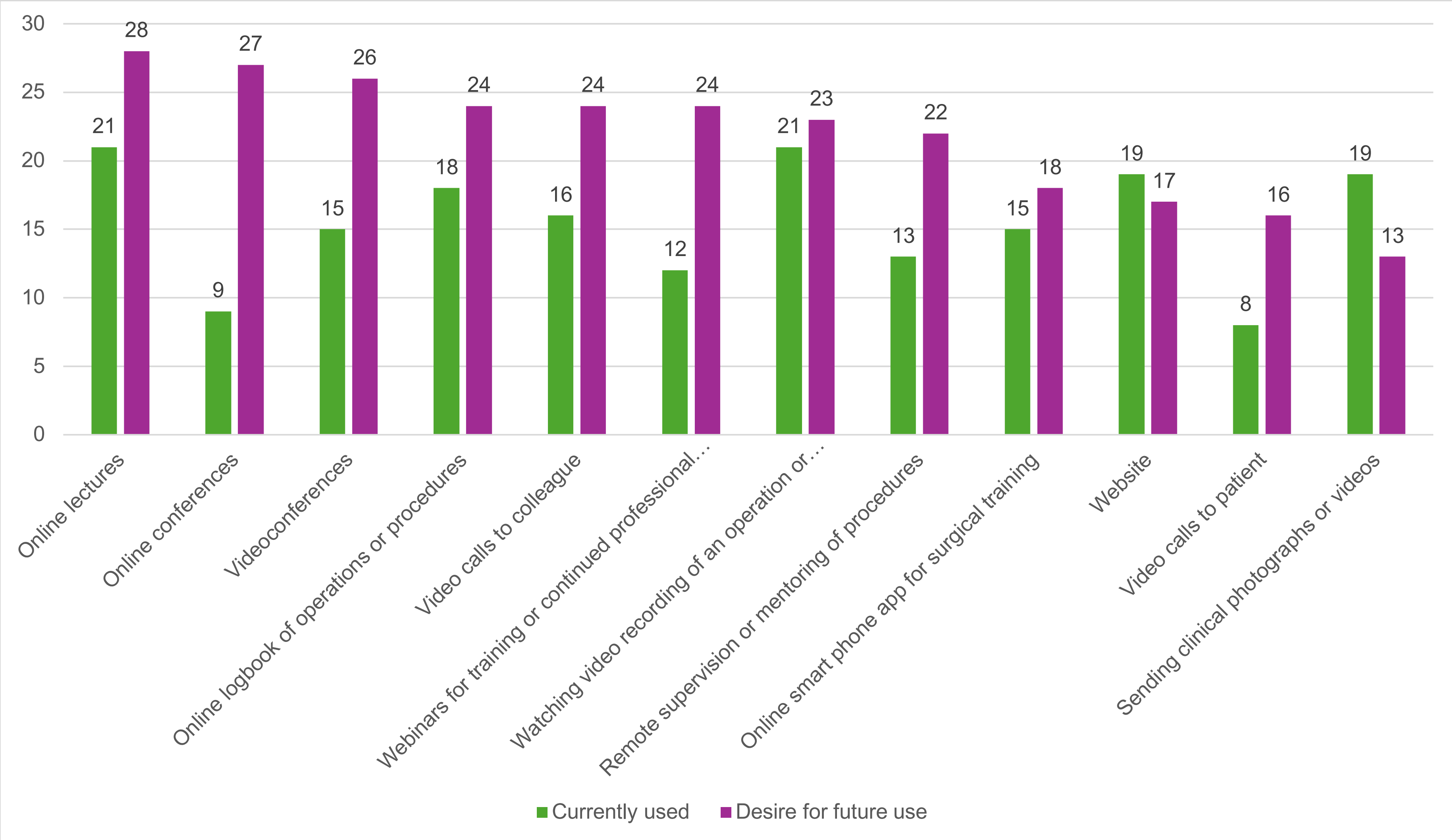


Figure 5-7. *Barriers to use of technology amongst APs in Somaliland (N=41).*

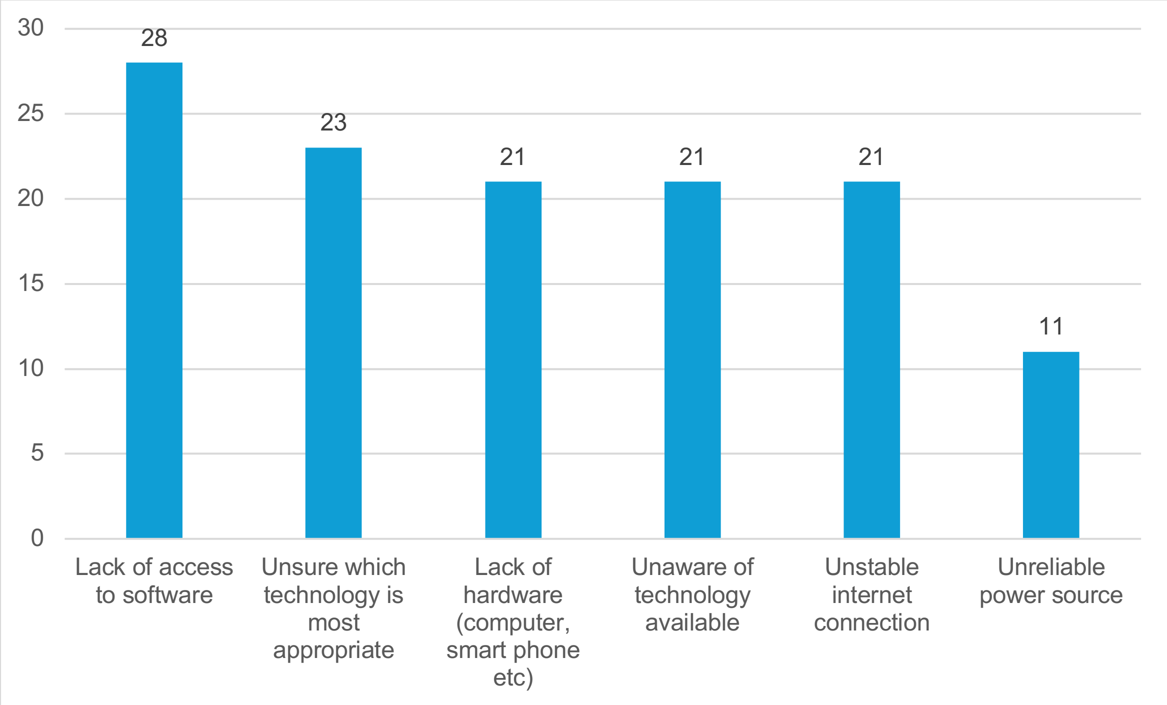


Figure 7 above, displays the respondents' answers to the question *"What are the barriers to using technology in your current place of work?".* Access to software was the most frequently reported barrier, by 68.29% (28) of respondents, followed by 'Unsure of which technology is most appropriate' by 56.09% (23). *'Lack of hardware'*, *'unaware of technology available'* and '*unstable internet connection'* were the joint third most frequently reported barrier, by 51.21% (21) of respondents. '*Unstable power source'* was the least frequently reported barrier, reported by 26.83% (11) of respondents.

5.3.5 Qualitative analysis

The open text answers to the question: 'How could technology best be used to improve training or patient care in your place of work?' were analysed using a framework thematic analysis as outlined in Chapter 4. The initial themes that developed are displayed in Table 6 below. Following initial development of the 'template' or 'framework' this was further refined, with the addition of key extracts from the open text answers to provide meaningful examples of the themes identified – see Table 7, the unique ID given to each respondent is in brackets after the quote.

Table 5-6*. ‘Clustering’ of initial key themes and sub-themes from the framework analysis of answers to the question: 'How could technology best be used to improve training or patient care in your place of work?' (N = 41).*

Themes	Sub-themes
Communication	Communication with colleagues
	Communication with patients
	Collaboration
Patient care	Virtual care
	Reducing medical error
Training	CPD
	Procedural training
Adopting new technology	Specific software or website
	Online logbook
	Adopting new equipment
Negative impressions	Technology not relevant
CPD	Online training

After coding, the initial clustering of themes and sub themes revealed 12 sub-themes, these were organised into 6 main themes (Table 6), these were further refined into 5 main themes (Table 7). The main themes highlighted the broad areas where respondents suggested technology could play a role. The sub-themes within ‘communication’ suggested technology could be used to facilitate ‘communication with patients’ *(“It improves communication between patients and healthcare professionals”* AP08) and with colleagues (*“Improved lines of communication”* AP07) in addition to supporting the concept of ‘collaboration’ (“*It will be great work develop network that can provide support”* AP22).

Within the theme of ‘patient care’ responses coalesced into two sub-themes; ‘virtual care’ (“*Accessibility to virtual care”* AP07) and ‘reducing medical error’ (*“Reduced medical errors”* AP07). The two sub-themes within ‘training’ were identified as ‘continued professional development’ (CPD) *(“Video conferences and online courses and simulations held once a year”* AP04) and ‘Specialist training’ (“By using advanced equipment” AP11).

The theme of ‘Adopting new technology’ had 3 sub-themes: ‘Specific software or website’ (*“Medscape”* AP10), ‘Desire for an online logbook’ (*“Online logbook”*

AP12) and ‘Adopting new equipment’ (*“We need more modern equipment to keep up with the developed world”* AP18).

Importantly there were also negative impressions expressed within the sub-theme of ‘Technology not relevant’ (*“Not much”* AP06).

Table 5-7. *Themes and subthemes identified in framework analysis of responses by APs (N=41).*

Themes	Sub-themes
Communication	Communication with colleagues *“Improved lines of communication”* (AP07)
	Communication with patients *“It improves communication between patients and health professionals”* (AP08)
	Collaboration *“It will be a great work develop network that provide support”* (AP22)
Patient care	Virtual care *“Accessibility to virtual care”* (AP07)
	Reducing medical error *“Reduced medical errors”* (AP07)
Training	CPD “Video conferences and online courses and simulations held once a year” (AP04)
	Specialist training *“By using advanced equipment”* (AP11)
	Online training ‘Video conferences and online courses’ (AP04)
Adopting new technology	Specific software or website “Medscape” (AP10)
	Desire for an online logbook *“Online logbook of operations” (AP 12)*
	Adopting new equipment *“We need modern equipment to keep up with the developed world”* (AP18)
Negative impressions	Technology not relevant *“Not much”* (AP06)

5.3.6 Reliability

A principal component analysis (PCA) was conducted, the results for the PCA for section A of the HH TNA table used are displayed in Table 5 below and a Scree plot in Figure 5 below. Table 8 shows that over 67% of variance within the survey is explained by 2 factors. The scree plot displayed in Figure 8 shows an inflection point at 3 factors, also suggesting that 2 factors within the survey are responsible for the majority of the variance within the survey. Both analyses suggest that 2 factors should be used for the PCA.(322)

A factor analysis was performed using Varimax rotation on each of the 12 items for each column (or rating scale) on the HH TNA survey. The Kaiser-Meyer-Olkin measure verified the sampling adequacy for the analysis of 0.694, which is above the acceptable limit 0.5 according to Kaiser & Rice.(323) An initial analysis obtained eigenvalues for each factor in the data. Two factors had eigenvalues over Kaiser's criterion of 1 and in combination explained 67.482% of the variance - see Table 8. The scree plot also identified an inflexion point at 3 factors suggesting that 2 factors should be retained for the analysis – see Figure 8.

Table 9 shows the factor loadings after Varimax rotation for each of the 4 scales. There were no observed patterns of clustering on the same factors, therefore the factors were not named and were numbered instead. This is likely due to the modest sample size, in a larger sample, items would be expected to cluster around similar characteristics, with items pertaining to perioperative care for example, clustering together.

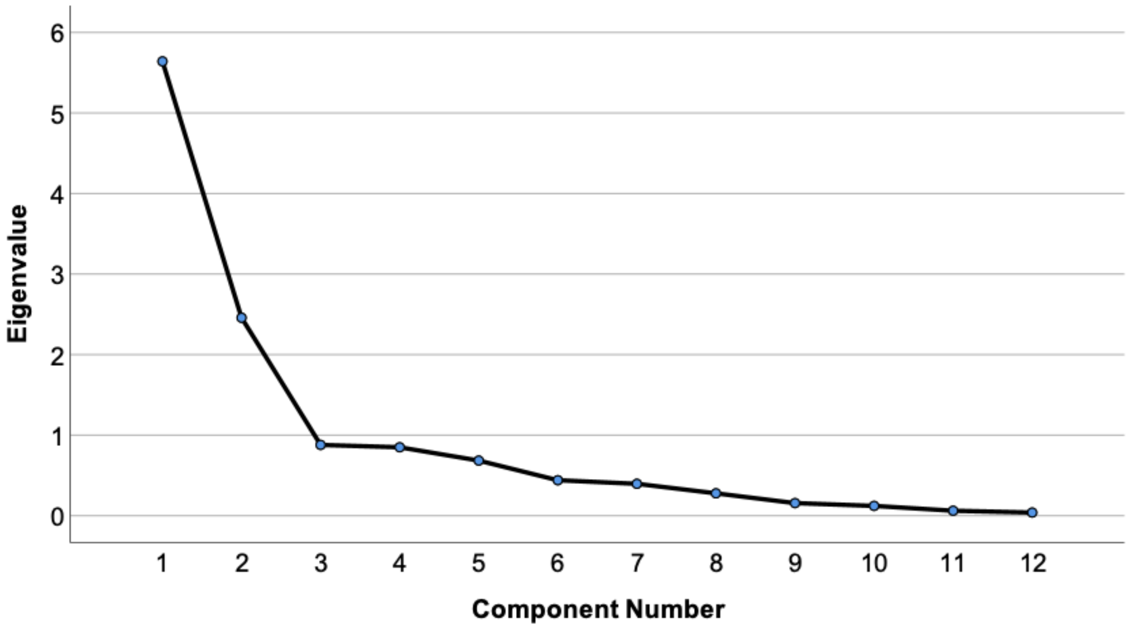
Table 5-8. *Variance of factors for rating scale A – Importance in Somaliland Anaesthesia Providers survey (N=41). Indicating that over 67% of variance is explained by 2 factors.*

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings		
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	5.640	47.004	47.004	5.640	47.004	47.004	4.093	34.110	34.110
2	2.457	20.478	67.482	2.457	20.478	67.482	4.005	33.372	67.482
3	.879	7.321	74.803						
4	.849	7.075	81.878						
5	.684	5.701	87.579						
6	.440	3.667	91.247						
7	.396	3.297	94.544						
8	.277	2.311	96.855						
9	.156	1.300	98.155						
10	.121	1.012	99.167						
11	.061	.511	99.678						
12	.039	.322	100.000						

Extraction Method: Principal Component Analysis.

Figure 5-8. *Scree plot displaying eigenvalue for each number of factors for scale A – Importance (N=41). The inflection point at 3 indicates the majority of variance is due to 2 factors.*



The principal component analysis was repeated for each of the scales with results in Table 10, the Cronbach's alpha, standardised alpha and KMO measure are displayed in Table 11.

Table 5-9*. Summary of exploratory factor analysis result for the Somaliland Anaesthesia Providers survey for scale A - Importance. Note values >0.40 are in bold (N = 41). As both the variance of factors (Table 8) and eigenvalues (Figure 8) suggest the majority of variance was explained by 2 factors, 2 factors were retained for the principal component analysis (PCA).*

Item	Rotated factor loadings	
	1	2
General Anaesthesia - Importance	**.596**	.246
Regional Anaesthesia - Importance	**.819**	-.215
Spinal Anaesthesia - Importance	.273	**.765**
ET intubation - Importance	.094	**.732**
FONA - Importance	**.590**	.162
Periop. complications - Importance	.027	**.926**
Pre-operative assess - Importance	.140	**.922**
Periop. analgesia - Importance	**.803**	.152
Neonatal resuscitation - Importance	.275	**.781**
Paediatric anaesthesia - Importance	.610	**.492**
Geriatric anaesthesia - Importance	**.835**	.381
Medical Mx. of co-morbid. - Importance	**.908**	.151

Extraction Method: Principal Component Analysis.
Rotation Method: Varimax with Kaiser Normalization.

a. Rotation converged in 3 iterations.

Table 5-10. *Factors and skills for each of the rating scales. Each of the items on the questionnaire are displayed in the groups based on the rotated factor loadings – see Table 9 above. Items with high values from the principal component analysis (PCA) in factor 1 are grouped together and those with high values in factor 2 are grouped together for each scale.*

Rating scale	Factor	Survey item
A - Importance	1	General anaesthesia
		Emergency front of neck airway (cricothyroidotomy)
		Geriatric anaesthesia
		Perioperative analgesia
		Medical management of co-morbidities
		Paediatric anaesthesia
		Regional anaesthesia
	2	Perioperative assessment
		Endotracheal intubation
		Spinal anaesthesia
		Management of perioperative complications
		Neonatal resuscitation
B – Performance	1	Paediatric anaesthesia
		Endotracheal intubation
		Spinal anaesthesia
		General anaesthesia
		Perioperative assessment
		Neonatal resuscitation
		Perioperative analgesia
	2	Geriatric anaesthesia
		Medical management of co-morbidities
		Management of perioperative complications
	3	Emergency front of neck airway (cricothyroidotomy)
		Regional anaesthesia

Scale	Factor	Survey item
D – Improving training	1	Perioperative assessment
		General anaesthesia
		Spinal anaesthesia
		Management of perioperative complications
		Endotracheal intubation
		Neonatal resuscitation
	2	Medical management of co-morbidities
		Geriatric anaesthesia
		Paediatric anaesthesia
		Perioperative analgesia
		Emergency front of neck airway (cricothyroidotomy)
		Regional anaesthesia
E – Improving situation	1	Endotracheal intubation
		Perioperative assessment
		Neonatal resuscitation
		Spinal anaesthesia
		General anaesthesia
		Management of perioperative complications
		Perioperative analgesia
	2	Medical management of co-morbidities
		Regional anaesthesia
		Geriatric anaesthesia
		Paediatric anaesthesia
		Emergency front of neck airway (cricothyroidotomy)

Table 5-11. *Factors and their corresponding Cronbach's Alpha and standardised Alpha for each analysis. Note rating scale C asked 'How often do you perform this procedure per year?" so was excluded from the reliability analysis.*

Factor	**Number of Items**	**Cronbach's Alpha**	**Standardised Alpha**	**KMO**
Scale A - Importance				
1	7	0.845	0.881	0.694
2	5	0.891	0.894	
Scale B - Performance				
1	7	0.88	0.898	0.698
2	3	0.832	0.829	
3	2	0.532	0.532	
Scale D – Improving training				
1	6	0.878	0.880	0.745
2	6	0.674	0.730	
Scale E – Improving work situation				
1	7	0.866	0.865	0.645
2	3	0.706	0.755	

A alpha of >0.9 can be considered as displaying multicollinearity – meaning some items may be considered redundant as they are testing the same question with different wording.(300) As no alpha values >0.9 were returned, no items were considered for removal from the survey.

5.4 Surgical Providers

Responses were received from 69 SPs, 57 (82.61%) of which were doctors without specialist training, 5 (7.25%) were surgeons and 5 (7.25%) were obstetricians. As there are no confirmed overall numbers of SPs in Somaliland, response rates have been subdivided into specialists, giving a response rate of 33.33% of surgeons, 21.43% of obstetricians. The demographics of respondents can be found in Table 12 below.

Table 5-12. *Demographics of SP respondents in Somaliland (N =69).*

Demographic	Number	Percentage
Age		
18 – 24	4	5.80%
25 – 34	59	85.51%
35 - 44	6	8.70%
45 - 54	0	-
55 - 64	0	-
65 or above	0	-
Gender		
Male	47	68.12%
Female	22	31.88%
Profession		
Doctor/Physician	57	82.61%
Surgeon (Doctor with formal post-graduate training in surgery)	5	7.25%
Obstetrician/Gynaecologist	5	7.25%
No answer	2	2.90%
Level of training		
Student	2	72.46%
Qualified healthcare professional	50	21.74%
Specialist (with postgraduate training in your speciality)	15	2.90%
No answer	2	2.90%
Experience		
Less than 3 years	42	60.87%
3 – 5 years	15	21.74%
6 – 10 years	12	17.39%
11 – 15 years	0	-
16 – 20 years	0	-
More than 20 years	0	-
Location of training		
Somaliland	60	86.96%
Uganda	2	2.90%
Egypt	1	1.45%
Somalia	2	1.45%
Ethiopia	2	2.90%
No answer	2	2.90%
Region of work		
Marodi Jeh	9	13.04%

Awdal	44	63.77%
Togdheer	7	10.14%
Sanaag	2	2.90%
Gabiley	1	1.45%
Sahil	0	-
Sool	2	2.90%
No answer	4	5.80%
Workplace setting		
Urban	52	75.36%
Rural	17	24.64%
Workplace finance		
Public/government facility	41	59.42%
Private facility	24	34.78%
Non-governmental organisation (NGO) or charity	4	5.80%
WHO level		
Primary care/community facility	23	33.33%
Secondary care/WHO Level 1 hospital	33	47.83%
Tertiary care/WHO Level 2 or 3 hospital	13	18.84%
NHPC Licence		
No	34	49.28%
Yes	30	43.48%
Don't know	3	4.35%
No answer	2	2.90%

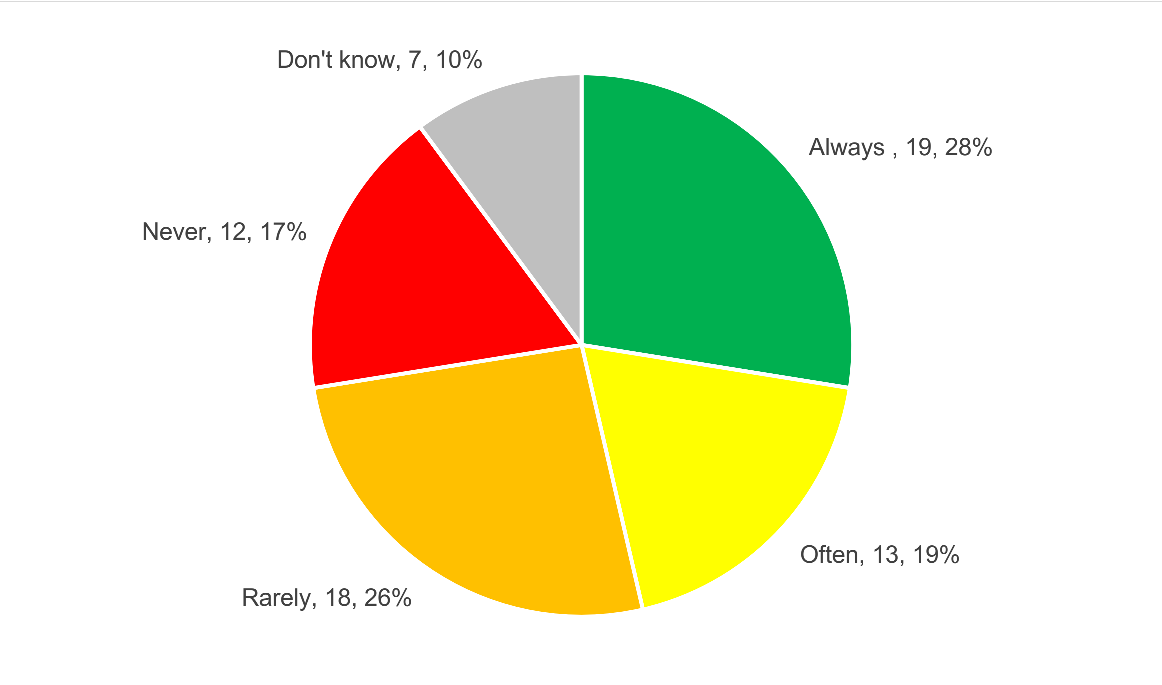
5.4.1 Demographics

Of the 69 SP respondents, 68.11% (47) were male and 31.88% (22) were female, 5.80% (4) were aged 18 – 24, 85.51% (59) were between 24-34 and 8.70% (6) were between 34-44. There were no respondents aged 45 or above. The vast majority (72.46%, 50) were qualified doctors, 21.74% (15) were specialists with formal postgraduate training, 2.90% (2) were medical students and 2.90% (2) did not answer. Similar to the APs, the cohort was relatively junior, with 60.87% (42) having less than 3 years of postgraduate experience, 21.74% (15) having between 3-5 years, and 17.39% (12) having between 6-10 years' experience.

When looking at the location of training, 86.96% (60) were trained (or in training) in Somaliland, 2.90% (2) each in Uganda and Somalia, and 1.45% (1) each from Egypt and Ethiopia, 2.90% (2) gave no answer. A significant majority (63.77%,

44) worked in Awdarl region, 13.04% (9) in Mariodi Jeh, 20.14% (7) in Togdheer, 2.90% each in Sanaag and Gabiley. No answer was given by 5.80% (4). Working in an urban setting was more common (75.36%, 52) than a rural setting (14.64%, 17). Secondary care/WHO level 1 hospital was the most common facilty with 47.83% (33) of responses, followed by primary care/community facility by 33.33% (23) and tertiary care/WHO level 2 or 3 hospital by 18.84% (13). Public/government facility was the most frequent finance type with 59.42% (41) of response, followed by prvate facility by 34.78% (24) and NGO or charity facility by 5.80% (4). A registered NHPC license was reported by only 43.38% (30).

Figure 5-9. *Answers to the question "Do you use the WHO Surgical Safety Checklist" from SPs in Somaliland (N=69).*



The WHO Surgical Safety Checklist was used ‘always’ by 27.54% (19) of SP respondents, ‘often’ by 18.84% (13), ‘rarely’ by 26.09% (18) and ‘never’ by 17.39% (12) – see Figure 9 above. Seven (10.14%) respondents reported ‘I don’t know what this is’.

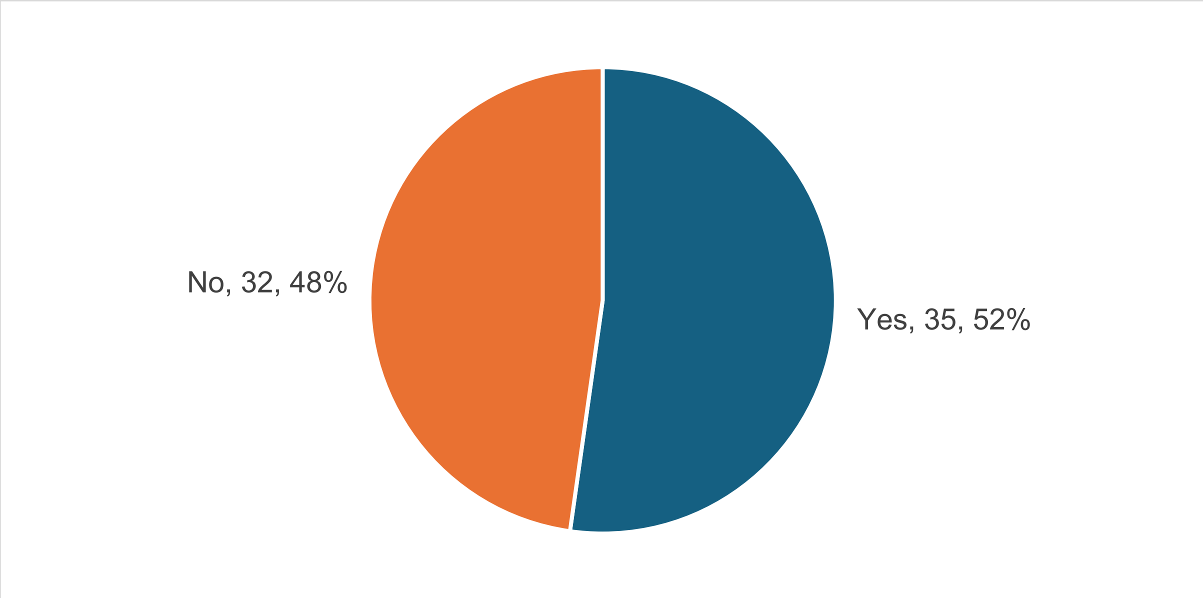
5.4.1 Use of technology

Technology was currently in use by 52.24% (35) of SP respondents either in training or in clinical practice, these are displayed in Table 12.

The most frequently reported technology currently in use amongst SPs was ‘Video calls to colleagues’, ‘Sending clinical photographs or videos’ and ‘Online lectures’, each of these was reported by 26.09% (18) of respondents – see Figure 10. Remote supervision of procedures was the least frequently reported use of technology, by 2.90% (2) of respondents.

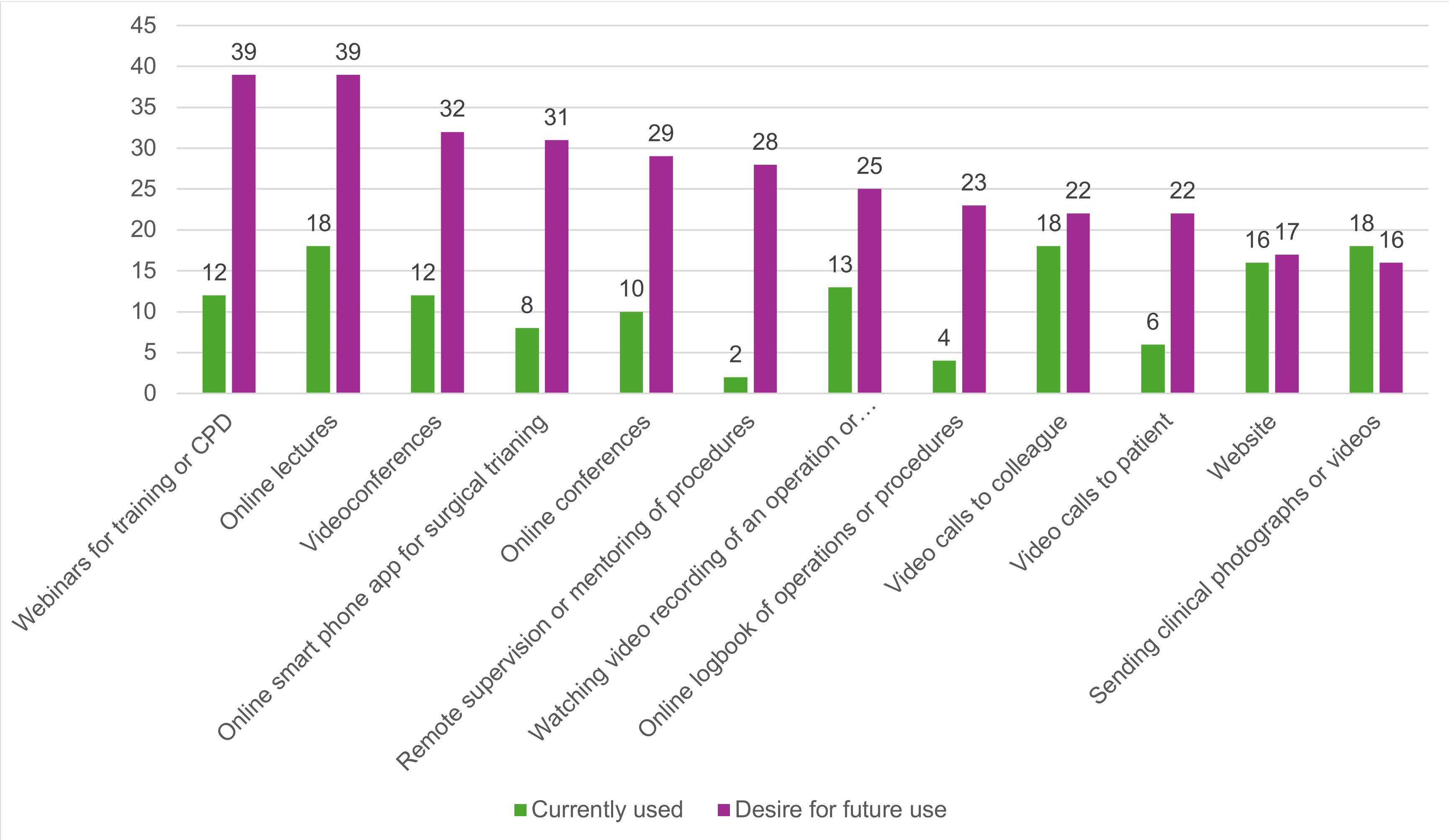
Both ‘online lectures’ and ‘Webinars for training or continued professional development (CPD)’ were the most frequently response for the future use of technology, by 56.52% (39) of respondents – also in Figure 10. ‘Videoconferences’ were the second most frequently reported, by 46.38% (32). ‘Sending clinical photographs or videos’ was the least frequent response, by 23.19% (16).

Table 5-13. *SP responses to the question "Is technology currently used in either your clinical practice (such as video calls to a patient or colleague) or training (such as an online webinar or watching a*



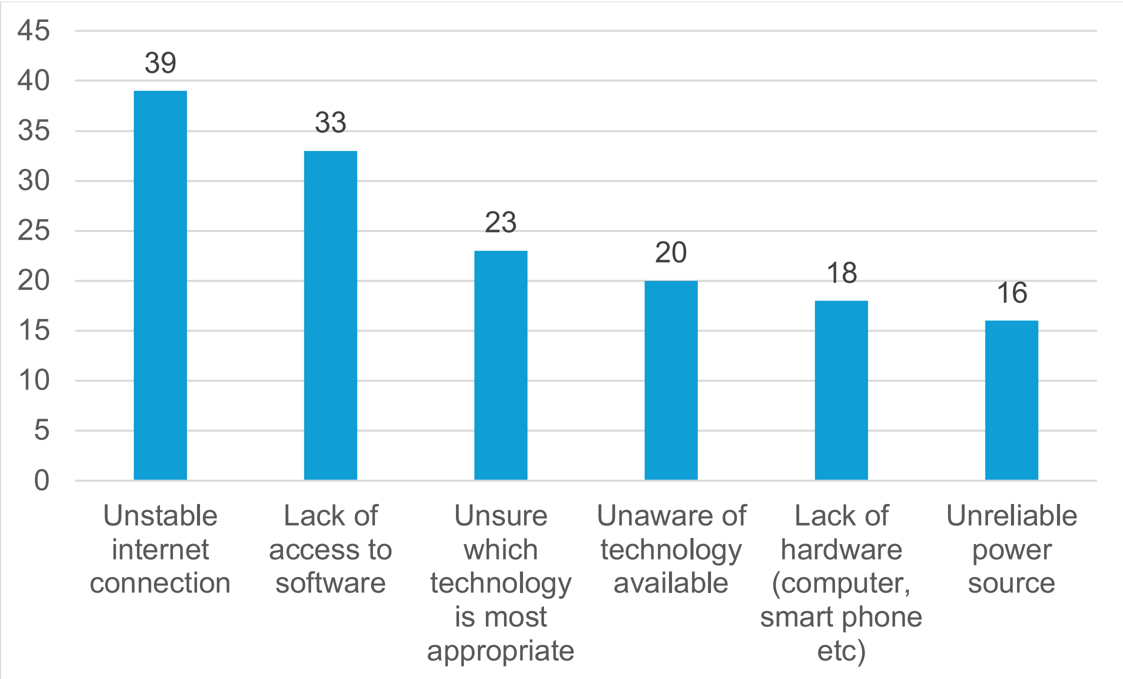
video recording of an operation"? (N=67).

Figure 5-10. *SPs responses to the current use of technology and the desire for future use of technology in both training and clinical practice (N=69).*



When asked *'What are the barriers to the use of technology in your current place of work?', 'Unstable internet'* was the most frequently reported, by 56.21% (39) of SPs, followed by *'Lack of access to software'* by 47.83% (33) and '*Unsure which technology is most appropriate'* by 33.33% (23) – see Figure 11 below. 'Unreliable power source' was the least frequently reported barrier, by 23.19% (16).

Figure 5-11. *SP responses to the barriers to the use of technology in training (N=69).*



5.4.2 Qualitative analysis

The SP's answers to the question: *'How could technology best be used to improve training or patient care in your place of work?'* were analysed the same framework as developed for the APs, with some relevant additions to the codes used. The 7 themes and 24 sub-themes identified are displayed in Table 14 below.

***Table 5-14**. Themes and sub-themes identified in the framework analysis of SP responses to the question 'How could technology best be used to improve training or patient care in your place of work?'. N=69.*

Themes	Sub-themes
Communication	Communication with colleagues *"Communication among colleagues and staff"* (SP37)
	Communication with patients *"you can simplify patient's health conditions by showing vedios involving patients condition"* (SP07)
	Collaboration *"Collaboration and teamwork will help"* (SP41)
Patient care	Virtual care *"Easy follow up for patient after discharge"* (SP23)
	Health promotion "The best way to use it is in patient education. Most people here are nomads and illiterate people who doesn't really know what disease are" (SP21)
Training	Online training '*Online lecture series'* (SP54)
	Post graduate CPD *"by getting latest updates and guidelines*" (SP17)
	Emergency surgical procedures "*To train young doctors for basic surgical procedures that is life saving like chest tube."* (SP43)
	Train the trainers *To train health workers how to use it" (*SP19)
	Desire for better initial training "we also need to Do more training for our surgeons and also to train young doctors for basic surgical procedures" (SP43)
	Broadcasting procedures to trainees "As tool for Teaching the junior doctors watching the surgery outside the theatre via smart TV" (SP37)
Embracing innovation	Remote mentoring *"It will enable us to get supervision from a far remote areas while doing surgical procedures."* (SP32)
	Specific software or website "UpToDate" (SP01)
	Adopting new techniques "it will be good if we access more techniques" (SP40)
Negative impressions	Negative perceptions "We didn't use most of the time" (SP47)
	Other barriers *"Most people here are nomads and illiterate people who doesn't really know what disease are and how to deal with them and their concept of medicine and how it benefits human health."* (SP21)
Hardware	Adopting new equipment *"Ultrasound will help visualise more"* (SP43)
	Improving infrastructure *"It would have been amazing to have strong stable internet connection"* (SP50)
	Operating theatre infrastructure

	"Laparoscopic cholecystectomy used by few hospitals in our setting, if this equipment were widely spread in every hospitals this make difference." (SP53)
System improvement	Patient outcome data "Making online system of collecting patients date, which is available all governmental hospitals." (SP32)
	Facilitating clinical research *"I recommend for every hospital to use its special programme to Recording patient's data and to be easy for the future getting patient's data for research."* (SP18)
	Video record of surgery *"To improve Internet connection and being able to get a record video about that surgery."* (SP13)
	Improved data management *"Patient records can be electronic, including patient data, images and investigations"* (SP36)
	New referral pathways *"We can improve our heath care system by improving the way of referring patients" (*SP28)

'Communication' emerged as a theme, both with colleagues ("*Communication among colleagues and staff"* SP37) and with patients (*"you can simplify patient's health conditions by showing videos involving patients condition"* SP07) and in relation to 'collaboration' (*"Collaboration and teamwork will help"* SP41).

Within 'patient care', respondents identified a role for 'virtual care' ('*Easy follow up for patient after discharge'* SP23) and 'health promotion' *("The best way to use it is in patient education. Most people here are nomads and illiterate people who doesn't really know what disease are"* SP21).

Six subthemes related to 'training'. Respondents outlined a role for 'online training' ('*Online lecture series'* SP54), 'post-graduate CPD' (*"by getting latest updates and guidelines*" SP17) and for 'emergency surgical procedures' ("*To train young doctors for basic surgical procedures that is life saving like chest tube."* SP43). There was also a desire for 'train the trainer' style courses (*"To train health workers how to use it"* SP19), as well as a 'desire for better initial training' (*"we also need to Do more training for our surgeons and also to train young doctors for basic surgical procedures"* SP43). The final sub-theme within training was 'broadcasting procedure to trainees' *("As tool for Teaching the junior doctors watching the surgery outside the theatre via smart TV"* SP37).

Within 'embracing innovation', three sub-themes were identified. 'remote mentoring' (*"It will enable us to get supervision from a far remote areas while doing* *surgical procedures."* SP32), 'specific software or website' ("*UpToDate"* SP01) and 'adopting new techniques' (*"it will be good if we access more techniques"* SP40).

There were 2 sub-themes within 'negative impressions'; 'negative perceptions' (*"We didn't use [it] most of the time"* SP47) and 'other barriers' (*"Most people here are nomads and illiterate people"* SP21).

The theme of 'hardware' was divided into 3 subthemes. 'Adopting new equipment' (*"Ultrasound will help visualise more"* SP43), 'improving infrastructure' (*"It would have been amazing to have strong stable internet connection"* SP50) and 'operating theatre infrastructure' (*"Laparoscopic cholecystectomy used by few hospitals in our setting, if this equipment were widely spread in every hospitals this make difference."* SP53).

Finally, 5 subthemes within 'systems improvement' were identified. 'Patient outcome data' (*"Making online system of collecting patients date, which is available all governmental hospitals."* SP32), 'facilitating clinical research' *"I recommend for every hospital to use its special programme to Recording patient's data and to be easy for the future getting patient's data for research."* SP18), 'video record of surgery' ("*being able to get a record video about that surgery."* SP13), 'improved data management (*"Patient records can be electronic, including patient data, images and investigations"* SP36) and 'new referral pathways' (*We can improve our heath care system by improving the way of referring patients"* SP28).

5.4.3 Survey changes based on pilot study

An error was identified in the SPs survey when respondents moved from one page to another. This resulted in the SPs not being presented with the HH TNA table, where they were asked to rank the importance and performance of a set of skills. This aspect of the survey was changed to ensure that all respondents were shown this table, and the table was simplified into one table with 5 ranking columns rather than 2 separate tables.

Additionally, the frequency of surgical procedures was changed from a Likert scale of 'daily' to 'never' to box where respondents could estimate the number of times per year they performed the procedure in question.

5.5 Discussion

The survey has highlighted a number of important trends. Amongst APs, nearly 15% of respondents reported either no access or only infrequent access to O2 saturation monitoring intra-operatively. Additionally, only 51% of APs and 28% of SPs reported that they ‘always’ use the WHO Surgical Safety Checklist.(321) The HH TNA of APs highlighted that emergency front of neck access (cricothyroidotomy) was a ‘high intervention priority’ procedure amongst APs. Regional anaesthesia, medical management of co-morbidities and anaesthesia in geriatric populations were also considered outliers, in terms of performance, and should also be the focus of further intervention. Importantly, mixed interventions were desired by trainees indicating that training alone would be insufficient, and that improvements to the work situation also need to be addressed. To clearly demonstrate the utility of this tool in practice, a repeat TNA could be performed after an intervention targeting emergency cricothyroidotomy. This would allow the longer-term impact of this promising tool to be evaluated. As training is a continuous process, longer term data will be helpful in this regard. Further work could also focus on the use of this tool to evaluate the impact of a training intervention.

Importantly the numbers of SPs (69) and APs (41) identified in this study is significantly higher than the number of specialist surgeons (15) and anaesthetists (3) in previous work by Dahir et al.(309) This highlights the ongoing surgical and anaesthetic task sharing commonplace in low- and middle-income countries and reinforces the fact that any intervention targeted at the surgical workforce needs to be multidisciplinary by design or risk excluding the majority of clinicians who provide anaesthetic or surgical care.(324)

The reliability of these results was established through the exploratory factor analysis, and comparison of Cronbach’s alpha with the standardised alpha.(287) Minimal differences were seen between the results for Cronbach’s alpha and the standardised alpha indicating comparable variance. Factor 3 within ‘performance’ was the only factor that resulted in a alpha value less than the conventionally accepted value of 0.7.(300) These results suggest that the scales and results provided can be considered reliable.

The importance of a well conducted and thorough pilot study was highlighted during this process as an error within the SPs online survey resulted in the failure to collect data on the respective ratings on performance and importance of surgical skills. The frequency of procedure used was also changed from a Likert scale from 'never' to 'daily' to a free text box that allowed respondents to enter in the approximate number of times per year that they perform each skill. This allowed more granular data to be collected. Additionally, questions regarding the use of technology in training and in clinical practice were combined into one question to reduce repetition in the survey to encourage a higher response rate. Despite the issues highlighted by the pilot study, useful data was still generated that will be shared with collaborating partners to help improve the surgical care system in Somaliland.

The framework analysis approach used proved to be practical tool with over 100 responses analysed and resulted in insightful perspectives. Anaesthesia Providers identified a number of key areas where technology could play a significant role, the themes identified were: communication; patient care; training; adopting new technology and importantly also some expressed reservations about the utility of adopting new technology. Interestingly, most of the sub-themes that developed were focussing on relatively simple technologies such as video calls to patients and colleagues or online learning. There was more limited appetite for more complicated applications such as remote mentoring.

Surgical Providers identified many of the same themes as above, but additional themes were also identified: embracing innovation; hardware and systems improvement. There was desire for application of technology to collect patient outcome data, share local guidelines and to facilitate clinical audit and research. Additionally, adoption of laparoscopic techniques was identified as a priority. As with the APs there was limited desire for more complicated application of technology but consistent desire to improve the surgical care system with respect to both training and patient care. There was no mention from any respondents of artificial intelligence, virtual, augmented or extended reality – all of which have recently been proposed as having potential benefit within Global Surgery from high income country authors.(325–328)

A further benefit of this project was through collaboration with colleagues in Somaliland. By jointly conducting a research project from initial proposal, including designing the survey and securing ethical approval through to data collection, analysis of the results and writing an academic article, local research capacity has also been strengthened.

5.5.1 Limitations

The overall numbers are relatively modest, although in a country with a small healthcare worker population it has received a good response rate, especially from Anaesthesia Providers. The demographics of APs show that the responding cohort are relatively young, urban and at the start of their careers, this likely adds some bias to the data set. This may be in part, due to the survey being primarily released online, therefore the cohort that responds are likely to be younger and more comfortable with technology. It could be argued that the younger healthcare workers would be more likely to be familiar with, and have a larger appetite for, the adoption of technology in healthcare. Therefore, there should be some caution applied when generalising the results of this study to the wider population and particularly to the more senior and more rural members of the workforce. However, as evidenced with a high response rate, a significant proportion of the workforce have been included.

The Hennessy-Hicks methodology, although robust, does imply an arbitrary cut between when a skill is considered ‘satisfactory performance’ or ‘high intervention priority’- see Figures 3 and 4. This is set at a mean of 3.5 on a Likert scale of 1-7. Caution should be applied when interpreting this cut off, and as such, skills that are approaching the halfway mark have been identified as ‘areas of concern’ in this study.

5.6 Conclusion

This chapter has demonstrated that conducting a pragmatic TNA of the surgical team in low resource setting, such as Somaliland, is both feasible and can generate potentially useful data that could be used to improve training and professional development. Using the HH TNA methodology ensured a rigorous approach to conducting a mixed-methods study resulting in reliable and valid data allowing meaningful conclusions to be drawn. Additionally, the development of a novel TNA tool, developed specifically for use amongst surgical teams, will facilitate performing a TNA of surgical teams in other locations. The importance of a robust pilot study was demonstrated, with numerous alterations to the survey outlined above. Longer term data will help to define the utility of this tool to identify interventions and measure the impact according to the needs expressed by healthcare workers. Chapter 6 will focus on the application of this surgical TNA tool amongst General Surgeons in South Africa.

Chapter 6 - Results of a Training Needs Analysis of General Surgeons in South Africa

"In order to address the current and future burden of disease treatable by surgical care, South Africa needs a robust surgical healthcare system with adequate human resources." (228)

6.1 Introduction

Earlier chapters have reported the Lancet Commission on Global Surgery's (LCoGS) estimate that an additional 143 million procedures per year and an additional one million surgical, anaesthetic and obstetric (SAO) providers are needed to meet the minimum safe threshold defined by the World Health Organisation (WHO).(10,329) To improve surgical training capacity effectively, focus should be placed on those areas with the greatest workforce deficit and the greatest area of training need. A Training Needs Analysis (TNA) can be an effective way to identify the areas of greatest training need.

This chapter will report on a TNA of General Surgeons in South Africa using an online survey of the surgical workforce. South Africa is an upper-middle income country with one of the highest surgeons densities in Africa.(330) Surgical training in South Africa required overseas study until the 1960's and is now delegated by the Colleges of Medicine of South Africa to the academic surgical departments of the eight medical schools across the country.(331) As with most countries, surgeons are inequitably distributed, with a higher density in urban areas, and an estimated 60% of general surgeons working exclusively in the private sector.(332) An estimated 86% of the population of South Africa rely on the public sector, however less than half of healthcare professionals work in the public sector.(228) Additionally, the healthcare needs of South Africa are significant, with a mortality rate from interpersonal violence approximately seven times the global average, and a mortality from road traffic injuries double the global average.(333)

Significant improvements in increasing the surgical workforce have been made in recent decades according to a recent study of the Health Professionals

Council of South Africa.(334) The density of surgeons, anaesthetists and obstetricians (SAO density) has increased from 6.3 per 100,000 in 2004 to 10.5/100,000 in 2019.(228) However, this still falls short of the 20/100,000 minimum standard advised by the Lancet Commission on Global Surgery (LCoGS).(10) Within South Africa, there are significant differences in the distribution of SAO providers, with the urban Western Cape region having nearly 20 times higher density of the specialist surgical workforce compared to rural Limpopo province.(228)

There are limitations with applying the SAO metric to South Africa, as it has been estimated that 80% of the surgical providers are non-specialist surgeons (defined as any post-internship physician providing surgical care, excluding consultant surgeons).(332) Family physicians provide a crucial role and are expected to have formal training in surgery and obstetrics to enable them to deliver surgical care in rural settings, where access to larger hospitals is difficult.(335)

Despite the importance of family physicians in providing surgical care, the scope of this TNA was restricted to General Surgeons (both consultants and registrars) to ensure that the data generated, and training needs identified were relevant to the collaborating organisations.

Retention of surgeons within sub-Saharan Africa more broadly is a significant issue, as many African countries do not have formal post-graduate residency training programmes. This means many surgeons will need to leave their country of origin for specialist training and often these surgeons do not return.(336) Retention of these surgeons in the country where they are most needed is critical. Training within Africa has been shown to have higher retention rates.(337) As an upper middle-income country with well-developed surgical training pathways, South Africa has been suggested as a regional training hub for those surgeons without access to formal programmes within their own country.(221,338) This approach has been estimated to have led to the retention within sub-Saharan Africa of over 90% of trainees from the University of Cape Town training programme.(339)

6.1.1 Collaborating partners

Any international study relies on successful collaboration; this is especially true in any attempt to strengthen a surgical system. This study was conducted as a collaboration between the following groups:

- The Global Surgery Policy Unit (GSPU), a collaboration between the Royal College of Surgeons of England (RCS Eng) and the London School of Economics and Political Science (LSE).
- The Association of Surgeons of South Africa (SASSA)
- The Surgical Research Society of Southern Africa (SRS SA)
- The South African Society for Surgeons in Training (SASSiT)

6.2 Methodology

The development of the TNA survey was described in detail in Chapter 4. In summary, a modified version of the Hennessy-Hicks Training Needs Analysis (HH TNA) survey was used.(285) The skills assessed were changed from those relevant to nurses to the 'basket' of critical surgical procedures proposed by Weiser et al.(311) The 'basket' of surgical skills was modified to ensure that it was relevant to the local healthcare system. Respondents were asked to rate their current performance of each skill and the importance of each skill to their job on a Likert scale of 1-7. Using the same 1-7 Likert scale, respondents were then asked to rate the importance of improving training compared to the importance of improving their work situation on improving their performance of each skill.

6.2.1 Survey design

Data collection was through an online survey using software from JotForm (JotForm Inc. San Francisco, USA). The scope of this survey was General Surgery Registrars and Consultants within 5 years of qualification. Those working in the public and private sector were included.

Dissemination of the survey was through the Heads of Departments (HoDs) of General Surgery units across South Africa and through the Association of Surgeons of South Africa (ASSA) and the South African Society for Surgeons in Training (SASSiT). Further participants were recruited by 'snowball sampling' and targeted social media posts. An introductory page was present at the start of the survey explaining the background to the project and the rationale. Respondents were asked to tick a box indicating their consent to being part of the study. The participants were pseudo-anonymised in data analysis and have been fully anonymised in all research outputs.

Data was downloaded from JotForm to Microsoft Excel (Microsoft® Excel, Microsoft®, Version 16.80), quantitative data was analysed using SPSS (IBM® SPSS® Statistics, Version 29) and qualitative data was analysed using NVivo 12 (Nvivo© 1999-2019 QSR International Pty Ltd, Version 12.7.0). Quantitative and qualitative data were collected over the same time period using a convergent model and data was integrated at the analysis stage.(292) Quantitative data was analysed using descriptive statistics, with mean and standard deviation (SD) for normally distributed data and median and interquartile range (IQR) for non-normal data. Qualitative data analysed using a framework thematic analysis approach – as outlined in Chapter 4. Means were compared using a paired T-test with two-sided significance set at 0.05.

6.2.2 Reliability and validity

The HH TNA has been well validated in the UK primary care nursing population and used amongst health care professionals across the world.(286,288–290,316) However, as this study used it in a very different context with significant structural changes, an analysis of the reliability and validity of the survey was undertaken as a secondary outcome of the study. Validation of this modified version of the HH TNA may encourage other researchers to use this modified version in future.

An exploratory factor analysis was undertaken for each rating scale in the skills section of the survey using principal components extraction and Varimax rotation, following the psychometric validation methodology of the original Hennessy-Hicks TNA survey.(287,297) Following this methodology, an analysis of reliability was undertaken using Cronbach's Alpha.(287,299) Cronbach's alpha is a measure of the internal consistency or reliability of a scale, and is expressed as a number between 0 and 1.(300) Although there is no agreed minimum alpha value, any item with an alpha value of 0.7 or more is considered acceptable reliability.(300) The standardised alpha was also calculated; this is the alpha value that would theoretically be obtained if all of the items are standardised to a variance of 1. Where items in a scale have comparable variance the difference between the actual alpha and the standardised alpha will be minimal.(287)

6.2.3 Ethical approval

Formal ethical approval was provided by both the London School of Economics and Political Science Health Policy Department (ID: 221598) and by the University of Witwatersrand Human Research Ethics Committee (HREC). Project oversight was undertaken by the Co-Directors of the Global Surgery Policy Unit (GSPU) in collaboration with the Society of Research Surgeons of Southern Africa (SRS SA).

6.3 Results

In total, 59 responses were received giving a response rate of 3.02% of consultant general surgeons and 12.45% of registrars. Of these, 54.24% (32) were male and 45.77% (27) female – see Table 1. The highest number of responses was from the 25-34 age group with 33.90% (20) followed by the 35-44 group (30.51%, 18). One student (1.69%) completed the survey, most responses were from registrars (50.85%, 30) followed by consultants (45.76%, 27). Of the registrars, 15.25% (9) were in 1st or 2nd year of training, 8.47% (5) were in their 3rd year, 5.08% (3) in 4th year, 6.78% (4) in 5th year, 1.69% (1) in 6th year and 1.69% (1) did not answer.

All respondents trained, or were in training, in South Africa. A majority (77.97%, 16) worked in urban setting. Of consultants, 75% (21) worked in a public or academic setting and 25% (7) worked in a private setting. The World Health Organization (WHO) level of facility was 3.39% (2) in primary care/community facility, 13.56% (8) in secondary care/WHO Level 1 and 83.05% (49) in tertiary care/WHO Level 2/3. The career intent of registrars was split between public practice 6.77% (4), private practice 1.69% (1), mixed public & private 32.20% (19) and academic practice 8.47% (5).

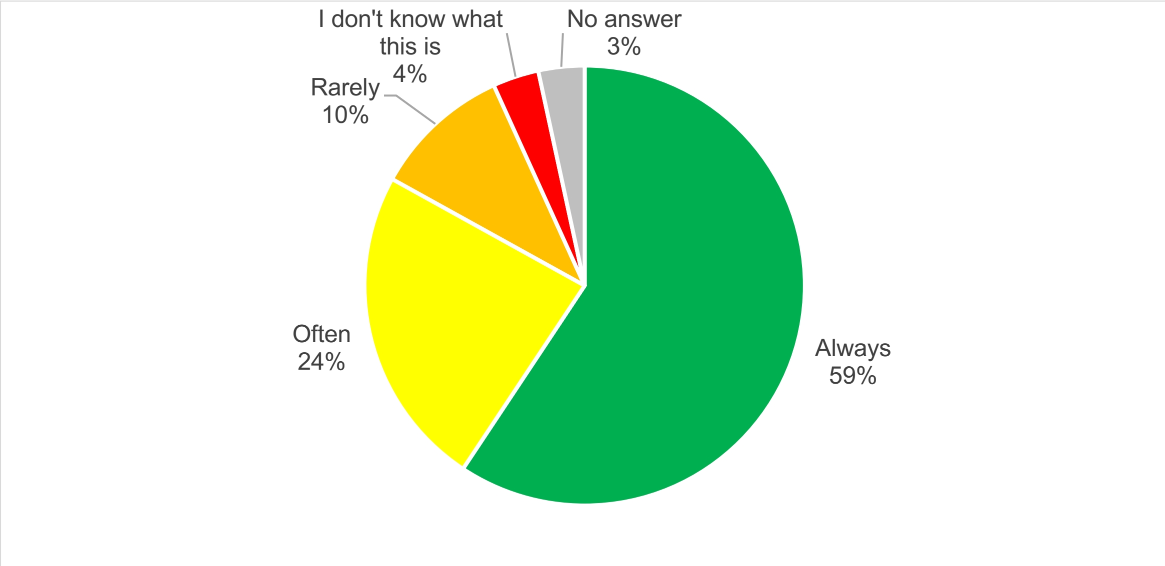
Table 6-1. *Demographics of respondents, N=59.*

Demographic	Number	Percentage
Age		
18 – 24	1	1.69%
25 – 34	20	33.90%
35 – 44	18	30.51%
45 – 54	7	11.86%
55 – 64	9	15.25%
65 or above	4	6.78%
Gender		
Male	32	54.24%
Female	27	45.76%
Level of training		
Student	1	1.69%
Registrar	30	50.85%
Consultant	27	45.76%
No answer	1	1.69%
Year of training (Registrars)		
1	9	15.25%
2	9	15.25%
3	5	8.47%
4	3	5.08%
5	4	6.78%
6	1	1.69%
No answer	1	1.69%
Years of experience (Consultant)		
1	2	3.39%
2	0	-
3	1	1.69%
4	1	1.69%
5	1	1.69%
More than 5	22	37.29%
Location of training		
South Africa	59	100%
Other	0	-
Workplace setting		
Urban	46	77.97%
Rural	13	22.03%

Finance of workplace (consultant)		
Public/Government/Academic	21	35.59%
Private	7	33.90%
Career intent (registrars)		
Public practice	4	6.77%
Private facility	1	1.69%
Academic	5	8.47%
Mixture of public & private	19	32.20%
WHO level		
Primary care/community facility	2	3.39%
Secondary care/WHO Level 1 hospital	8	13.56%
Tertiary care/WHO Level 2 or 3 hospital	49	83.05%

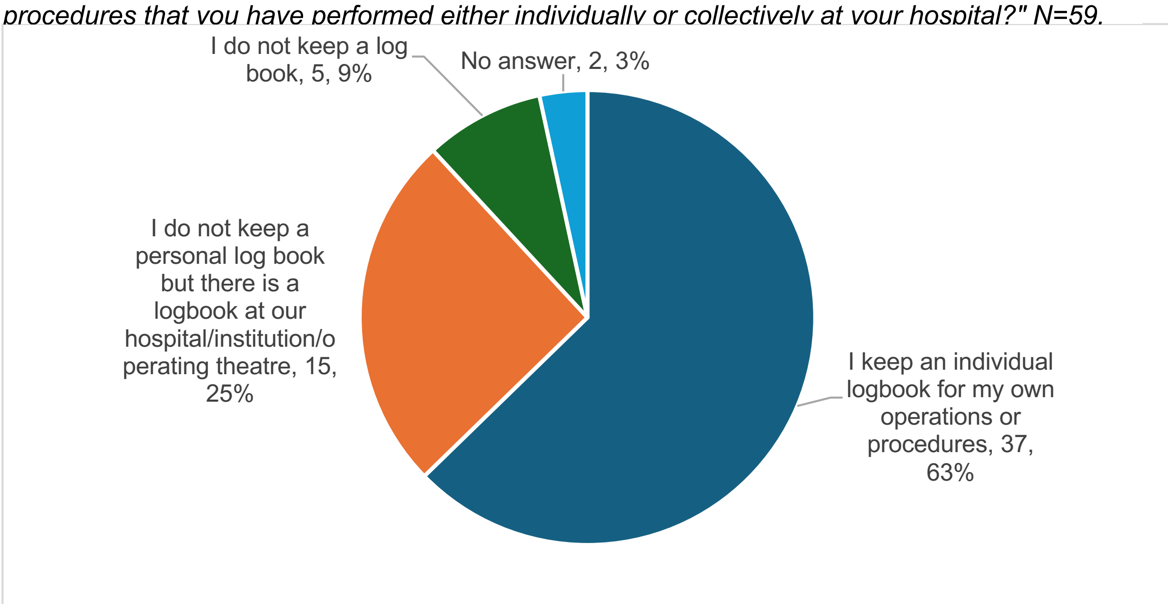
Responses to the question: 'do you use the WHO Surgical Safety Checklist?' are shown in Table 2. A clear majority 59.32% (35) always used it, followed by 23.73% (14) who used it often, 10.17% (6) used it rarely, and 3.39% (2) did not know what it was.

Figure 6-1. *Response to the question: Do you use the World Health Organisation Surgical Safety Checklist? N=59.*



The use of logbooks varied across the respondents – see Figure 2. A majority (62.71%, 37) kept an individual logbook, 25.42% (15) used an institutional or operating theatre logbook, and 8.47% (5) did not keep a logbook.

Figure 6-2. *Responses to the question: "Do you keep a logbook or record of the operations or procedures that you have performed either individually or collectively at your hospital?" N=59.*



6.3.1 Preparation for consultant practice

When consultants were asked the question 'How well did your training prepare you for consultant practice', the median answer was 6 with an interquartile range (IQR) of 4.50 - 6.0 – see Table 2 below.

Table 6-2. *Responses to the question 'how well did your training prepare you for consultant practice?' N=27.*

N	Valid	27
	Missing	0
Median		6.00
Percentiles	25	4.50
	75	6.00

6.3.2 Importance versus performance

The mean ratings for performance importance and performance of each skill can be seen in Table 3 below. The skills are presented in order of decreasing size of difference between importance and performance. The highest mean rating for importance was for tube thoracostomy with 6.97 (0.17), followed by stoma formation at 6.82 (0.47), and inguinal hernia repair (adults) at 6.82 (0.50). (1.42) The lowest mean rating for importance was venous cut down for trauma at 4.55 (2.46).

The highest mean rating of performance was for tube thoracostomy at 6.66 (1.10), followed by extremity amputation at 6.56 (0.67) and open appendicectomy at 6.26 (1.34). The lowest mean rating of performance was for inguinal hernia repair (paediatric) at 3.73 (1.91).

The largest difference between importance and performance, was found in thyroidectomy at 2.63, although this was not statistically significant (p 0.659). This was followed by modified radical mastectomy at 2.29 (p 0.001) and wide local excision for breast cancer at 2.25 (p 0.010). The lowest difference was found in venous cut down for trauma.

The same data are displayed as a quadrant graph in Figure 3 which demonstrates that all self-reported scores were within the 'satisfactory performance' quadrant. However, 3 skills can be seen very close to the border between 'satisfactory performance' and 'high intervention priority', these are: inguinal hernia repair (paediatric), trauma thoracotomy and thyroidectomy.

Table 6-3. *Mean rating, standard deviation, and significance of respondent ratings for importance and performance. N=39, * denotes a p value of < 0.05.*

Skill	Mean importance (SD)	Mean performance (SD)	Difference	Significance (Two-sided)
Thyroidectomy	6.39 (0.994)	3.76 (1.70)	2.63	0.659
Modified radical mastectomy	6.47 (0.94)	4.18 (2.38)	2.29	0.001*
Wide local excision for breast cancer	6.50 (0.976)	4.25 (2.54)	2.25	0.010*
Laparoscopic cholecystectomy	6.48 (1.23)	4.27 (1.79)	2.21	0.159
Trauma thoracotomy	5.90 (1.42)	3.83 (1.46)	2.07	0.407
Diagnostic laparoscopy for trauma	6.47 (0.94)	4.58 (1.86)	1.89	0.833
Inguinal hernia repair (paediatric)	5.57 (1.79)	3.73 (1.91)	1.84	0.013*
Laparoscopic appendectomy	6.06 (1.46)	4.29 (1.76)	1.77	0.379
Tracheostomy	6.74 (0.806)	5.06 (1.89)	1.68	0.113
Open cholecystectomy	5.88 (1.70)	4.28 (1.97)	1.6	<.001*
Liver packing	6.81 (0.64)	5.28 (1.69)	1.53	0.077*
Cricothyroidotomy and tracheostomy	6.42 (1.03)	5.00 (1.92)	1.42	0.007*
Inguinal hernia repair (adults)	6.82 (0.50)	5.41 (1.41)	1.41	0.17
Stoma formation	6.82 (0.47)	5.42 (1.80)	1.4	0.463
Splenectomy	6.12 (1.08)	4.84 (1.80)	1.28	0.561
Partial colectomy	6.28 (1.22)	5.03 (1.88)	1.25	0.196
Peritoneal pelvic packing	6.37 (1.22)	5.31 (1.80)	1.06	0.875
Small bowel resection	6.27 (1.35)	5.24 (2.17)	1.03	0.001*
Trauma laparotomy	6.63 (1.24)	5.67 (1.11)	0.96	0.641
Tube thoracostomy	6.97 (0.17)	6.66 (1.10)	0.31	0.552
Open appendectomy	6.55 (1.21)	6.26 (1.34)	0.29	<.001*
Extremity amputation	6.69 (0.97)	6.56 (0.67)	0.13	0.014*
Venous cut down	4.55 (2.46)	4.44 (1.99)	0.11	<.001*

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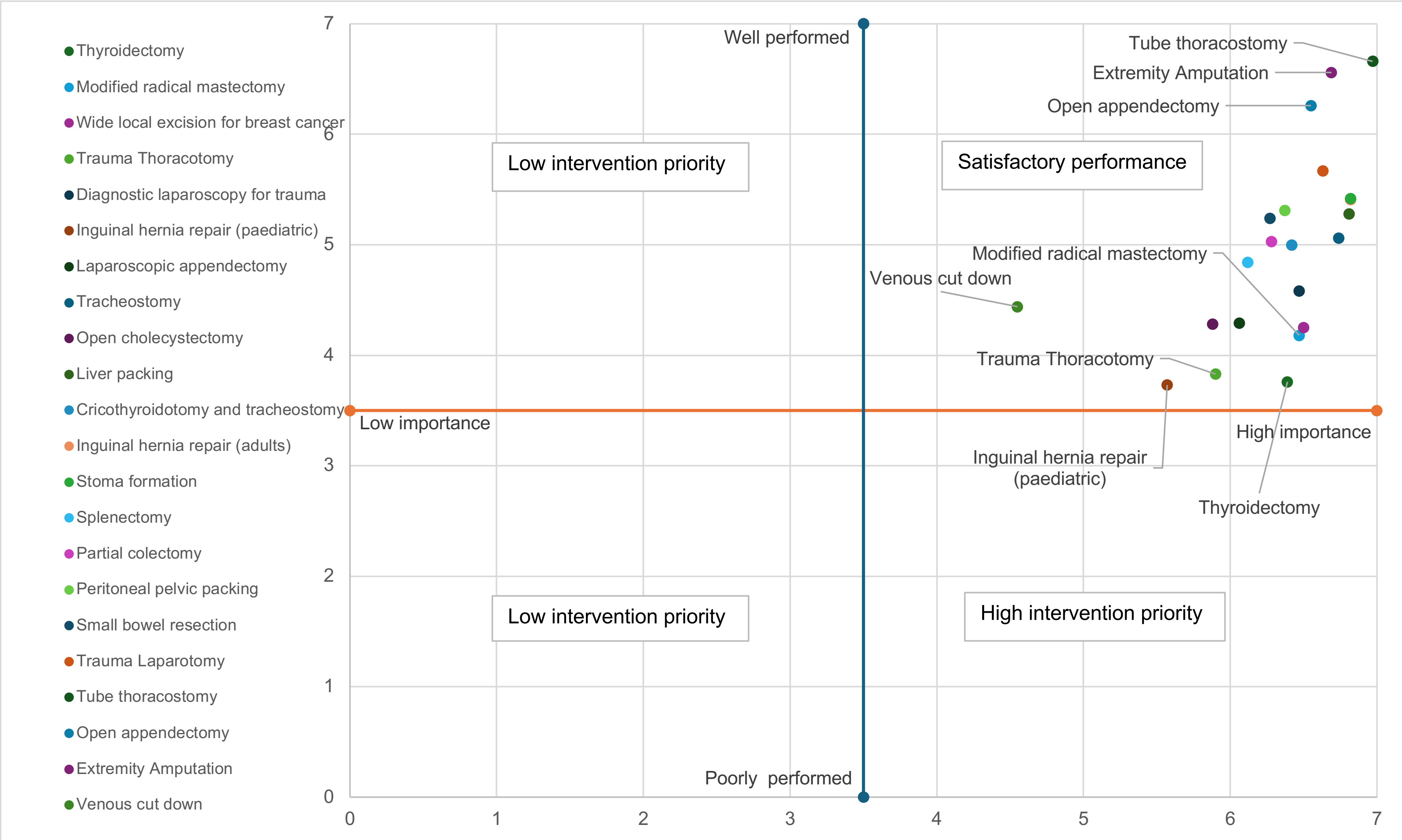
Figure 6-3. *Quadrant graph displaying mean ratings of importance versus mean ratings of performance of each skill by respondents. N=33.*



6.3.3 Training versus situation

Mean ratings for importance of improving training alone versus the importance of improving the work situation can be seen in Table 4 below. The skills are presented in order of size of difference between training and situation. The highest mean rating for improving training was laparoscopic appendicectomy at 5.96 (1.35), followed by laparoscopic cholecystectomy at 5.93 (1.31) and wide local excision for breast cancer at 5.92 (1.71). The lowest mean scores for training were found in venous cut down at 4.08 (1.82), extremity amputation at 4.43 (2.22) and inguinal hernia repair (paediatric) at 4.5 (2.22).

The highest mean ratings for importance of improving the work situation were stoma formation at 5.9 (1.42), laparoscopic appendicectomy at 5.75 (1.80) and laparoscopic cholecystectomy at 5.75 (1.70). The lowest mean ratings for situation were in tube thoracostomy at 4.17 (2.29), venous cut down at 4.33 (2.33) and tracheostomy at 4.33 (2.17).

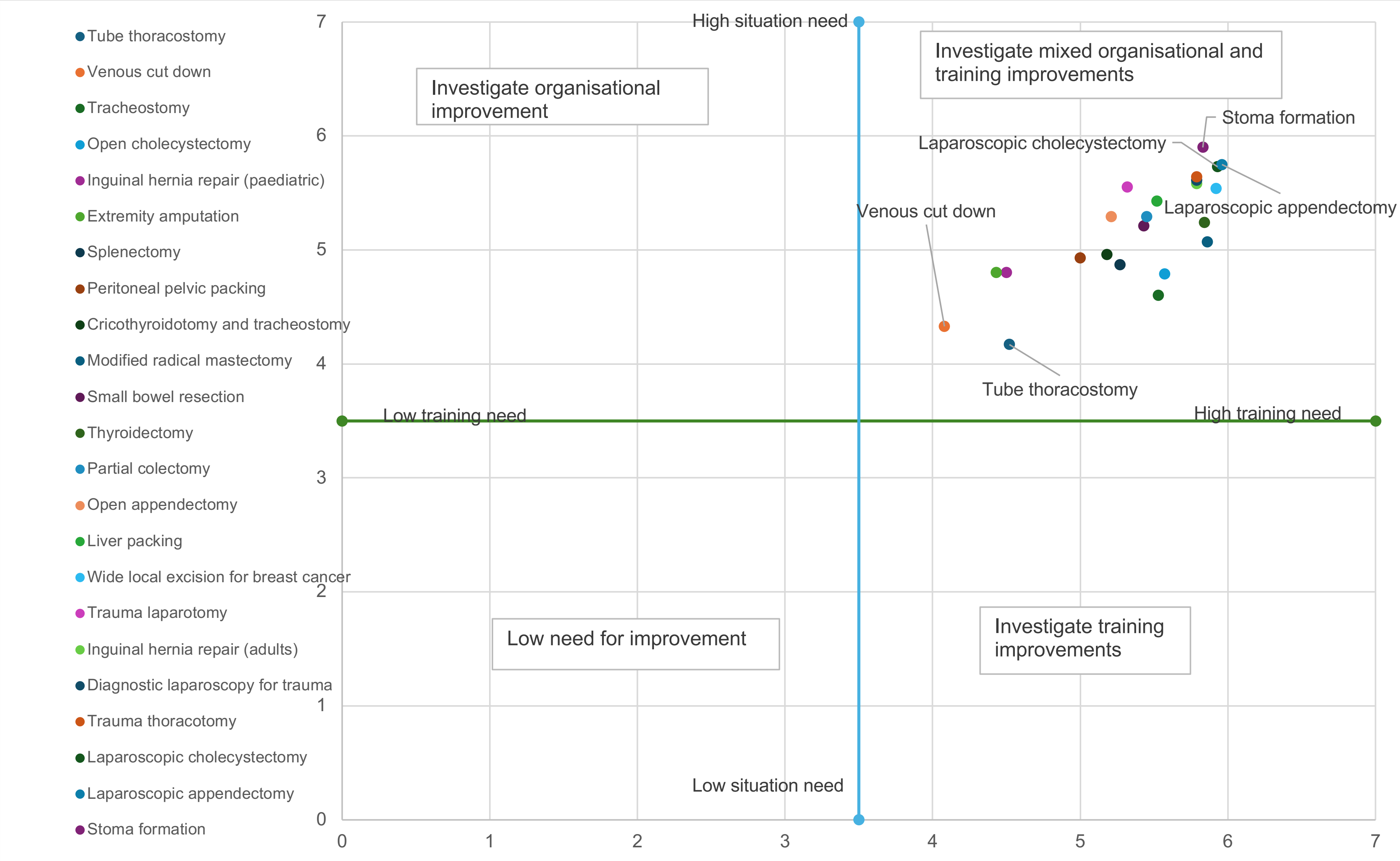
The most positive difference between means (favouring improving training) was found in tracheostomy at 0.93 (p 0.071), modified radical mastectomy at 0.79 (p 0.40) and open cholecystectomy at 0.78 ($p < 0.001$). The most negative difference between means (favouring improving the work situation) was in extremity amputation at -0.37 ($p < 0.001$), inguinal hernia repair (paediatric) at -0.3 (p 1.00) and venous cut down at -0.25 ($p < 0.001$).

The same data is displayed as a quadrant graph In Figure 4. All skills are shown in the 'mixed improvements' quadrant indicating improvements to both training and the work situation are desired by respondents.

Table 6-4. *Mean, standard deviation and significance of respondent ratings on the importance of improving training and improving the work situation for each skill. N = 39, * denotes a p value of <0.05.*

Skill	Mean training (SD)	Mean situation (SD)	Difference	Significance (Two-sided)
Tracheostomy	5.53 (1.60)	4.60 (2.17)	0.93	0.071
Modified radical mastectomy	5.86 (1.70)	5.07 (2.23)	0.79	.040*
Open cholecystectomy	5.57 (1.69)	4.79 (2.09)	0.78	<.001*
Thyroidectomy	5.84 (1.60)	5.24 (1.69)	0.6	.004*
Splenectomy	5.27 (1.86)	4.87 (1.99)	0.4	0.005
Wide local excision for breast cancer	5.92 (1.71)	5.54 (1.81)	0.38	<.001*
Tube thoracostomy	4.52 (2.18	4.17 (2.29)	0.35	<.001*
Cricothyroidotomy and tracheostomy	5.18 (1.77)	4.96 (1.90)	0.22	0.135
Small bowel resection	5.43 (1.74)	5.21 (1.84)	0.22	0.091
Laparoscopic appendectomy	5.96 (1.35)	5.75 (1.80)	0.21	<.001*
Inguinal hernia repair (adults)	5.79 (1.62)	5.58 (1.61)	0.21	<.001*
Laparoscopic cholecystectomy	5.93 (1.31)	5.73 (1.70)	0.2	<.001*
Diagnostic laparoscopy for trauma	5.79 (1.45)	5.61 (1.71)	0.18	.001*
Partial colectomy	5.45 (1.90)	5.29 (1.86)	0.16	0.053
Trauma thoracotomy	5.79 (1.45	5.64 (1.47)	0.15	0.005
Liver packing	5.52 (1.77)	5.43 (1.91)	0.09	0.285
Peritoneal pelvic packing	5.00 (2.02)	4.93 (2.15)	0.07	0.056
Stoma formation	5.83 (1.66)	5.90 (1.42)	-0.07	0.267
Open appendectomy	5.21 (1.89)	5.29 (1.82)	-0.08	<.001*
Trauma laparotomy	5.32 (2.01)	5.55 (2.01)	-0.23	<.001*
Venous cut down	4.08 (1.82)	4.33 (2.33)	-0.25	<.001*
Inguinal hernia repair (paediatric)	4.50 (2.22)	4.80 (1.87)	-0.3	1
Extremity amputation	4.43 (2.22)	4.80 (2.25)	-0.37	<.001*

Figure 6-4*. Figure 3. Quadrant graph displaying mean ratings of training improvements versus situation improvements of each skill by respondents. N=33.*



6.3.4 Annual frequency of skills

Table 5 below, reports how frequently each skill was performed by respondents per year, presented in decreasing order of frequency. The most frequently performed skills were trauma laparotomy at 50 (30-60) and extremity amputation also 50 (33-80), followed by tube thoracostomy at 40 (25-60). The least frequently performed skills were splenectomy at 4 (2-5) and venous cut down also 4 (0-19).

Table 6-5. *Median and interquartile range of annual frequency of each skill assessed. N – 32.*

Skill	Median	IQR
Trauma laparotomy	50	30-60
Extremity amputation	50	33-80
Tube thoracostomy	40	25 -60
Inguinal hernia repair (adults)	30	20-40
Stoma formation	25	10-50
Open appendectomy	25	10-84
Small bowel resection	20	2-40
Diagnostic laparoscopy for trauma	10	3-20
Cricothyroidotomy and tracheostomy	10	3-20
Liver packing	10	4-20
Partial colectomy	10	3-30
Laparoscopic cholecystectomy	10	5-20
Modified radical mastectomy	10	5-35
Trauma thoracotomy	5	2-10
Peritoneal pelvic packing	5	2-20
Laparoscopic appendectomy	5	2-15
Open cholecystectomy	5	2-10
Thyroidectomy	5	2-8
Inguinal hernia repair (paediatric)	5	3-13
Wide local excision for breast cancer	5	1-10
Tracheostomy	5	2-16
Splenectomy	4	2- 5
Venous cut down	4	0-19

6.3.5 Consultants

A sub-group analysis was performed comparing consultant response against registrars' responses. The mean ratings for importance and performance of each skill can be seen in Table 6 below, presented in order of decreasing size of difference between importance and performance. The highest mean rating for importance amongst consultants was for extremity amputation and tube thoracostomy both at 7 (0), these were followed by cricothyroidotomy and tracheostomy at 6.83 (0.41). The lowest mean ratings of importance were inguinal hernia repair (paediatric) at 4.33 (3.06), followed by venous cut down at 4.67 (2.73) and trauma thoracotomy (5.67 (1.21).

The highest mean ratings for performance amongst consultants were tube thoracostomy at 6.83 (0.41), extremity amputation at 6.67 (0.82) and open appendicectomy at 6.4 (0.89). The lowest mean ratings for performance were wide local excision for breast cancer at 2.00 (1.73), thyroidectomy at 3.17 (2.40) and trauma thoracotomy at 3.67 (1.37).

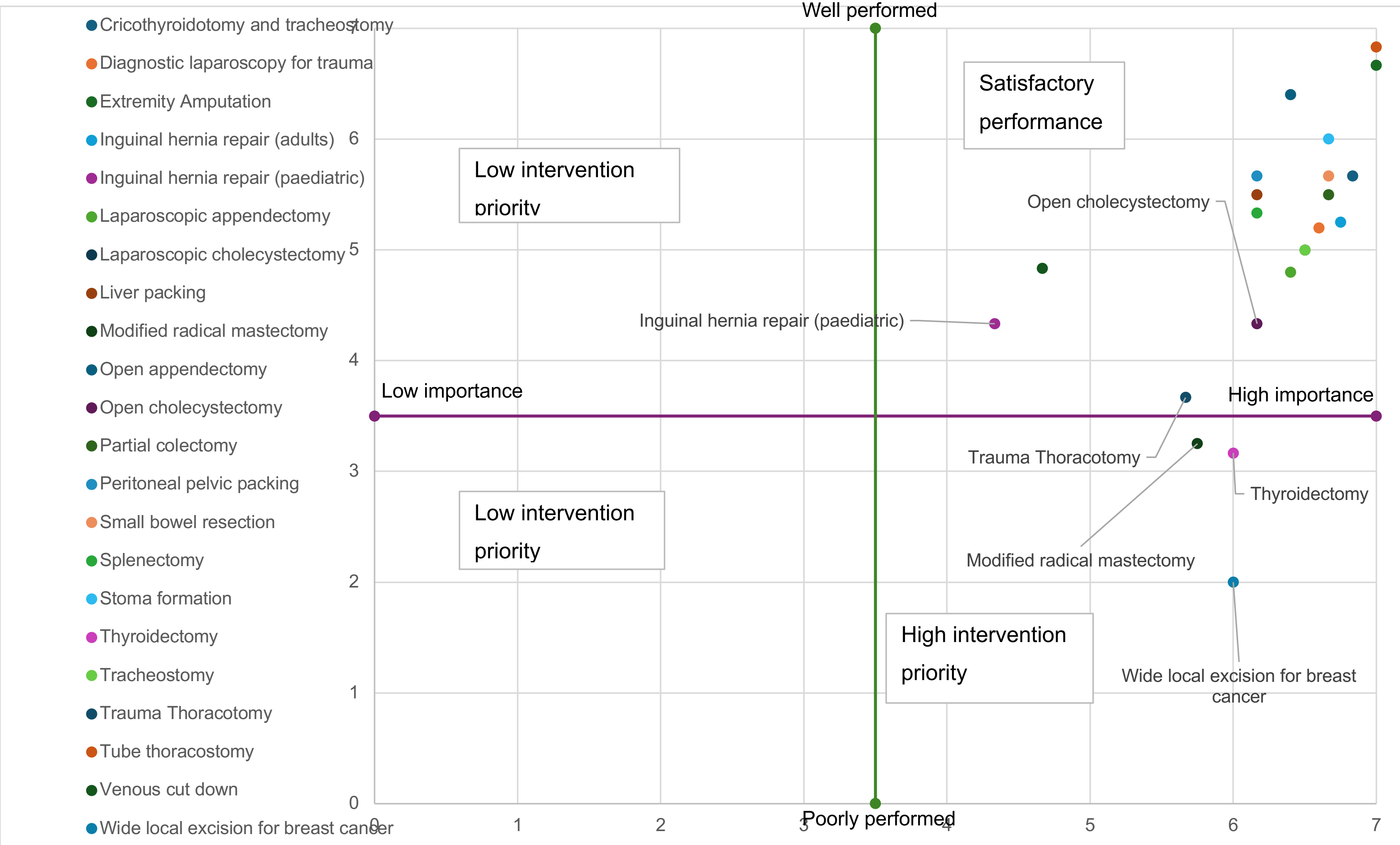
The greatest difference between importance and performance were found in wide local excision for breast cancer (4.00), followed by thyroidectomy (2.83) and modified radical mastectomy (2.50). Modified radical mastectomy was a statistically significant difference.

The same data are displayed in a quadrant graph in Figure 5. This graph highlights that wide local excision for breast cancer, modified radical mastectomy and thyroidectomy are all in the 'high intervention priority' according to the Hennessy-Hicks methodology. Trauma thoracotomy is also of concern.

Table 6-6. *Mean rating, standard deviation, and significance of consultant ratings for importance and performance. N=6, * denotes a p value of < 0.05.*

Skill	Mean importance (SD)	Mean performance (SD)	Difference	Significance (2-sided)
Wide local excision for breast cancer	6 (1.73)	2 (1.73)	4	0.057
Thyroidectomy	6 (1.41)	3.17 (2.40)	2.83	0.136
Modified radical mastectomy	5.75 (1.50)	3.25 (2.63)	2.5	0.03
Trauma Thoracotomy	5.67 (1.21)	3.67 (1.37)	2	0.025*
Open cholecystectomy	6.17 (1.60)	4.33 (2.50)	1.84	0.038*
Laparoscopic appendectomy	6.4 (1.34)	4.8 (1.30)	1.6	0.078
Laparoscopic cholecystectomy	6.5 (0.84)	5 (2.28)	1.5	0.165
Inguinal hernia repair (adults)	6.75 (0.50)	5.25 (0.96)	1.5	0.014*
Tracheostomy	6.5 (1.00)	5 (1.83)	1.5	0.103
Diagnostic laparoscopy for trauma	6.6 (0.89)	5.2 (1.79)	1.4	0.184
Partial colectomy	6.67 (0.82)	5.5 (1.77)	1.17	0.084
Cricothyroidotomy and tracheostomy	6.83 (0.41)	5.67 (1.21)	1.16	0.034*
Small bowel resection	6.67 (0.52)	5.67 (1.51)	1	0.076
Splenectomy	6.17 (0.98)	5.33 (2.25)	0.84	0.363
Trauma Laparotomy	6.17 (1.60)	5.5 (1.38)	0.67	0.543
Liver packing	6.17 (1.33)	5.5 (1.64)	0.67	0.102
Stoma formation	6.67 (0.52)	6 (0.89)	0.67	0.025*
Peritoneal pelvic packing	6.17 (1.60)	5.67 (1.75)	0.5	0.415
Extremity Amputation	7 (0)	6.67 (0.82)	0.33	0.363
Tube thoracostomy	7 (0)	6.83 (0.41)	0.17	0.363
Open appendectomy	6.4 (0.89)	6.4 (0.89)	0	.
Inguinal hernia repair (paediatric)	4.33 (3.06)	4.33 (2.52)	0	.
Venous cut down	4.67 (2.73)	4.83 (2.14)	-0.16	0.876

Figure 6-5. Quadrant graph displaying consultant's mean ratings of importance vs mean ratings of performance for each skil l. N = 8.



Mean ratings for importance of improving training alone versus the importance of improving the work situation can be seen in Table 7 below, presented in order of decreasing size of difference. The highest mean rating for improving situation amongst consultants was found in modified radical mastectomy at 6.75 (0.50), followed by wide local excision for breast cancer at 6.67 (0.58) and tracheostomy at 6.25 (0.96). The lowest mean ratings were open appendicectomy at 4.00 (1.73), tube thoracostomy at 4.00 (1.87) and small bowel resection at 4.17 (1.72).

The highest mean ratings for improving the work situation amongst consultants were wide local excision for breast cancer at 6.67 (0.58), laparoscopic cholecystectomy 6.50 (0.84) and laparoscopic appendicectomy at 6.40 (0.89). The lowest mean ratings were tube thoracostomy at 3.80 (2.39), small bowel resection at 4.83 (2.40) and extremity amputation also at 4.83 (2.40).

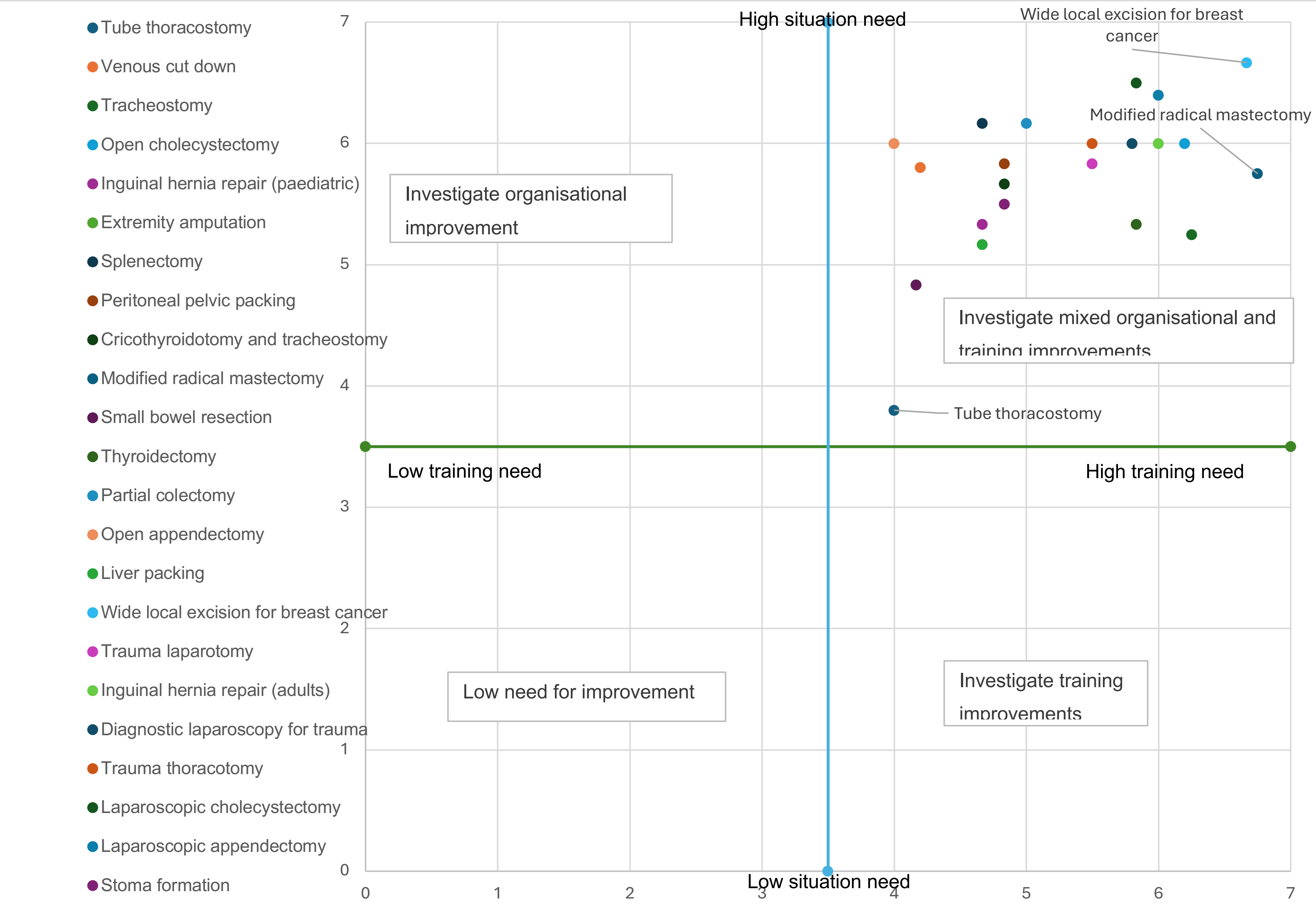
The most positive mean difference (favouring improving training) was highest for tracheostomy and modified radical mastectomy (both 1.00) followed by thyroidectomy (0.50). The most negative mean difference (favouring improving the work situation) was for open appendicectomy (-2.00), venous cut down (-1.60) and splenectomy (-1.5).

These data are also displayed in a quadrant graph in Figure 6, highlighting that all skills are in the high need for mixed training and work situation improvements quadrant.

Table 6-7. *Mean, standard deviation and significance of respondent ratings on the importance of improving training and improving the work situation for each skill. N = 6, * denotes a p value of <0.05.*

Skill	Mean training (SD)	Mean situation (SD)	Difference	Significance (2-tailed)
Modified radical mastectomy	6.75 (0.50)	5.75 (1.89)	1.00	0.391
Tracheostomy	6.25 (0.96)	5.25	1.00	0.391
Thyroidectomy	5.83 (1.33)	5.33 (1.51)	0.50	0.58
Tube thoracostomy	4.00 (1.87)	3.80 (2.39	0.20	0.854
Open cholecystectomy	6.2 (1.30)	6.00 (1.23)	0.20	0.374
Inguinal hernia repair (adults)	6.00 (1.41)	6.00 (1.41)	0	-
Wide local excision for breast cancer	6.67 (0.58)	6.67 (0.58)	0	-
Diagnostic laparoscopy for trauma	5.8 (1.30)	6.00 (1.23)	-0.20	0.704
Trauma Lap	5.5 (2.35)	5.83 (2.40)	-0.33	0.465
Laparoscopic appendectomy	6.00 (1.41)	6.4 (0.89)	-0.40	0.178
Trauma Thoracotomy	5.5 (1.38)	6.00 (1.67)	-0.50	0.542
Liver packing	4.67 (2.07)	5.17 (2.23)	-0.50	0.768
Extremity Amputation	4.17 (2.48)	4.83 (2.40)	-0.66	0.618
Small bowel resection	4.17 (1.72)	4.83 (2.40)	-0.66	0.625
Inguinal hernia repair (paediatric)	4.67 (3.22)	5.33 (2.08)	-0.66	0.84
Stoma formation	4.83 (2.14)	5.5 (1.38)	-0.67	0.611
Laparoscopic cholecystectomy	5.83 (1.33)	6.5 (0.84)	-0.67	0.102
Cricothyroidotomy and tracheostomy	4.83 (2.14)	5.67 (1.21)	-0.84	0.534
Peritoneal pelvic packing	4.83 (2.23)	5.83 (1.17)	-1.00	0.456
Partial colectomy	5.00 (2.28)	6.17 (0.98)	-1.17	0.341
Splenectomy	4.67 (1.97)	6.17 (1.17)	-1.50	0.178
Venous cut down	4.20 (0.84)	5.80 (2.17)	-1.60	0.178
Open appendectomy	4.00 (1.73)	6.00 (1.00)	-2.00	0.129

Figure 6-6. *Quadrant graph displaying consultant mean ratings for improving training vs improving work situation. N = 8.*



6.3.6 Registrars

The mean ratings for performance importance and performance of each skill can be seen in Table 8 below, sorted in descending size of difference between importance and performance. The highest mean rating for importance amongst registrars were liver packing at 6.96 (0.20) and tube thoracostomy also at 6.96 (0.20) followed by trauma laparotomy at 6.93 (0.39). The lowest mean rating of importance was venous cut down at 4.86 (2.29), followed by open cholecystectomy at 5.81 (1.74) and inguinal hernia (paediatric) at 5.96 (1.49).

The highest mean rating for performance by registrars was tube thoracostomy at 6.62 (1.20), followed by extremity amputation at 6.64 (0.65) and open appendicectomy at 6.23 (1.42). The lowest mean rating was inguinal hernia repair (paediatric) at 3.27 (1.56) followed by thyroidectomy at 3.82 (1.47) at and trauma thoracotomy at 3.88 (1.51).

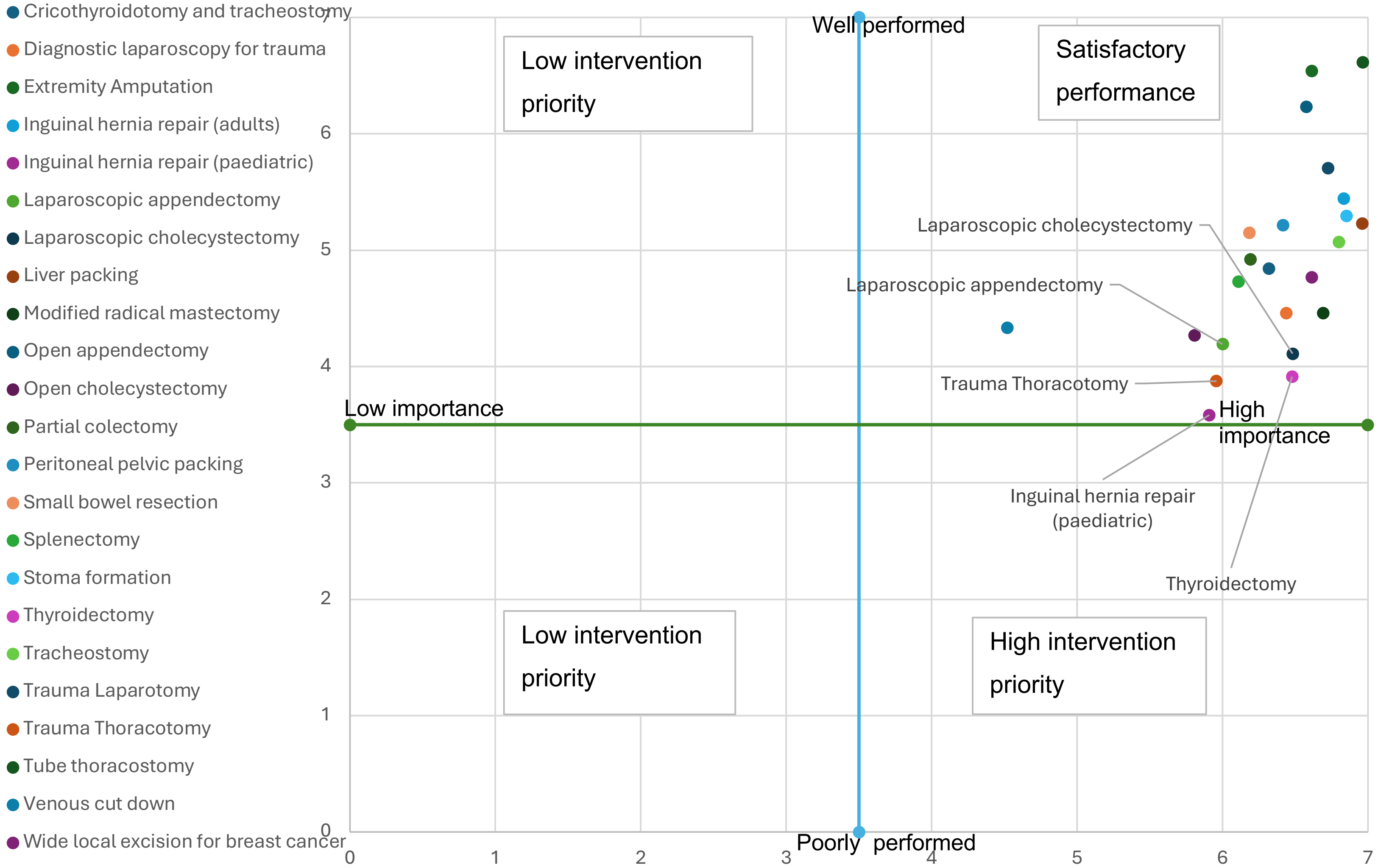
The highest mean difference was found in inguinal hernia repair (paediatric), (2.64) followed by thyroidectomy (2.63) and laparoscopic cholecystectomy (2.37) – all three of these were statistically significant. The lowest mean difference was extremity amputation 0.08), followed by tube thoracostomy (0.34), and open appendicectomy (0.35).

These data are displayed in a quadrant graph in Figure 7 below. This graph shows that all skills are in the 'satisfactory performance' quadrant, however inguinal hernia (paediatric), thyroidectomy and trauma thoracotomy are of concern.

Table 6-8. *Mean rating, standard deviation, and significance of registrar ratings for importance and performance. N=27, * denotes a p value of < 0.05.*

Skill	Mean importance (SD)	Mean performance (SD)	Difference	Significance (2-tailed)
Inguinal hernia repair (paediatric)	5.91 (1.30)	3.27 (1.56)	2.64	0.004*
Thyroidectomy	6.45 (0.91)	3.82 (1.47)	2.63	<.001*
Laparoscopic cholecystectomy	6.48 (1.31)	4.11 (1.68)	2.37	<.001*
Modified radical mastectomy	6.69 (0.63)	4.46 (2.33)	2.23	0.002*
Trauma Thoracotomy	5.96 (1.49)	3.88 (1.51)	2.08	<.001*
Diagnostic laparoscopy for trauma	6.44 (0.96)	4.44 (1.92)	2.00	<.001*
Wide local excision for breast cancer	6.62 (0.77)	4.77 (2.46)	1.85	0.006*
Laparoscopic appendectomy	6.00 (1.50)	4.19 (1.83)	1.81	0.002*
Liver packing	6.96 (0.20)	5.23 (1.73)	1.73	<.001*
Tracheostomy	6.79 (0.80)	5.07 (1.98)	1.72	0.005*
Stoma formation	6.85 (0.46)	5.3 (1.94)	1.55	<.001*
Open cholecystectomy	5.81 (1.74)	4.27 (1.89)	1.54	<.001*
Cricothyroidotomy and tracheostomy	6.32 (1.11)	4.84 (2.04)	1.48	<.001*
Inguinal hernia repair (adults)	6.83 (0.51)	5.44 (1.20)	1.39	<.001*
Splenectomy	6.08 (1.13)	4.73 (1.71)	1.35	0.002*
Partial colectomy	6.19 (1.30)	4.92 (1.92)	1.27	0.005*
Trauma Laparotomy	6.93 (0.39)	5.7 (1.07)	1.23	<.001*
Peritoneal pelvic packing	6.39 (1.16)	5.22 (1.83)	1.17	0.023*
Small bowel resection	6.19 (1.47)	5.15 (2.30)	1.04	0.011*
Venous cut down	4.86 (2.29)	4.33 (1.98)	0.53	0.069
Open appendectomy	6.58 (1.27)	6.23 (1.42)	0.35	0.095
Tube thoracostomy	6.96 (0.20)	6.62 (1.20)	0.34	0.153
Extremity Amputation	6.62 (1.06)	6.54 (0.65)	0.08	0.678

Figure 6-7. Quadrant graph displaying registrars' mean ratings of importance versus performance. N = 27.



The registrars' mean ratings of importance of improving training alone versus the importance of improving the work situation can be seen in Table 10 below. The highest mean rating for improving training alone was in stoma formation at 6.30 (1.02) followed by small bowel resection at 5.96 (1.30) and laparoscopic cholecystectomy 5.96 (1.33). The lowest mean rating was venous cut down at 4.05 (2.01), inguinal hernia repair (paediatric) at 4.33 (1.99) and extremity amputation at 4.50 (2.21).

The highest mean rating for improving the work situation amongst registrars was stoma formation at 6.00 (1.02), laparoscopic appendicectomy at 5.61 (5.55) and trauma thoracotomy at 5.55 (1.44). The lowest mean rating was venous cut down at 3.95 (2.27), tube thoracostomy ay 4.25 (2.31) and tracheostomy 4.36 (2.34).

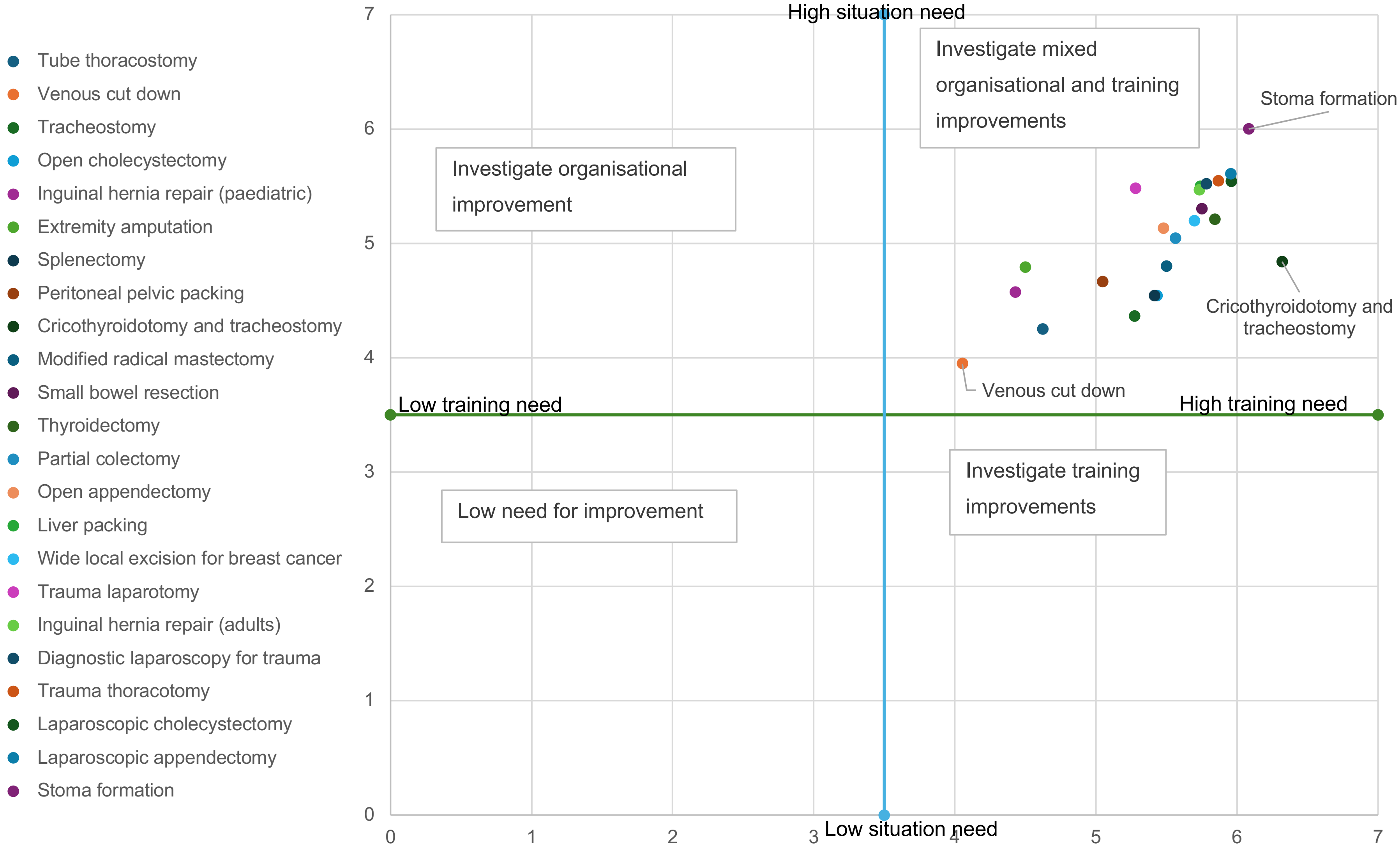
The most positive mean difference (favouring training improvements) was tracheostomy (0.91) followed by splenectomy (0.88) and open cholecystectomy (0.73). The most negative mean difference (favouring improving the work situation) was extremity amputation (-0.29), trauma laparotomy (-0.20) and inguinal hernia repair (paediatric) (-0.14).

These data are displayed in a quadrant graph in Figure 8 below. This highlights that mixed training and organisational improvements were desired for all skills.

Table 6-9. *Mean rating, standard deviation, and significance of registrar ratings for the importance of improving training alone and improving the work situation. N=27, * denotes a p value of < 0.05.*

Skill	Mean training (SD)	Mean situation (SD)	Difference	Significance (2-tailed)
Tracheostomy	5.27 (1.74)	4.36 (2.34)	0.91	0.176
Splenectomy	5.42 (1.84)	4.54 (2.04)	0.88	0.009*
Open cholecystectomy	5.43 (1.75)	4.70 (2.08)	0.73	0.067
Partial colectomy	5.77 (1.57)	5.05 (1.99)	0.72	0.05
Modified radical mastectomy	5.50 (1.90)	4.80 (2.25)	0.70	0.271
Small bowel resection	5.96 (1.30)	5.30 (1.72)	0.66	0.057
Thyroidectomy	5.84 (1.71)	5.21 (1.78)	0.63	0.069
Cricothyroidotomy and tracheostomy	5.27 (1.70)	4.77 (2.02)	0.50	0.224
Wide local excision for breast cancer	5.70 (1.89)	5.20 (1.93)	0.50	0.177
Laparoscopic cholecystectomy	5.96 (1.33)	5.54 (1.82)	0.42	0.125
Tube thoracostomy	4.63 (2.26)	4.25 (2.31)	0.38	0.351
Peritoneal pelvic packing	5.05 (2.01)	4.67 (2.31)	0.38	0.412
Trauma Thoracotomy	5.91 (1.51)	5.55 (1.44)	0.36	0.201
Liver packing	5.86 (1.58)	5.50 (1.87)	0.36	0.329
Open appendectomy	5.48 (1.86)	5.13 (1.94)	0.35	0.162
Laparoscopic appendectomy	5.96 (1.36)	5.61 (1.92)	0.35	0.201
Stoma formation	6.30 (1.02)	6.00 (1.45)	0.30	0.284
Diagnostic laparoscopy for trauma	5.78 (1.51)	5.52 (1.81)	0.26	0.426
Inguinal hernia repair (adults)	5.73 (1.71)	5.47 (1.69)	0.26	0.217
Venous cut down	4.05 (2.01)	3.95 (2.27)	0.10	0.725
Inguinal hernia repair (paediatric)	4.43 (1.99)	4.57 (1.90)	-0.14	0.859
Trauma Laparotomy	5.28 (2.07)	5.48 (1.96)	-0.20	0.54
Extremity Amputation	4.50 (2.21)	4.79 (2.24)	-0.29	0.381

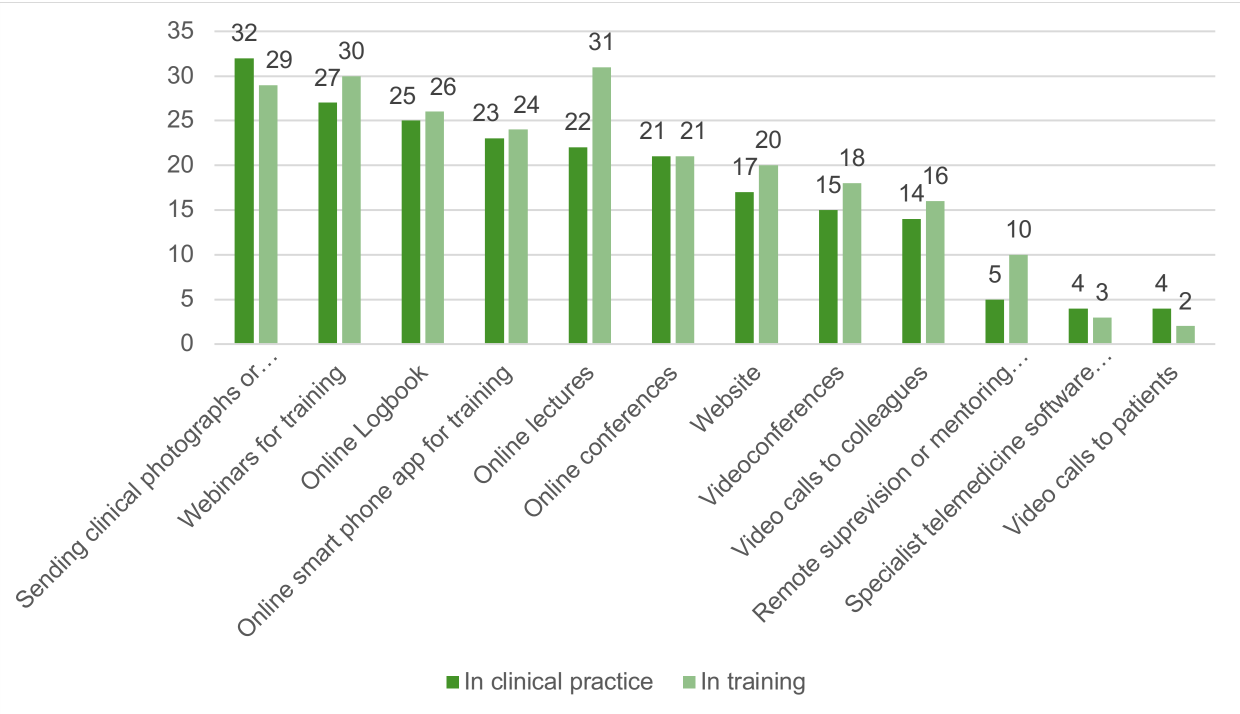
Figure 6-8. Quadrant graph displaying registrars' mean ratings of importance of improving training alone versus improving the work situation. N=27.



6.3.7 Use of technology

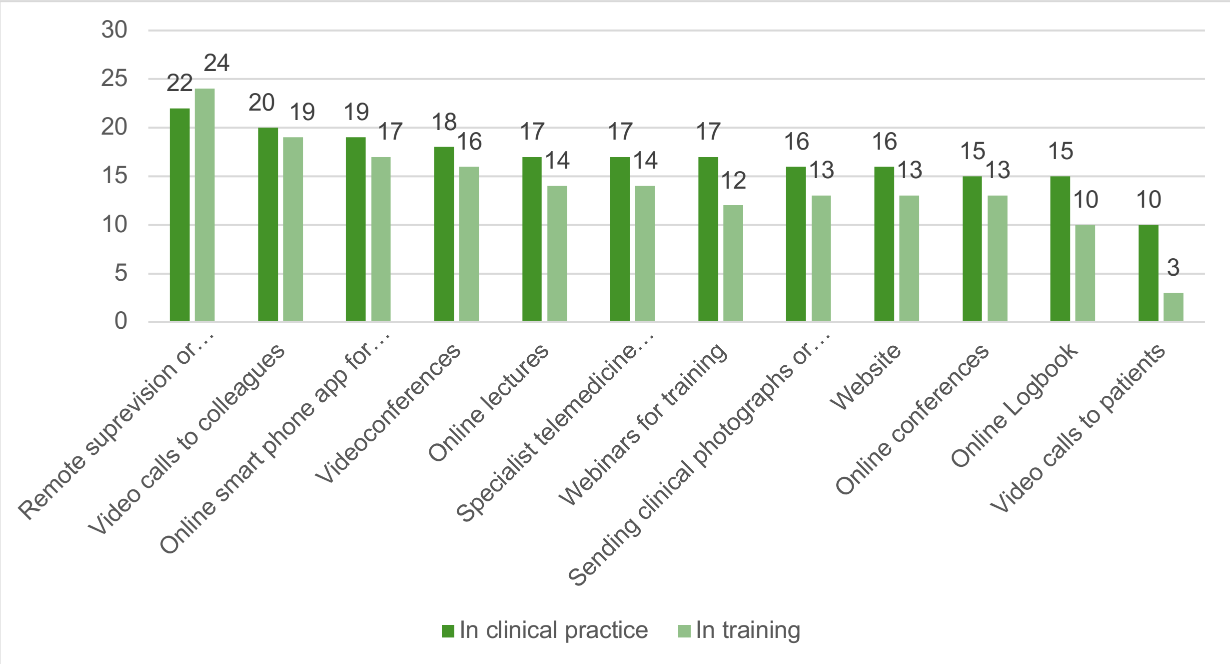
The most frequently used technology in clinical practice was 'sending clinical photographs or videos' by 54.24% (32) of respondents, followed by 'webinars' by 45.76% (27) and an 'online logbook' by 43.27% (25) – see Figure 9. The least frequently used technology was 'specialist telemedicine software' and 'video calls to patients', both used by 6.78% (4) of respondents. The most frequently used technology in training was 'online lectures' by 55.54% (31), followed by 'webinars' by 50.85% (3) and 'sending clinical photographs or videos' by 49.15% (29). The least frequently used was 'video calls to patients' by 3.39% (2) of respondents. One respondent (1.69%) also reported using a laparoscopic trainer at work in the free text comment box.

Figure 6-9. *Use of technology in clinical practice and training, N=37.*



When asked what technology respondents would like to see in use *in clinical practice* in future, the most frequent response was 'remote supervision or mentoring of procedures' by 37.29% (22), followed by 'video calls to colleagues' by 33.90% (20) and an 'online smartphone app for training' by 32.20% (19) – see Figure 10. The least frequent response was 'video calls to patients' by 16.95% (10). The most frequent response for future use of technology *in training* was ‘remote supervision or mentoring of procedures’ by 40.68%% (24), followed by ‘video calls to colleagues’ by 32.20% (19) and an ‘online smartphone app for training’ by 28.81% (17). The least frequent response was ‘video calls to patients’ by 5.08% (3). The two comments in

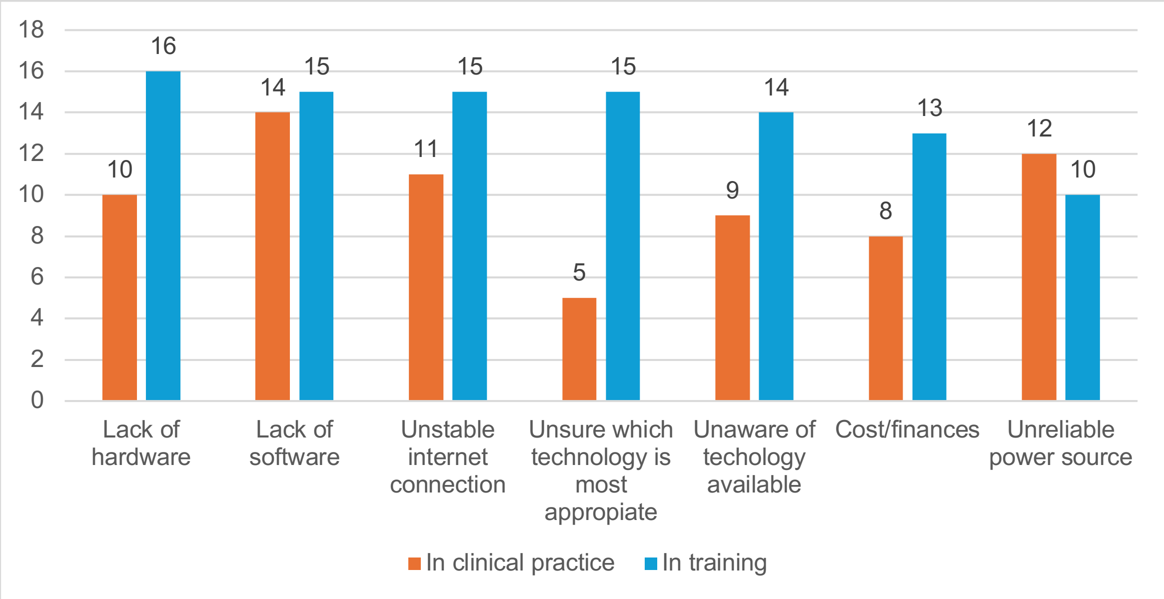
Figure 6-10. *Desire for future use of technology in clinical practice and in training, N=37.*



the free text box were ‘EMR improvements’ and ‘remote supervision’.

When asked about barriers to using technology *in clinical practice*, the most frequent answer was ‘lack of software’ by 23.72% (14), followed by an ‘unreliable power source’ by 20.33% (12) and an ‘unstable internet connection’ by 18.64% (11) – see Figure 11. The least frequently reported barrier in clinical practice was ‘unsure which technology was most appropriate’ by 8.47% (5). The most frequent response for barriers to use of technology *in training* was ‘lack of hardware’ by 27.11% (16), followed by ‘lack of software’, ‘unstable internet connection’ and unsure which ‘technology is most appropriate’, all by 25.42% (15). The least frequent barrier in training was an ‘unreliable power source’ by 16.95% (10).

Figure 6-11. *Barriers to the use of technology in clinical practice and in training, N=37.*



6.3.8 Thematic analysis

The open text answers were analysed using a framework thematic analysis as outlined in Chapter 4. Quotes from the free text answers have been used to add detail to the sub-themes with the anonymised responder identifier after the quotation.

Table 12 shows the results of this analysis to the question "Please specify the areas of your job in which you would like to receive further training." Five main themes were identified: 'technical skills', 'clinical development', 'no need to expand the role of technology', 'organisational & cultural improvements' and 'non-technical skills'.

Three themes within 'technical skills' were identified; 'minimal access surgery training' (*"Laparoscopic training — I have 3 years of surgical training and very minimal exposure to laparoscopic training which is a HUGE downfall in training"* SA48), 'endoscopy training' ("colonoscopy" SA01) and 'basic surgical skills training' (*"Training in routine procedures required for a standard surgical practice"* SA08).

Four sub-themes were identified within 'clinical development'; 'sub-specialist practice' (*"More exposure to "subspecialist" procedures"* SA39), 'care of the unwell surgical patient' (*"Practical day to day management of surgical workplace/patient"* SA08) 'broad based emergency surgical training' (*"Emergency thoracic, neuro and ENT surgery and basic paediatric surgery"* SA14) and 'adopting new technology' (*"Trained in the use of point-of-care ultrasound"* SA11).

There were two sub-themes identified in the theme of ‘no role for the expansion of technology in training’; ‘too late for further training’ (*“It is probably too late in my career to receive further training”* SA11) and ‘satisfaction with current training’ (*“I do not do the surgery for which I did not receive training, so no more problem.”* SA13).

Three themes were identified in ‘organisational: & cultural improvements’, ‘training hubs’ (*“special facilities that allow junior registrars to start doing operations with supervision to gain confidence and skills”* SA07), ‘simulation training’ (*“more simulation training”* SA34) and ‘surgical coaching’ (*“constructive criticism of operative technique”* SA12).

Within ‘non-technical skills’ four sub-themes were identified; ‘Human factors training’ (*“workplace dynamics/patient interaction/medicolegal implications of surgical practice”* SA08), ‘business management’ (*“public finance and management skill – these are expected of Heads of Departments, and we are not trained for this.”* SA50), ‘teaching skills’ (*“teaching students/interns”* SA39) and ‘research skills’ (“*conducting research*” SA44).

Table 6-10. *Framework analysis of answers to the question "Please specify the areas of your job which you would like to receive further training", N=59.*

Themes	Sub-themes
Technical skills	Minimal access surgery (MIS) training *"More training in laparoscopic procedures, especially laparoscopic treatment of acute cholecystitis which is not practiced in our training"* (SA32) *"Laparoscopic training — I have 3 years of surgical training and very minimal exposure to laparoscopic training which is a HUGE downfall in training"* (SA48)
	Endoscopy training *"Colonoscopy"* (SA01)
	Basic surgical skills training *"Training in routine procedures required for a standard surgical practice"* (SA08)
Clinical development	Sub-specialist practice *"More exposure to "subspecialist" procedures" (*SA39)
	Care of the unwell surgical patient *"Practical day to day management of surgical workplace/patient"* (SA08)
	Broad based emergency surgical training *"Emergency thoracic, neuro and ENT surgery and basic paediatric surgery" (*SA14)
	Adopting new technology *"Trained in the use of point-of-care ultrasound"* (SA11)
No need to expand the role of technology	Too late for further training *"It is probably too late in my career to receive further training"* (SA11)
	Satisfaction with current training *"I do not do the surgery for which I did not receive training, so no more problem."* (SA13)
Organisational & cultural improvements	Training hubs *"Special facilities that allow junior registrars to start doing operations with supervision to gain confidence and skills"* (SA07)
	Simulation training "*More sim training"* (SA34)
	Surgical coaching *"Constructive criticism of operative technique"* (SA12)
Non-technical skills	Human factors training *"Workplace dynamics/patient interaction/medicolegal implications of surgical practice" (*SA08)
	Business management *"Public finance and management skill – these are expected of Heads of Departments and we are not trained for this."* (SA50)
	Teaching skills *"Teaching students/interns"* (SA39)
	Research skills *"Conducting research"* (SA44)

Framework analysis of answers to the question: "*How could technology best be used to improve training in your place of work*?" are displayed in Table 13. The same sub-themes were identified using the same framework as applied in Table 3 above, however the sub-themes coalesced into different themes. Note, as answering this question was not compulsory, there were 11 responses.

Three major themes were identified: 'technology enhanced training', 'practical concerns' and 'improved data management'. Within 'technology enhanced training' three sub-themes were identified; 'simulation training' (*"Even if an application on computer or smart phone that has simulation can work"* SA01), 'video library' (*"Operative video banks"* SA03) and 'minimal access surgery training' ("Simulation or advanced laparoscopic trainers at the hospital." SA03).

There were two sub-themes within 'practical concerns'; 'concerns with bureaucracy' (*"needs to be interactive and integrated into the daily routine, not a separate enforced "checkbox" item. It should facilitate/enhance learning"* SA02) and 'Concerns with funding & infrastructure' (*"Increased funding for electronics and internet"* SA08).

Three themes were identified within 'improved data management'; 'Electronic patient records' (*"Computer database for patients records in all hospitals"* SA04), 'standardisation' ("*Local guidelines and protocols on a surgical app"* SA03) and 'research skills' (*"Make it helpful for research purposes"* SA10).

Table 6-11. *Framework analysis of answers to the question: "How could technology best be used to improve training in your place of work?" N=11.*

Themes	Sub-themes
Technology enhanced training	Simulation training *"Even if an application on computer or smart phone that has simulation can work"* SA01
	Video library *"Operative video banks"* SA03
	Minimal access surgery training "*Simulation or advanced laparoscopic trainers at the hospital."* SA03
Practical concerns	Concerns with bureaucracy *"Needs to be interactive and integrated into the daily routine, not a separate enforced "checkbox" item. It should facilitate/enhance learning"* SA02
	Concerns with funding & infrastructure *"Increased funding for electronics and internet"* SA08
Improve data management	Electronic patient records *"Computer database for patients records in all hospitals"* SA04
	Standardisation "*Local guidelines and protocols on a surgical app"* SA03
	Research skills *"Make it helpful for research purposes"* SA10

Framework analysis of the 44 responses to the question: "*Do you have any other suggestions on how to improve surgical training in South Africa*?" are displayed in Table 14 below. The same framework was applied as in Tables 12 and 13 above, however, a number of different major themes were identified.

Six major themes were identified: 'technical skills', 'faith in the current system', 'advanced clinical practice', 'more individualised surgical training', 'broad surgical experience' and 'organisational improvement's.

Within 'technical skills', 4 sub-themes were identified; 'minimal access surgery training' *("More focus on doing the gold standards for patients (laparoscopic and robotic) and taking the time and patience to teach this."* SA41), 'teaching skills' (*"Better teachers all around. Many people are in consultant posts for a long time and don't have an interest in teaching. They do however make you put your name down as lead surgeon for logbook purposes but very rarely allow you to actually do the procedure."* SA41), 'endoscopy training' (*"Dedicated endoscopy training with minimum numbers to be completed."* SA35), and 'video library' (*"YouTube channel with operations performed locally."* SA09).

There was one theme within ‘faith in the current system’ – ‘satisfaction with current training’ (*“Training is still very good”* SA04).

Two sub-themes were identified within ‘advanced clinical practice’: ‘fellowships’ (*“Access to funding to allow registrars to get the training elsewhere is their institute falls short”* SA41) and ‘sub-specialist practice’ (“*It is imperative that all trainees rotate through sub-specialty units to obtain the basic skills required as a general surgeon to perform common operations e.g. A proper mastectomy, adequate axillary dissection, a safe thyroid lobectomy.”* SA10).

Within ‘individualised surgical training’, three sub-themes were identified: ‘surgical coaching’ (“*Registrars should report their weak points to professors during their last year as registrar, so that theatre assistance shifts could be done. I for instance never had the privilege to have done a mastectomy under supervision.”* SA28), ‘different learning needs for international trainees’ (*“International trainee should get more surgical exposures and learn how to operate without hesitation and self-doubt.”* SA07) and ‘Target training to local patient need’ (*“Firstly, to identify the needs of South African patients and adjust training to meet these needs.”* SA08).

Three sub-themes were identified within ‘broad based surgical experience’; ‘access to training in private facilities’ (*“I would suggest making registrars rotate through private hospitals with private consultants compulsory to get exposure to first world level of care, and exposure to procedures not offered or performed in the state sector.”* SA29), ‘access to training in rural facilities’ (“*General surgeons in rural hospitals have to perform all forms of emergency and acute care surgery, it differs from hospital to hospital, short rotations in above specialities with a longer rotation in paediatric surgery would be sensible. Rural Hospitals offer a lot of learning opportunities for the development of skills needed as a general surgeon.” SA13) and ‘Broad emergency surgical training’ (“The volume of “bread & butter” procedures that every surgeon should be competent at are done in regional hospitals, not in tertiary hospitals.” SA37).*

‘Organisational improvements’ comprised of 6 sub-themes: ‘concerns with funding and infrastructure’ (*“Need to ensure nurses and ancillary staff are employed to reduce the chances of bed-closures and related limitations to clinical exposure.” SA43),* ‘improved administrative support’ *(“There needs to be better administrative support to allow registrars to focus on skills and knowledge acquisition, e.g. oncologist nurses, booking list staff.” SA19),* ‘improved academic processes’ *(“More* *stringent requirements for number of surgeries performed prior to being allowed to write final exams" SA32)*, 'Uncertain training environment' *("We also need to adjust training programs in line with the current international/climate. What worked in the past may not work now in a post -Covid/ unstable economic/political climate. A lot more variables need to be taken into consideration." SA08)*, 'standardisation' (*"Centralised surgical guidelines app on management of conditions."* SA09), and 'more frequent conferences' ("Frequent physical conferences" SA03).

Two of the sub-themes focussed on the 'wider surgical team'; ''multidisciplinary training' ("*better nursing training to allow after hours use of [laparoscopic] equipment"* SA02) and 'more anaesthesia providers' (*"Must ensure sufficient anaesthesia providers (consider starting Nurse Anaesthesia/PA) to allow more access to theatres in public so operative numbers can be higher and emergencies access OT earlier with resultant less complication.")*

<u>Table 6-12.</u> Framework analysis of answers to the question: "Do you have any other suggestions on how to improve surgical training in South Africa?". N=44.

Themes	Sub-themes
Technical skills	Minimal access surgery training "*More focus on doing the gold standards for patients (laparoscopic and robotic) and taking the time and patience to teach this."* SA41
	Teaching skills *"Better teachers all around. Many people are in consultant posts for a long time and don't have an interest in teaching. They do however make you put your name down as lead surgeon for logbook purposes but very rarely allow you to actually do the procedure."* SA41
	Endoscopy training *"Dedicated endoscopy training with minimum numbers to be completed."* SA35
	Video library *"YouTube channel with operations performed locally."* SA09
Faith in current system	Satisfaction with training *"Training is still very good"* SA04
Advanced clinical practice	Fellowships *"Access to funding to allow registrars to get the training elsewhere if their institute falls short"* SA41
	Sub-specialist practice "*It is imperative that all trainees rotate through sub-specialty units to obtain the basic skills required as a general surgeon to perform common operations e.g. A proper mastectomy, adequate axillary dissection, a safe thyroid lobectomy."* SA10
More individualised surgical training	Surgical coaching *"Registrars should report their weak points to professors during their last year as registrar, so that theatre assistance shifts could be done. I for instance never had the privilege to have done a mastectomy under supervision."* SA28
	Different learning needs for international trainees *"International trainee should get more surgical exposures and learn how to operate without hesitation and self-doubt."* SA07
	Target training to local patient need *"Firstly, to identify the needs of South African patients and adjust training to meet these needs."* SA08
Broad surgical experience	Access to training in private facilities *"I would suggest making registrars rotate through private hospitals with private consultants compulsory to get exposure to first world level of care, and exposure to procedures not offered or performed in the state sector."* SA29
	Access to training in rural facilities "*General surgeons in rural hospitals have to perform all forms of emergency and acute care surgery, it differs from hospital to hospital, short rotations in above specialities with a longer rotation in pediatric surgery would be sensible. Rural Hospitals offer a lot of learning opportunities for the development of skills needed as a general surgeon." SA13*
	Broad based emergency surgical training *"The volume of "bread & butter" procedures that every surgeon should be competent at are done in regional hospitals, not in tertiary hospitals."* SA37
Organisational improvements	Concerns with funding & infrastructure *"Need to ensure nurses and ancillary staff are employed to reduce the chances of bed-closures and related limitations to clinical exposure." SA43*
	Improved administrative support "*There needs to be better administrative support to allow registrars to focus on skills and knowledge acquisition, e.g. oncologist nurses, booking list staff."* SA19

	Improved academic processes *"More stringent requirements for number of surgeries performed prior to being allowed to write final exams"* SA32
	Uncertain training environment *"We also need to adjust training programs in line with the current international/climate. What worked in the past may not work now in a post - Covid/ unstable economic/political climate. A lot more variables need to be taken into consideration." SA08*
	Standardisation *"Centralised surgical guidelines app on management of conditions."* SA09
	More frequent conferences "Frequent physical conferences" SA03
Wider surgical team	Multidisciplinary training "*better nursing training to allow after hours use of [laparoscopic] equipment*" SA02
	More anaesthesia providers *"Must ensure sufficient anaesthesia providers (consider starting Nurse Anaesthesia/PA) to allow more access to theatres in public so operative numbers can be higher and emergencies access OT earlier with resultant less complication."*

Consultants were asked: "what skills or clinical situations were you not adequately prepared for in your surgical training?", the same framework analysis approach as explained above was used and the results are displayed in Table 15, below. Five major themes were identified: 'desire for coaching', 'technical skills', 'non-technical skills', 'broader clinical experience' and 'satisfaction with current training'.

'Desire for surgical coaching' (*"Was trained in a circuit of hospitals with very high surgical volumes. As a consequence, no specific skills deficits. What was lacking was adequate supervision in the early parts of this training."* SA12) and 'satisfaction with current training' (*"None, we were well prepared."* SA23*)* were individual themes, whereas the other 3 major themes emerged around multiple sub-themes.

Within 'technical skills' there were two sub themes: ' endoscopy training' (*'endoscopy'* SA21) and .minimal access surgery training' (*"One's real training only starts when you become a consultant. Then you go and look for opportunities to upskill yourself. Laparoscopic skills are always lacking in training."* SA22).

There were 3 sub-themes within non-technical skills: 'research skills' (*"Research" SA24), '*business management' ("*Running a private practice" SA20)* and "leadership & management" *("Dealing with organizational politics." SA07).*

Two sub-themes were grouped into 'broader clinical experience'*:* 'broad based emergency surgical training' *("Burr holes, thoracotomy" SA04*) and 'sub-specialist practice *(“Elective surgery exposure, specifically rotations through sub-specialty units. When I trained, there was only one such unit and it was in Vascular Surgery.” SA05).*

Table 6-13. *Framework analysis of consultant’s answers to the questions: “what skills or clinical situations were you not adequately prepared for in your surgical training? .N=27.*

Theme	Sub-theme
Desire for coaching	Surgical coaching *“Was trained in a circuit of hospitals with very high surgical volumes. As a consequence, no specific skills deficits. What was lacking was adequate supervision in the early parts of this training.”* SA12
Technical skills	Endoscopy training *“Endoscopy”* SA21
	Minimal access surgery training *“One’s real training only starts when you become a consultant. Then you go and look for opportunities to upskill yourself. Laparoscopic skills are always lacking in training.”* SA22
Non-technical skills	Research skills *“Research”* SA24
	Business management *“Running a private practice” SA20*
	Leadership & management *“Dealing with organizational politics.”* SA07
Broader clinical experience	Broad based emergency surgical training *“Burr holes, thoracotomy”* SA04
	Sub-specialist practice *“Elective surgery exposure, specifically rotations through sub-specialty units. When I trained, there was only one such unit and it was in Vascular Surgery.”* SA05
Satisfaction with current training	Satisfaction with training *“None, we were well prepared.”* SA23

6.3.9 Reliability analysis

Following the methodology of the development of the original Hennessy-Hicks TNA and used in chapter 5, a principal component analysis (PCA) was attempted, for each of the scales however, due to the small sample size with limited variability in the results, a PCA was not possible. The overall Kaiser-Meyer-Olkin (KMO) measure for sampling adequacy for the analysis was 0.515. A reliability analysis was performed by assessing each rating scale with the results in Table 16 below, indicating a high level of reliability.

Table 6-14. *Cronbach's alpha and standardised alpha for each of the rating scales. N = 37.*

Scale	Cronbach’s alpha	Standardised alpha
A – Importance	0.828	0.870
B – Performance	0.931	0.936
C – Training	0.971	0.973
D – Situation	0.939	0.926

6.4 Discussion

South Africa has a proud history of surgical training, and is often seen as representing the refence standard for Africa.(331) One recent survey identified the breadth of experienced gained by surgeons trained in South Africa, and highlighted the utility of this experience in providing care in humanitarian settings.(330) This is in contrast to the experience of many surgeons training in high income countries (HICs) in Western Europe and North America.(340) Overall, the cohort of surgeons surveyed as part of this study felt well prepared for working as a consultant in South Africa, with a median response of 6 on a scale of 1-7.

6.4.1 Modified Hennessy-Hicks TNA

The Hennessy-Hicks TNA proved a practical and useful tool for identifying the training needs of General Surgeons in South Africa. High rates of self-reported performance were noted in most skills, along with high rates of importance of all the skills assessed. Trauma and emergency general surgery skills were generally rated as the most important and the highest performance, except for trauma thoracotomy – the performance of this skill was a noted outlier. The three most frequently performed procedures were all related to trauma and in keeping with recent studies such as Chu et al 2019, which highlight the high confidence in trauma skills amongst South African general surgeons.(330) Trauma thoracotomy, however, should be considered as an area for focussed improvement, with mixed training and organisational improvements desired by respondents. This relative lack of confidence is despite the skill being performed a median of 5 times per year by respondents, far higher than in most HICs.(341)

Paediatric inguinal hernia repair, thyroidectomy, and trauma thoracotomy were rated as the lowest performance, and should be considered for further improvements both in training and in the work situation. In addition, modified mastectomy and wide local excision for breast cancer were comparatively low in performance scores and had high differences between importance and performance. These procedures were also infrequently performed with median annual frequencies of 10 and 5 respectively. Again, mixed training and organisational improvements were desired by respondents.

6.4.2 Use of technology

Webinars, online logbooks, and smart phone apps were all commonly used by respondents to augment their surgical training. Whilst there was desire amongst the respondents to see adoption of applications such as remote supervision of procedures in future, the most common use currently in practice was sharing clinical photographs or videos with colleagues. This suggests that the more advanced applications of technology in training such as for use in simulation or remote supervision of operative procedures are yet to be realised in mainstream surgical training. This may be, in part, due to the concerns with lack of access to both hardware and software reported by respondents.

The qualitative data also added important detail to this study. When asked about which areas of their job respondents would like further training, only a minority mentioned increased use of technology. There was a clear desire for improved access to minimally invasive surgery (MIS) with training and equipment for both laparoscopic and robotic surgery lacking. This is in keeping with a recent South African Society of Surgeons in Training (SASSiT) report on general surgery training that described access to MIS as a key concern.(342) Additionally, improvements were suggested in a culture of surgical coaching, sub-speciality training such as fellowships, as well as further training in research, teaching, business management and human factors skills. These findings agree with the SASSiT report that described current trainees' dissatisfaction with the level of supervision in theatre and protected time for academic practice.

Broader access to surgical training facilities was also advocated by respondents. Although the current training system was felt to give a broad skillset, some respondents highlighted the lack of access to training in rural facilities and in private facilities as a limitation of the current system.

When asked specifically on the role technology could play in improving technology respondents tended to focus on the practical applications of technology in day-to-day practice. Simulation training, video libraries of operations and MIS training were all suggested as areas where technology could play an important role. However electronic patient records and the use of an app to host guidelines to improve standardisation of care were also suggested, highlighting that the use of technology can have a much broader impact on the healthcare system and should not be focussed on surgery alone. It is important also to note, that concerns were raised about the practicalities of adopting new technology, as some respondents reported issues with access to the required hardware – similar concerns were raised by a recent survey of medical school simulation staff in South Africa.(343)

6.4.3 Improving training

Beyond technical skills and the use of technology, there were a number of important themes identified to improve surgical training in South Africa. The theme of 'non-technical skills' was identified in responses to the open text questions, as respondents identified skills such as business management, running a private practice and personnel management as areas that further training would be beneficial. These themes are unlikely to be unique to South Africa, as the recent focus on non-technical skills in many surgical systems has become more evidence in recent years.(344–347)

Similar themes were identified when consultants were asked what their surgical training failed to prepare them for. Technical skills were suggested, although infrequently, and mostly with respect to MIS such as laparoscopy, robotic surgery and endoscopy. Desire for further training in this area has also been identified in other published surveys on South African trainees.(348) A number of themes focussed on the non-technical skills described above and the desire for training in research and teaching skills, highlighting that rounded training that goes beyond technical and clinical skills is desired.

Many respondents reported satisfaction with their training programmes, this was evidenced by the relatively high scores given to the performance of most skills included in the analysis. This correlates with high satisfaction with training found in other African surgical training programmes.(349,350) One prospective study in Rwanda and South Africa identified high levels of trainee autonomy with similar mortality rates as consultant led operations.(351) This trends are in comparison with surgical training in some high income countries, where operative experience, confidence and satisfaction have declined.(352,353) Mutually beneficial exchanges and fellowships could be established, allowing for trainees with good operative experience to undergo training in minimal access techniques and research skills in high income countries, and trainees lacking in confidence in open surgery to undergo training in low or middle-income countries to develop their technical skills, especially in open surgery and trauma.(348,354) Care must be given to ensure that such schemes do not contribute to the 'brain drain' of surgeons from where they are needed most.

Rudolfson and colleagues demonstrated that South Africa already acts as 'a hub for surgical migration and training'.(221) This study estimated that 11% of SAO specialists were foreign medical graduates, just over half of which originated from a low- or middle-income country. Additionally, the authors estimated 15% of South African SAO specialists currently work in a high-income country. Monitoring this trend of SAO specialists could give insights into what are the factors that stimulate migration of healthcare workers, known as the 'push' and 'pull' factors.(355) Additionally, long term trends could identify what proportion of these healthcare workers return to their country of origin or training, and what are the factors that encourage them to do so. For many LMICs, retention of the few SAO providers that they have is an urgent priority.

One interesting trend from this study was that consultant surgeons consistently highlighted performance of some skills lower than their registrar counterparts – this was seen most clearly in thyroidectomy, wide local excision for breast cancer and modified radical mastectomy. From this study it is impossible to suggest why consultants are less confident than registrars at these procedures, but it may be due to specialisation in different fields, resulting in some consultant surgeons rarely performing those procedures, or conversely it could represent improvement in the quality of training in recent years.

6.4.4 Limitations

This study was small, with a younger cohort than in a recent, larger study.(330) This will add a degree of bias to the results as the data may be skewed to the needs of the younger generations of surgeons. However, as these surgeons have more recently completed training and will be part of the work force for much longer, it can be argued that targeting their learning needs will have a greater long-term impact to the workforce. Additionally, the relatively low KMO measure likely highlights that a larger sample would have allowed firmer conclusions to be drawn, and caution must be used before generalising conclusions from this study to the wider cohort of surgeons in South Africa.

Most importantly, self-reported confidence is not the same as competence at performing a skill, although they are likely to be related.(356) However, assessing individual performance of surgeons on a variety of skills using validated measures such as OSATs is impractical on a large scale. Self-reported confidence therefore represents a pragmatic balance between accuracy and ability to evaluate surgeons at scale. Additionally, access to online operative logbooks was beyond the remit of this study, although it would have produced more accurate data than self-reported frequency of performance of each skill.

Finally, it is important to note over 60% of the general surgical workforce are non-specialist surgeons in South Africa.(332) Medical officers, family physicians and other non-specialists were not included in this study and their training needs should be the focus of future work in this area.

6.5 Conclusion

This chapter has proven that a training needs analysis of General Surgeons in a middle-income country such as South Africa is practical, cost effective and can generate useful data to help surgical training and the wider healthcare system. Overall, respondents felt well prepared for practice as a consultant surgeon in South Africa and valued the broad surgical experience provided. Targeted improvements are warranted in the 'outlier' procedures such as paediatric inguinal hernia repair, trauma thoracotomy and thyroidectomy and increased adoption of minimally invasive techniques such as laparoscopy and endoscopy.

There was desire for greater use of technology particularly in providing simulation and laparoscopic training but also for improving patient records, data management and in research. It is important to note, the needs of a mature training system such as South Africa will likely be very different to other sub-Saharan African countries so care must be taken before extrapolating these results to other populations.

Having outlined the increasing surgical workload, the need to expand the workforce and improve equity of access, this study has demonstrated that a modified version of the HH TNA survey can be used to guide improvements the surgical training system.

The breadth of experience and satisfaction with the performance of most emergency and trauma skills assessed, highlighted that the skills of surgeons trained in South Africa are highly suitable in humanitarian deployments. The definition of humanitarian surgery is yet to be defined and will be the focus of the next chapter.

Chapter 7 - Defining Humanitarian Surgery; an international Delphi study

"As local as possible, as international as necessary" (357)

7.1 Introduction

Low- and middle-income countries are more frequently the site of humanitarian disasters.(358) This is despite, and likely to contribute to, the existing vast burden of surgical disease highlighted in Chapter 2 and the workforce crisis in Chapter 3. Furthermore, Humanitarian Medical Organisations (HMOs) such as Médecins sans Frontières (MSF) and the International Committee of the Red Cross (ICRC) have increasingly looked to recruit surgeons from low- and middle-income countries (LMICs) as these clinicians often have broader experience and a wider skillset more suited to these environments.(330,359) Defining the skillset required however, is difficult when the field itself is yet to be fully defined. LMIC countries, therefore, have a greater pre-existing burden of disease, a smaller pre-existing surgical workforce to respond, are more likely to be affected by, sudden onset disasters (SODs), and most likely to be providing the workforce to respond to the crisis, without the academic focus on clinical outcome reporting that is common place in HIC health systems. Because of these facts it is essential that the workforce from LMICs are involved in defining this crucial area of global health.

An agreed definition of *global health* ensured clarity on the aims, on how to achieve them, and the skills and resources required.(9) More recently, Dare and colleagues offered the following widely-used definition of g*lobal surgery*: "an area of study, research, practice, and advocacy that seeks to improve health outcomes and achieve health equity for all people who require surgical care, with a special emphasis on underserved populations and populations in crisis".(8) This definition includes both underserved populations and populations in crisis but did not define crises in the context of humanitarian medicine.(33)

Frequently the term 'Humanitarian Surgery' is used to broadly describe surgical work undertaken for underserved populations, for example in charitable or disease-specific surgical missions, as well as disaster responses for populations in crisis.(22,23) Indeed, there have been over 45 different terms to describe short-term charitable surgical missions.(24–27) Without a clear definition of Humanitarian Surgery, it is difficult to interpret published data and analyses.(24) This issue was particularly apparent in the response to the 2010 Haiti earthquake where widespread concerns were raised about the variable capability and quality of care in some of these organisations.(29,360) In an effort to move towards more professional delivery of care, the World Health Organization (WHO) developed the Emergency Medical Teams (EMT) minimal technical standards (known as the 'Blue Book') and specific guidance for teams deploying into armed conflicts – the 'Red Book'.(30–32)

Clarity on the terminology will help to identify the capabilities, experience and qualifications required for teams and individuals to effectively deliver care in these very demanding environments. Additionally, separating humanitarian activities from longer term, capacity building global surgery programmes activities will allow for comparison of effectiveness, cost-effectiveness, and sustainability of these platforms against international standards such as the WHO EMT minimum technical standards.(30–32)

This chapter outlines an international Delphi process to gain consensus drawn from experts in the fields of global surgery, conflict and disaster response to define the term Humanitarian Surgery.

7.2 Methodology

An online Delphi process was conducted and reported following the Standards for Reporting Qualitative Research (SRQR) guidelines – see appendix (Table 7.1).(361) A dedicated online software was used (Welphi©, Lisbon). Ethical review and approval was provided by the London School of Economics and Political Science (reference: 91957). Research was conducted in concordance with the principles of the Declaration of Helsinki.(362) Data were exported to Microsoft Excel (version 16.67, Microsoft Corporation, 2022) for analysis, and statistical analysis was conducted using SPSS (version 27, IBM Corp.© 1989, 2020).

A broad, international, multidisciplinary group of stakeholders was identified through a literature review, personal contacts of the authors, and the Royal College of Surgeons of England's (RCS England) Global Affairs department. In total, 157 stakeholders were invited to participate via email and encouraged to invite colleagues who also met the inclusion criteria – see Tables 1 and 2 for the full demographics and Appendix 7.3 for the list of collaborators. Snowball sampling was used through emails and social media channels to widen participation.

7.2.1 Inclusion & exclusion criteria

To ensure respondents had sufficient experience to make an informed decision on the constituent parts of the definition, the following inclusion criteria were used:

1. Age >18.
2. Ability to speak, read or write any of the six official languages of the United Nations: English, French, Spanish, Arabic, Russian, Chinese.

And at least one of the following:

3. Active in humanitarian or global surgery/global health either in research capacity or in healthcare development or provision (within the last 5 years).
4. Currently (within last 12 months) affiliated with an organisation involved in global and/or humanitarian surgery.
5. Patient or public representative with experience of a sudden onset disaster.
6. A healthcare worker who works primarily in a low- or middle- income country.

Public involvement was carried out in concordance with the guidance for reporting involvement of patients and public - short form (GRIPP2-SF) framework and aimed to ensure the voices of those who may receive humanitarian surgical care were represented - see Appendix 7.2.(363) The Delphi process was held over three rounds followed by a definition workshop to agree on the final wording as described below and displayed in Figure 1.

7.2.2 Rounds in detail

In round 1, 10 researchers were invited to take part, representing a mixture of academics, clinicians and global health workers from a variety of countries. The respondents were asked to answer the question: ‘what is humanitarian surgery?’. Dare’s definition of global surgery was used as a comparator and a link to this paper was provided.(8) This question was also asked to the followers of the RCS England's social media channels and snowball sampling was encouraged. Free text answers to this question were collated through an online survey tool and used, alongside a focussed, online discussion to formulate the statements for voting in later rounds. The responses were analysed thematically, using a framework analysis approach, and the responses were used to build an online survey using the Welphi platform. Respondents were asked to rate their agreement with the statements on a Likert scale of 1 (strongly disagree) – 6 (strongly agree). An option to select 'don't know' was included as the stakeholders were a heterogenous group with varied experience.(364,365) The survey was piloted amongst a small group of academics, clinicians, and a patient representative prior to wider circulation.

In round 2, the online survey was sent to the stakeholders by email and each participant was asked to rate their agreement with the statements. As part of this round, participants were offered the opportunity to volunteer further ideas to be taken forward to future rounds. An initial 2-week window was given to complete the online survey; this was extended by a further 2 weeks to encourage greater participation from respondents from low-income and middle- income countries. Responses were analysed for agreement and consensus (see below), and statements that reached both consensus and agreement were taken forward to round 3.

In round 3, an updated survey including additional ideas generated from round 2 was sent to the participants along with the individual's previous responses. Respondents were shown the group median response and the interquartile range (IQR), both in values and in graphical format.(366) Statements that reached agreement and consensus were taken forward to the definition workshop.

Finally, an online definition workshop was held. with the 10 researchers from round 1 and additional invited respondents from rounds 2 and 3 to ensure a balanced view from a varied group of professional, geographical and ethnic backgrounds. See Tables 1 and 2 for full demographic details. Respondents were invited to review the 10 statements that reached agreement and consensus and to decide on the wording of the definition.

7.2.3 Definitions

When using the Delphi methodology, it is important to be clear about the definitions used. For this study, the following definitions were used:

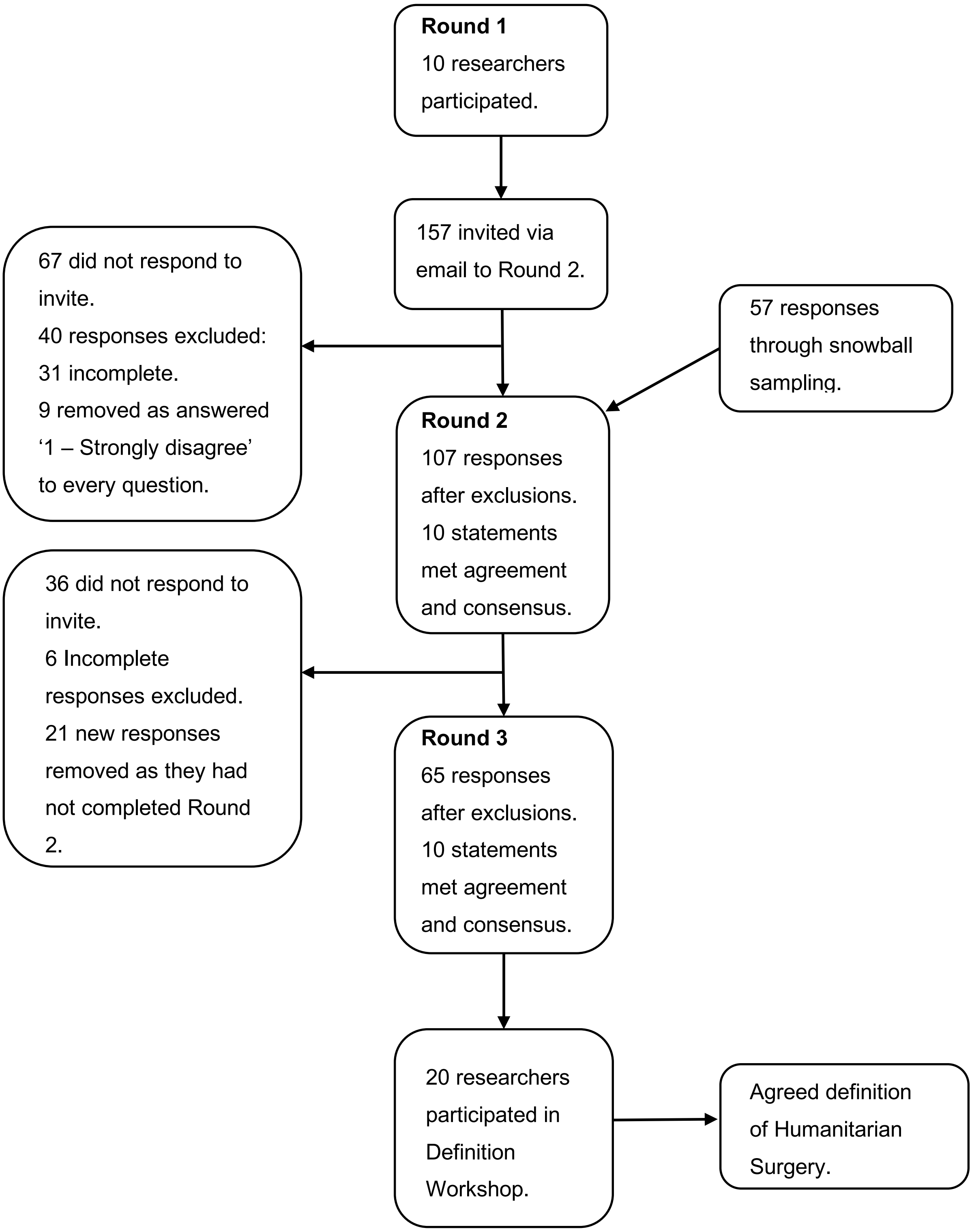
- Agreement refers to the individual participant agreeing with a statement; this then provides group opinion, or central tendency, and can be measured by the group mean or median.(367)
- Consensus refers to the extent to which participants agree with each other; this is measured by the interquartile range (IQR).(367)

Median and IQR were selected for reporting data as they are generally considered more robust than mean and standard deviation when using Delphi methodolgy.(368) A group median of $\geq$ 4 was decided as the group agreeing with the statement. Consensus was determined using IQR to assess the variance of response; an IQR of <2 was chosen as a cut off to indicate group consensus.

7.3 Results

In total, 147 responses were recorded. After exclusions, 107 responses were recorded in round 2, and 65 responses in round 3 – see Figure 1 below for an overview.

Figure 7-1. *Schematic overview of Delphi process.*



Responses came from 6 separate countries in round 1; 34 separate countries in round 2; 27 countries in round 3; and 8 countries in the definition workshop (see Table 1).

Table 7-1. *Number of participants by country of practice, with income classification of country in brackets. DW = definition workshop.*

Country of practice	Round 1	Round 2	Round 3	DW
United Kingdom (High)	3	29	24	5
Yemen (Low)	1	22	7	1
Kenya (Low middle)	1	5	1	1
India (Low middle)		4	3	
Sierra Leone (Low)		3	1	
Palestinian National Authority (Low middle)	1	3	3	1
Syria (Low)		3	1	
Cameroon (Low middle)	1	3	1	2
Egypt (Low middle)	1	3	2	1
Australia (High)		2	1	
Sri Lanka (Low middle)		2	2	
Nigeria (Low middle)		2	2	
Lebanon (Lower middle)		2	1	
Somalia (Low)		1		
United States (High)		1	1	1
Benin (Low middle)		1		
Ireland (High)		1	1	
Japan (High)		1	1	
Ethiopia (Low)		1		1
Jordan (Upper middle)		1	1	
United Arab Emirates (High)		1	1	
Colombia (Upper middle)		1		
China (Upper middle)		1	1	
Libya (Upper middle)		1	1	
Spain (High)		1	1	
Sudan (Low)		1		
Nepal (Low middle)		1	1	
Uganda (Low)		1	1	
Democratic Republic of the Congo (Low)		1	1	
Norway (High)		1		
Greece (High)		1	1	
Brazil (Upper middle)		1	1	
Qatar (High)		1	1	
Global (N/A)	2	4	2	9
Total	10	107	65	22

During round 1, 50% (5) of responses came from respondents based in low or middle- income countries; this was 53% (57) in round 2; 42% (27) in round 3; and 73% (16) in the definition workshop. A full breakdown of the demographics can be found in Table 2 below.

Table 7-2. Demographics of respondents by round.

	Round 1 N=10	**Round 2 N=107**	**Round 3 N=65**	**Definition Workshop N=22**
Gender				
Sex ratio (M:F)	5:5	85:22	52:13	11:11
Profession				
Surgeon	6	65	49	8
Physician	1	13	6	2
Humanitarian/aid/global health workers or programme managers	2	4	2	2
Nurse	0	9	2	1
Anaesthetists/Anaesthesiologists	0	7	1	1
Academic	1	4	3	6
Public health doctor	0	2	0	0
Public/patient representative	0	1	1	1
Pharmacist	0	1	0	0
Dental student	0	1	1	1
Experience				
0-5 years	1	22	9	6
5-10 years	1	34	21	7
10-20 years	5	26	15	2
20+ years	3	25	20	7
World bank Income Classification of country of work				
Low	1	33	11	2
Lower Middle	4	26	17	5
Upper Middle	0	7	4	0
High	3	38	31	6
Global or multiple world regions	2	4	2	9
Ethnicity				
White/Caucasian	3	36	28	9
Arabic	4	34	16	4
Asian: Indian, Pakistani, Sri Lankan	0	12	11	2
Asian: Japanese	0	1	1	0
Asian: Nepalese	0	1	1	0
Black: African or Caribbean	3	16	5	7
Mixed ethnicity	0	2	1	0
Prefer not to say	0	5	2	0

7.3.1 Statements

Round 1 generated 25 statements, these were separated into 4 themes:

1. Who should deliver humanitarian surgical care?
2. What care should be delivered?
3. Where should humanitarian surgery be delivered?
4. When should humanitarian surgery be delivered?

Ten of these statements reached agreement and consensus in round 2, all of which met agreement and consensus in round 3. The final 10 statements are presented in Table 3 along with the respective median and IQR. The trend of the median and IQR across rounds 2 and 3 is shown in brackets after the values. In each of the 10 agreed statements, the median was either stable or increasing and the IQR was either stable or narrowing, indicating a high degree of both agreement and consensus.

Table 7-3. *The 10 statements that reached agreement and consensus in the Delphi process. Text in italics identifies text added after feedback from round 2.*

No	Theme	Statement	Median (trend)	IQR (trend)
1	**Who**	Delivered by: multidisciplinary team of surgeons, anaesthesia providers, nurses and other healthcare professionals including, where practical; pharmacists, lab technicians, and specialists in policy, logistics and security.	4 (stable)	1 (stable)
2	**Who**	Delivered in co-ordination with the local health system and the local government.	4.5 (increasing)	1 (stable)
3	**What**	Humanitarian Surgery should be delivered in line with the Humanitarian Principles (Humanity, Neutrality, Impartiality, and Independence).	5 (increasing)	0 (narrowing)
4	**What**	Humanitarian Surgery includes emergency adult & paediatric, surgical, anaesthetic, obstetric and trauma care.	5 (increasing)	0 (narrowing)
5	**What**	Humanitarian Surgery should include pre-operative, intra-operative, post-operative care and follow up, *although these may not all be with the same provider*.	5 (stable)	1 (stable)
6	**What**	Humanitarian Surgery should collect standardised data for clinical governance.	4.5 (stable)	1 (stable)
7	**What**	Humanitarian Surgery should use standardised protocols *or guidelines* for care, *although these may need to be tailored to the individual circumstance.*	4 (stable)	1 (narrowing)
8	**Where**	In conflict and post conflict zones.	5 (stable)	1 (stable)
9	**Where**	In areas of sudden onset disasters (SODs).	5 (increasing)	0 (stable)
10	**When**	When the local health system is, or is at risk of, being overwhelmed.	4.5 (increasing)	1 (stable)

The full list of the 15 statements that did not reach agreement can be seen in Table 4, along with the median and IQR from voting in round 2.

Table 7-4. *The 15 statements that did not reach either agreement or consensus after round 1.*

	Theme	Statement	Median	IQR
11	**Who**	Relies on international and inter-sectional collaboration	3.5	2
12	**What**	Humanitarian Surgery is a sub-speciality of 'Global Surgery'	3.5	2
13	**What**	The term Humanitarian Surgery is interchangeable with Global Surgery	3.5	3
14	**What**	Humanitarian Surgery should build local capacity	3.5	1
15	**What**	Humanitarian Surgery should provide preventative care such as contraception	3.5	2
16	**What**	Humanitarian Surgery should provide rehabilitation	3.5	2
17	**What**	Humanitarian Surgery should provide palliative care	3.5	1
18	**What**	Humanitarian Surgery should provide non-emergency care such as elective hernia repair.	3.5	3
19	**What**	Humanitarian Surgery is not primarily intended to resolve the crisis but provide essential care.	3.5	1
20	**What**	Humanitarian Surgery should provide education, research and/or advocacy expertise in addition to a clinical role.	3.5	1
21	**Where**	Where there are failed or failing health systems.	3.5	1
22	**Where**	Wherever it takes place, Humanitarian Surgery should be adapted to the local context, both in terms of human and material resource.	3.5	1
23	**When**	For a defined period of time.	3.5	1
24	**When**	When invited by the local population or local government.	3.5	2
25	**When**	Is a temporary necessity.	3.5	1

7.3.2 Full definition

Using the 10 statements agreed within this study, the researchers present at the definition workshop agreed on the following definition of Humanitarian Surgery: *an area for study, research and practice that focuses on surgical care in conflict and post conflict zones, in areas of sudden onset disasters and when the local health system is overwhelmed. Emergency surgical care, including anaesthesia, should be provided to patients of all ages. Perioperative and follow-up care should be provided, although these may not be by the same clinician. Care should be delivered in line with the core humanitarian principles (humanity, neutrality, impartiality, and independence), and, wherever possible, in co-ordination with the local health system and government. Humanitarian Surgery is a multidisciplinary field involving surgical and anaesthetic providers, nurses, rehabilitation specialists, and other healthcare professionals including pharmacists, laboratory technicians, and specialists in policy, logistics and security. Standardised data should be collected, and standardised protocols, or guidelines, should be used, although these should be tailored to the individual circumstance.*

7.3.3 Working definition

As the above definition is extensive, we have followed the example of Dare and colleagues by proposing a shorter working definition: *Humanitarian Surgery is an area for study, research and practice that focuses on the co-ordinated provision of emergency surgical care, in accordance with the humanitarian principles, in conflict and post conflict zones, in areas of sudden onset disasters and when the local health system is overwhelmed*.

7.4 Discussion

Defining the term Humanitarian Surgery has a number of benefits. Firstly, it will allow comparison of humanitarian surgical activities against agreed standards.(369–371) Agreeing what *is* considered Humanitarian Surgery also allows clarity on what should *not* be considered humanitarian surgery. The current use of confusing and often contradictory terms prevents meaningful evaluation and quality assurance. Clarity about what is, and what should not be, considered as Humanitarian Surgery will allow more meaningful collection and comparison of data.

Similar efforts have been made within other fields such as infectious diseases, military global health and paediatrics.(372–374)

Secondly, agreeing on the definition helps move the discussion towards addressing diverse ethical and logistical challenges regarding the scope and the remit of Humanitarian Surgery. Key questions also need to be addressed: when should teams be deployed? For how long should they deploy? How, and when, do these teams handover to local health systems appropriately and safely? What are reasonable expectations from humanitarian surgical care, and how should they be communicated to patients and the local health system? Attempting to answer these questions will be complex and may raise difficult practical or ethical dilemmas. Future work should focus on other qualitative research methods to explore key concepts in more depth.

This definition of Humanitarian Surgery provides a framework that will allow more robust comparison of activities and encourage professional training. Humanitarian crises are complex situations fraught with danger, and mistakes can have far-reaching and severe consequences for patients, communities, providers and local health systems.(20,28,29) The teams who deploy into them must be suitably trained and experienced to provide a high standard of care for vulnerable populations.

Conflict and sudden onset disasters have both been included in this definition of Humanitarian Surgery. The determinants of conflict are dynamic, complex and can be exacerbated by the effect of sudden onset disasters (SODs), climate change and urbanisation.(375,376) Thus, making a distinction between humanitarian crises due to armed conflict or any other causes is unhelpful. Whilst the response to any crisis must be tailored to the individual situation, humanitarian surgical teams will be expected to respond to a wide variety of crises.

The motivation of individuals, organisations, and funders to provide Humanitarian Surgery has not been addressed in this article. The reason why an individual may offer their services (either with or without payment) to provide Humanitarian Surgery are nuanced and have been assessed elsewhere.(377–381)

The scope of Humanitarian Surgery remains contentious. Statements suggesting that Humanitarian Surgery should build local capacity and include rehabilitation and palliative care failed to reach agreement. It is important to note that both rehabilitation and palliative care form an essential part of both the WHO EMT, 2020 Consensus Framework and the Sphere handbook minimum standards.(32,370,371) Thus, although not included in the consensus definition provided here, access to these services should be considered part of the continuum of care for surgical patients in humanitarian settings. Importantly, a review of the WHO led trauma system set up during the battle of Mosul identified that "post-operative and rehabilitative care needs were inadequately developed and supported".(35)

It is also important to note that the WHO EMT programme calls for all member states to develop national EMTs, and this work should be strongly supported as part of the wider effort to 'de-colonise' humanitarian aid through reducing the dependence on EMTs and NGOs based mainly in Europe and North America. The World Humanitarian Summit in 2016 reinforced this concept with the motto; "*as local as possible, as international as necessary*".(357) However, in large SODs or large scale conflicts, the local health response is likely to be overwhelmed even in High Income Countries as evidenced by the US Navy's humanitarian assistance in response to the Tohuko earthquake and Fukushima nuclear incident in Japan in 2011.(382)

A more recent development has been the rise of private sector NGOs providing humanitarian care.(383) These groups can provide care in certain situations where Humanitarian Medical Organisations (HMOs) cannot, such as in the UN/WHO led trauma response to the battle for Mosul in 2016. Here, private sector NGOs provided EMTs that were able to work closely with military organisations to ensure that they could deploy closer to the point of wounding whilst maintaining their staff's safety.(35,384) Large HMO such as MSF and ICRC were unable to work so closely with military organisations for fear of compromising their humanitarian principles.(384) This trauma system, based on military doctrine of escalating levels of care from 'trauma stabilisation points' within 10 minutes of combat to field hospitals within an hour by ambulance, was estimated to save between 1,500 – 1,800 lives after independent analysis by the Johns Hopkins Centre for Humanitarian Health.(35,384,385) Given that these private sector EMTs can address an unmet need within the humanitarian sector, future research and evaluation work should include these organisations, and policy to ensure timely and coherent co-ordination can be developed.

7.4.1 Limitations

Despite the efforts made to ensure a representative group of respondents, surgeons were over-represented, and this may have narrowed the scope of this Delphi study. However, there was a broad mix of respondents from a wide variety of disciplines. Additionally, there were no responses from non-physician clinicians such as Community Health Officers who provide a significant proportion of surgical care in many regions across the world, capturing their views should be the focus of further work in this area.

As in any qualitative research, there is bias within this study. The areas of highest responses were countries where the RCS England's Humanitarian Surgery Initiative (HSI) Fellows are based. The five Fellows based outside of the UK are primarily clinicians in their local health system and were working part time for the RCS England. This ensured that the voices of those working in low- and middle-income countries have been expressed, whilst ensuring that their time is appropriately renumerated. Additionally, all HSI Fellows undertook fully funded research methods e-learning to ensure there was a lasting benefit to research capacity within their health systems.

The UK was the country with the highest number of responses, which may also over-emphasise a high-income country or donor perspective. However, overall, there was good geographic representation in each round of the study, and at least 50% of responses were from low or middle- income countries. Accessing patient or public representatives from low- or middle- income countries proved difficult. Although based in the UK, the patient representative did have direct experience of a SOD and gave a unique insight.

The dropout rate in between rounds 2 and 3 was higher than expected. This is likely to be due to extending the initial data collection period. This extension was decided to encourage greater participation from low- and middle-income countries. This did lead to significantly more responses from low- and middle-income countries, but likely at the cost of a higher attrition rate between rounds.

7.5 Conclusion

This is the first study to agree on a definition of Humanitarian Surgery and crucially represents the views of clinicians in low- and middle-income countries who are more likely to be affected by sudden onset disaster and conflict and also represents the views of those from large international Humanitarian Medical Organisations. Agreeing a definition will help facilitate high quality humanitarian surgical care and will provoke further debate and research in this area. This research has been recently published in the BJS under the title: 'Defining humanitarian surgery; international consensus in global surgery'.(386)

Chapter 8 - Discussion and conclusions

"There is an urgent need to identify effective real-world interventions in LMICs to improve the quality of surgical care " (387)

8.1 Introduction

This study has highlighted a number of important and ongoing issues; firstly, the burden of surgical disease in low-income and middle-income countries (LMICs) is vast and growing. Secondly, there is a significant workforce gap, and the workforce is inequitably distributed. Thirdly, potentially useful data can be generated to target local training needs through a modified version of the Hennessy-Hicks training needs analysis (HH TNA) questionnaire. Data generated in this way can be used to target improvements in training to ensure high quality provision of surgical care. Fourthly, the role that technology can play in expanding the capacity and improving the quality of training has been explored. Each of these conclusions will be explored in more detail in this chapter.

Crucially, treating all low-income and middle-income countries as one homogenous group must be avoided. There is an ongoing need for individualised assessments of burden of disease, of the workforce gap and for the training needs for the local healthcare workers. Projects like the Global Burden of Disease (GBD) study allow the healthcare needs of individual countries and regions to be measured in a standardized manner.(195,200) The widespread growth of National Surgical Obstetric and Anaesthesia Plans (NSOAPs) is to be encouraged and can help to plan and deliver surgical services at the macro level.(213) Additional tools that can help with the more granular aspects of workforce planning are the WHO Situational Analysis Tool which can be used to give a snapshot of the current provision of surgical services in a specific location.(271)

This study has demonstrated that a modified HH TNA can be used to enhance these more established tools by identifying the areas of greatest training need amongst surgical teams. This can be done pragmatically and ethically in collaboration with national organisations.

8.2 The burden of surgical disease in LMICs

The systematic review in Chapter 2 of this thesis highlighted that the burden of surgical disease in LMICs is vast and growing. International projects such as the Global Burden of Disease (GBD) study have allowed long term analysis of trends in specific diseases and disease groupings across the world. Although many of these estimates can vary widely, depending on the primary source used, the GBD study is continually updated to improve the accuracy of the reported results.

The development of the disability adjusted life year (DALY) metric was a key contribution of the GBD study and is now widely used as the measurement of burden of disease. The GBD study has also highlighted that an increasing proportion of global DALYs are due to non-communicable diseases and injuries – conditions for which surgery is often essential. These trends are demonstrated visually in Figure 1, adapted from Murray et al 2013.(193)

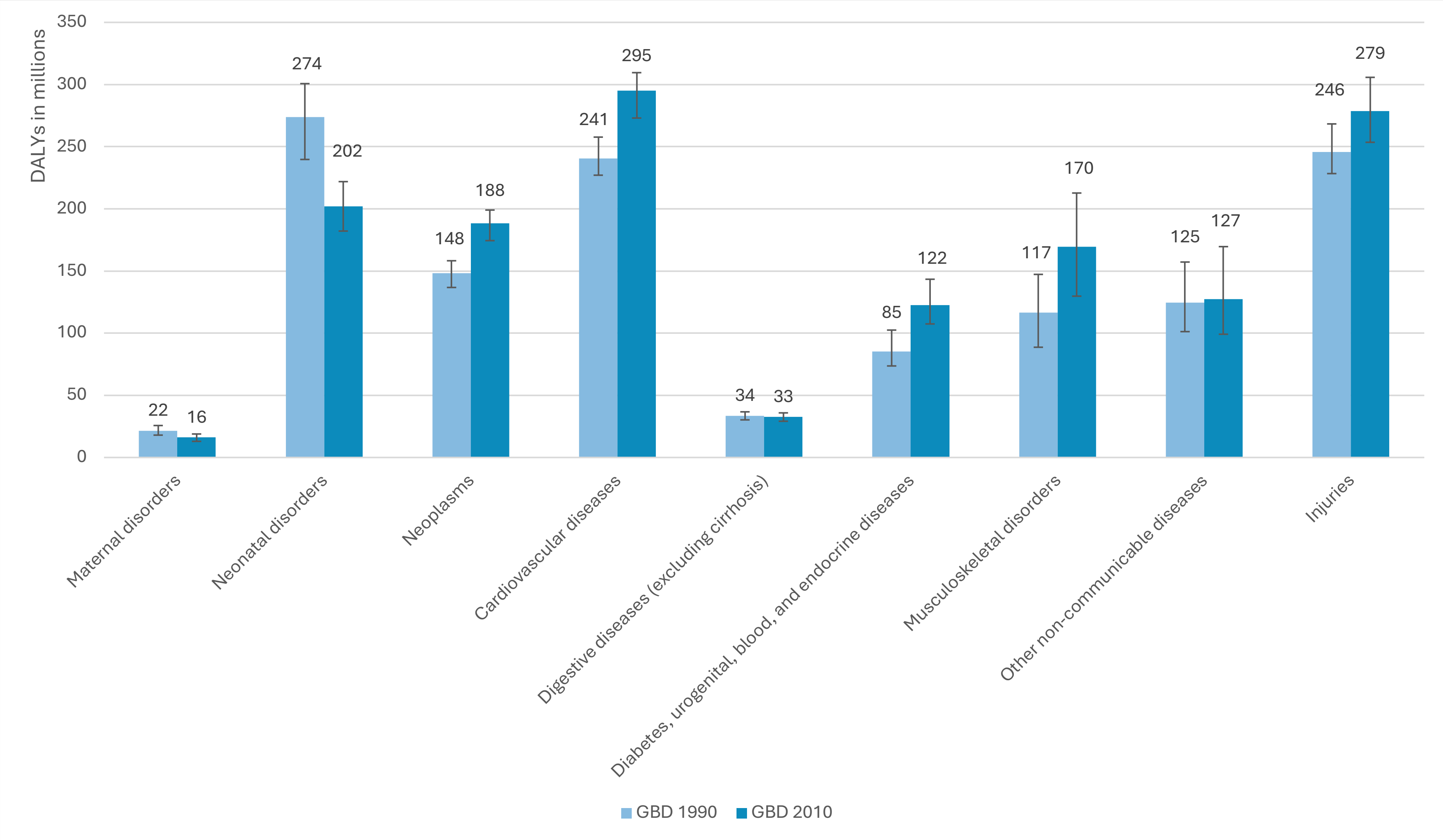
Regional trends in this systematic review highlight that the burden of disease varies widely across the world. In the African WHO region, the highest burden of disease is from cardiovascular diseases, followed by congenital anomalies, neoplasms and injuries. Surgery is an essential part of the management of these conditions. Although the overall burden of many neoplasms are decreasing over time, the burden of stomach, prostate and neurological cancers are increasing in Africa. Within the Eastern Mediterranean region, the highest burden of cancers was due to tracheal, bronchial and lung (TBL) cancers alongside breast and gastric cancers. South Asia and East Asia were reported as having the highest absolute burden of disease due to surgical conditions, in keeping with the large populations in those regions. These differing patterns of disease burden highlight the need for any intervention to be targeted to the local population’s healthcare needs.

The macro level data highlighted the inequitable allocation of research activity, with the some of the regions with the highest burden of disease being also the regions with the fewest research studies focussing on their population. Improving research capacity within these regions must also be the focus of the international community so that accurate national and sub-national estimates are available from to the governments and policy makers to improve healthcare for their population.

The trends over time show that the burden due to communicable, maternal and neonatal disease has fallen significantly over the GBD study period, as shown in

Figure 1. However, DALYs due to neoplasms, cardiovascular disease, diabetes, musculoskeletal disease, injuries and other non-communicable diseases have increased. This demonstrates the critical importance of surgical care now and in the future, as the strain on surgical systems is likely to continue to grow. The GBD studies have also demonstrated the important relationship between socio-demographic index (SDI) and health. SDI is a composite indicator of a national development using fertility rates, mean education and lag distributed income per capita and recorded as a number between 0 and 1. Countries in the lowest SDI quintile were found to have the largest increase in burden of disease from cancer as well as suffering higher mortality – these countries should be the focus of international surgical system strengthening initiatives. These surgical strengthening initiatives have been called for by the Emergency, Critical and Operative care (ECO) Resolution of the 76th World Health Assembly.(388) Additionally, this resolution urges all nation states to integrate surgical care within plans for Universal Health Coverage (UHC). Importantly, all aspects of surgical care, from pre-hospital, in hospital and post discharge rehabilitation were included in this statement alongside the mechanisms to coordinate care and provide oversight and governance. The impact of COVID-19 on elective surgical care highlighted the fragility of many systems, even in high-income countries, and the resolution emphasised that surgical care should be protected wherever possible in disasters and conflict affected areas.

Figure 8-1. *DALYs (in millions) due to surgical disease groupings globally from 1990 – 2010 with 95% CIs from Murray et al 2013.*

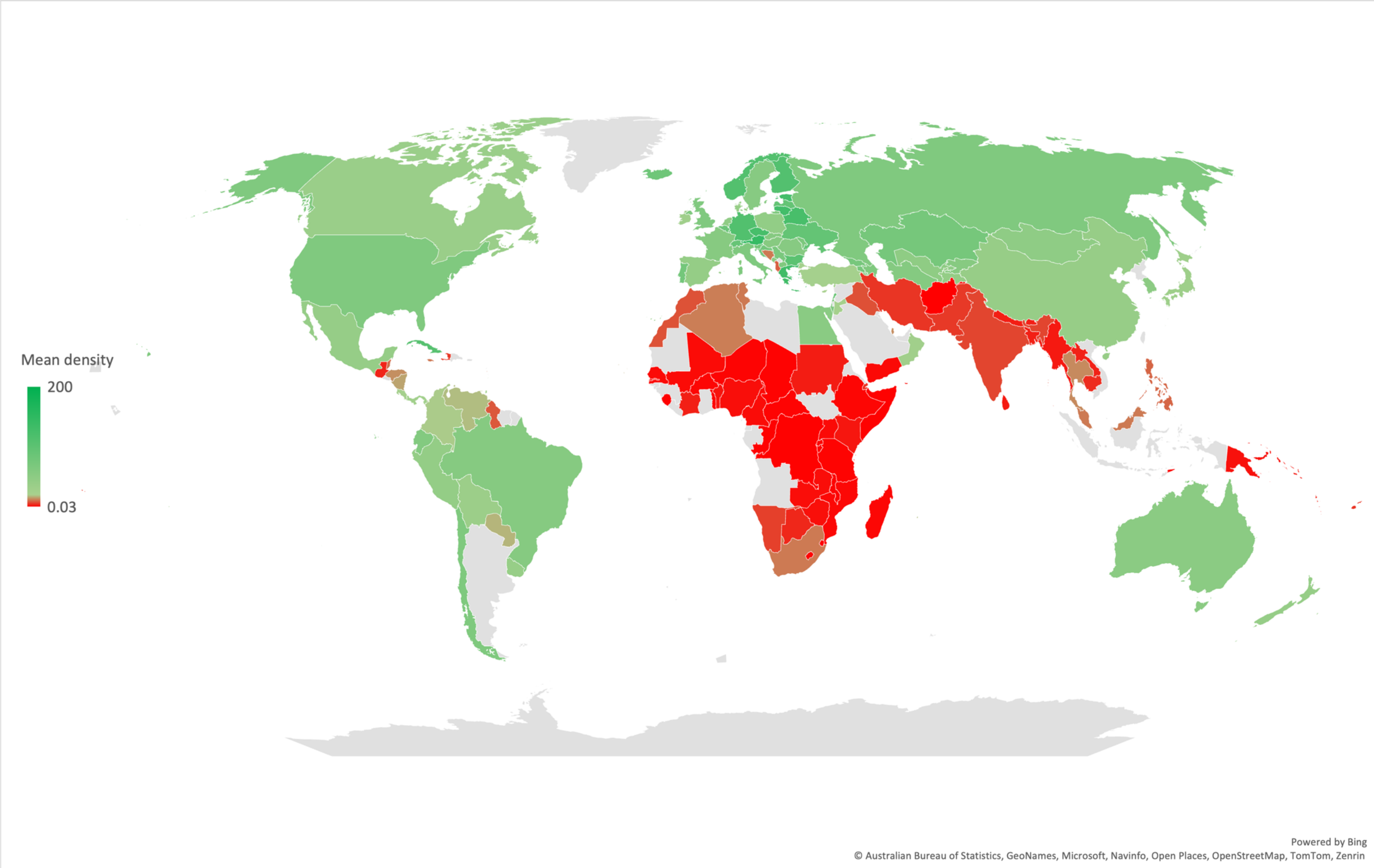


8.3 The surgical workforce gap in LMICs

Ensuring an adequate number of suitably trained and experienced staff in the areas they are needed, remains a significant challenge to healthcare systems across the world. The density of surgeons, obstetricians and anaesthetists (SAO density) is an indicator devised by the Lancet Commission on Global Surgery (LCoGS) authors in an effort to standardise the measurement and reporting of the international surgical workforce.(10) A benchmark minimum standard of 20 per 100,000 population has been suggested, as figures lower than this are associated with significantly higher mortality, while mortality benefits plateau beyond 40 per 100,000.(10) This metric was updated in 2021 to include all providers of surgery, anaesthesia or obstetric care rather than focussing on specialist physicians.(14) The systematic review in Chapter 3 used the SAO density metric in combination with the synthesis without meta-analysis (SWiM) guideline to produce accurate estimates of SAO density from all LMICs recording data.

Figure 2 below, shows the SAO density for the world with data from Holmer et al 2015 combined with the Specialist Surgical Workforce data collected by The World Bank.(207,260) This map clearly highlights the geographical inequity in the surgical workforce. The workforce crisis is most apparent in Africa and South East Asia. Notably there is only one country (the Seychelles) in Africa that meets the LCoGS minimum SAO density of 20/100,000, whereas there are only 2 countries in Europe (Albania and Bosnia) that *do not* meet the minimum SAO density. It is also important to note that many of the countries with large workforce deficits have the highest proportion of their workforce working overseas i.e. those countries that can least afford to, are losing the highest proportion of their healthcare workers to opportunities overseas.(221) Furthermore, these countries are often also the subject of the fewest research studies – adding to the inequitable allocation of resource. Reducing the effect of the ‘brain-drain’ in these countries through focussing on retention of healthcare workers is an important but under-appreciated area of global surgical system strengthening.(266) The pay and working conditions are often significantly better in high income countries than in low- or middle-income countries, however there are also many more opportunities for career advancement, sub-specialisation and academic progression in HICs. Many well-meaning organisations based in HICs have tried to export their training courses to low resource settings in an attempt to prevent the brain-drain effect, however these courses are often designed for HIC environments and may not be appropriate for the low resource context. A training needs analysis (TNA) is one way of ensuring that training is designed with the needs of the workforce in mind and can be tailored to the resource constraints of the health system in question.

Figure 8-2. *Mean SAO density per 100,000 per country from Holmer et al 2015 and the World Bank Red indicates density < 20 per 100,000..*



8.4 Hennessy-Hicks TNA

The Hennessy-Hicks Training Needs Analysis (HH TNA) tool was developed in Birmingham in the late 1990s, using a robust and psychometrically valid methodology.(287) Although initially developed for use amongst community nurses, it was licensed to the World Health Organisation (WHO) and is the most commonly used TNA tool in use in healthcare globally.(276) Its use amongst physicians is more limited in the published literature, and this study is the first to use a modified version of the study to assess surgical and anaesthetic providers.(276,288,289)

A key modification in this study was changing the skills assessed to technical skills which were relevant to the study population. Due to the significant structural changes, an assessment of reliability and validity was undertaken following the original methodology used by Hennessy and Hicks.(287) The modifications to the HH TNA tool were based on a thorough literature review and in close collaboration with the key national organisations that were important stakeholders in this research project.

The assessment of reliability and validity is important when trying to assess latent variables – facets which cannot be directly measured. One example of this is the Maslach Burnout Inventory (MBI), which uses subscales on factors such as 'emotional exhaustion' to evaluate overall burnout. (389,390) The necessity and benefit of measuring latent factors when assessing discrete technical skills is unclear, as the HH TNA has not been used for the purpose previously. The psychometric principles are arguably less relevant when the HH TNA is used to measure the confidence in performing technical skills, compared to assessing the non-technical aspects of a healthcare workers job such as communication. For technical skills, objective measures of performance do exist, such as OSATS – Objective Technical Assessment of Skills.(283) However, even in high-income countries (HICs), it can be challenging to find the time and resources required to apply OSATS to assess trainees at scale within a training programme. These resource constraints are often more acute in low- and middle-income countries, although there have been recent studies demonstrating their use in small studies in laparoscopic surgery in Africa.(391,392)

Self-reported confidence, although imperfect as a measure of competence, is a practical way to assess large numbers of clinicians quickly without requiring large amounts of human or material resource. The relationship between confidence and competence in performing technical skills should be explored further. In addition, the methodology used by the original HH TNA to discriminate between ‘satisfactory performance’ and ‘high intervention priority’ is arbitrary, with the cut off set at 3.5 on a scale of 1-7. This has clear limitations, as the difference between the performance of any skill rated at 3.4 compared to 3.6 is unlikely to be clinically relevant but will be reported in different categories using the HH TNA methodology. Conversely, the difference in performance between a skill rated at 7 compared to one rated at 3.6 would be expected to be clinically significant and yet both would be reported in the ‘satisfactory performance’ category. Clearly, any skill with a performance rating approaching the arbitrary cut off of 3.5 should also be an area of concern and has been reported so in this study. Although the quadrant graphs are a helpful method of displaying the data collected in a visually appealing manner, it could be argued they can simplify the message and encourage the relatively binary interpretation of an arbitrary cut off. For this reason, multiple methods of presenting the data have been attempted to give a more holistic view of the skills assessed.

The guidance in Dillman et al and Rees et al was followed to ensure the development of the survey was conducted in a rigorous and scientific manner.(291,393) However, as with many research projects using survey methods, gaining an adequate response rate was challenging. The response rate of 12% of general surgery registrars in South Africa is lower than the mean of 52% quoted by a recent systematic review on surveys in surgical education.(394) No financial or other incentive was offered to respondents for completing the survey. Incentives have been shown to only increase response rates modestly compared to surveys without incentive and there were logistical issues with delivering financial incentives to multiple countries. However, an incentive, either pre-paid or promised incentive could be used in future in an attempt to increase the response rate.(291) Additionally, it could be argued that the order of the surveys could have been changed to increase the number of successfully completed surveys. Having the HH TNA table question before the demographic questions could have engaged respondents from the outset and reduced the number of surveys that were started but not completed.(291)

It could also be argued that the HH TNA could be applied in a different way amongst the same study populations to generate more useful data. A single one-off snapshot can highlight important trends, as evidenced by this study. However, using it over a longer time period and assessing trainees as they finish their training programme may give more accurate data as to the overall performance of a training system. The snapshot methodology used in this study makes it more difficult to assess whether a trainee is low in confidence due to issues in the training programme or is an appropriate response for their stage in training.

Collaboration with key stakeholders is an essential part of any successful research project, and this importance is magnified when conducting ethical research in global surgery. Meeting with and trying to understand the priorities of key professional organisations within Somaliland and South Africa ensured that the surveys used collected meaningful data which was relevant to the local health system. This was most apparent when selecting which surgical or anaesthetic skills to be included in the modified survey. Although this reduced the ability to compare results between locations, this was less important than generating useful data that could be used to improve training in both locations. This process could have been increased further, by appointing hospital leads in across both countries, which could have increased local buy in within each hospital and increased the response rate.

8.4.1 Somaliland

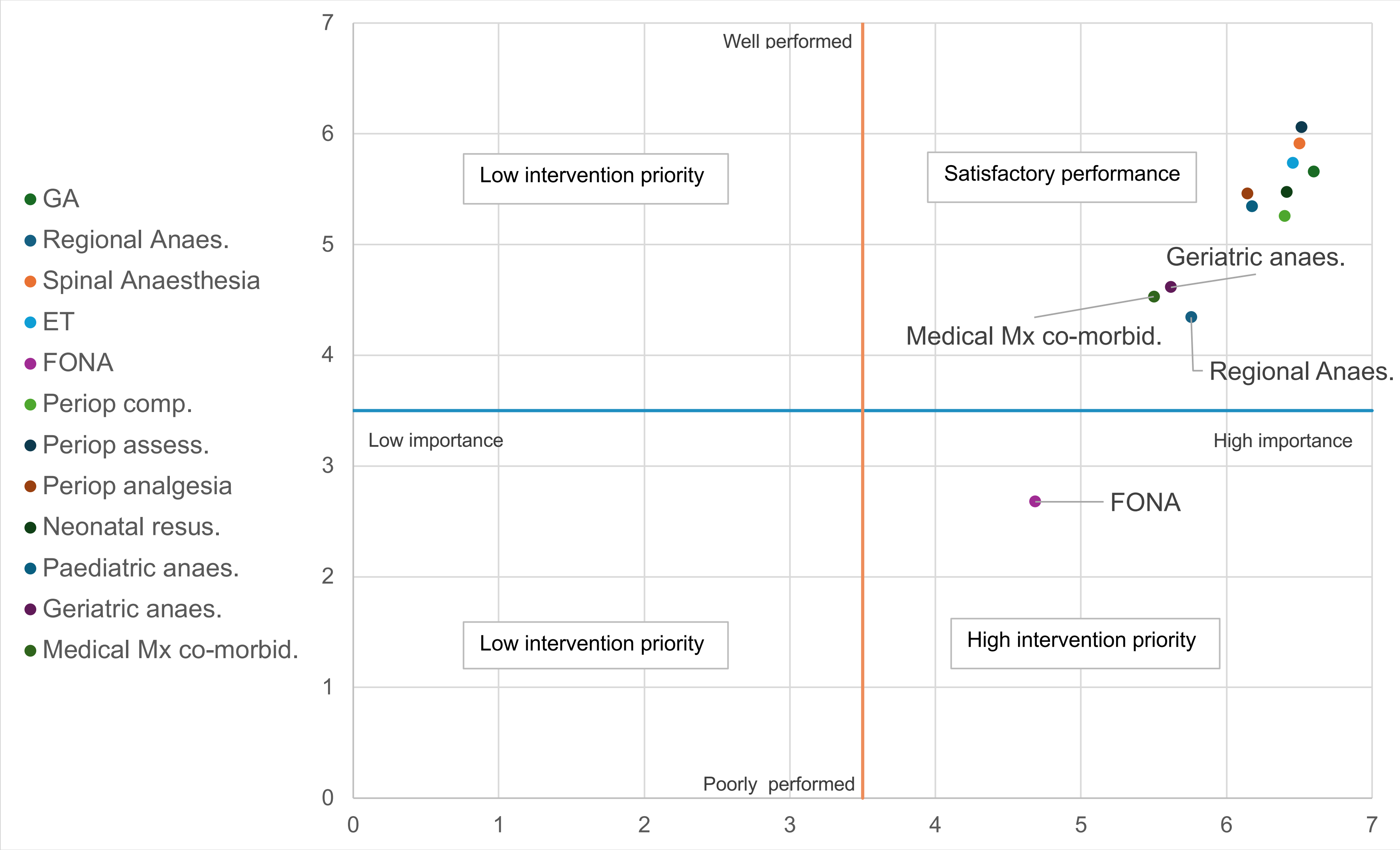
The TNA conducted in Somaliland has demonstrated that the HH TNA can be used successfully in a low-income African country even where English is the 2nd or 3rd spoken language. Although the absolute numbers were low, the response rate was relatively high (59% of anaesthesia providers, 33% of surgeons and 21% of obstetricians), demonstrating that distributing the survey online is practical in this country. Additionally, the survey was used to collect data from specialist physicians, non-specialist physicians and other clinicians such as nurse anaesthesia providers. Capturing data from a mixed workforce is crucial, especially in LMICs where due to chronic shortages of physicians, 'task sharing' and 'task shifting' are an essential part of the delivery of surgical care.(324)

Although not part of the original HH TNA methodology, the mixed methods survey was used to collect other useful data. This data highlighted ongoing concerns with access to reliable oxygen monitoring in the operating theatre environment and that a majority of Surgical Providers (SPs) used the WHO Surgical Safety Checklist infrequently. These two areas should be the focus of future efforts to strengthen the surgical system in Somaliland.

The performance of emergency cricothyroidotomy (front of neck access or FONA) was reported as an area of concern using the HH TNA methodology – see Figure 3 below. This data is being used to generate procedures specific training for Anaesthesia Providers (APs) in Somaliland. Mixed training and organisational improvements were desired in every skill, highlighting the importance of wider surgical system strengthening rather than focussing on improving training alone.

Despite the infrastructure challenges in Somaliland, respondents expressed a desire for greater use of technology in training and in the delivery of healthcare. Interestingly, many of the themes identified in the qualitative analysis described the use of technology to improve communication with patients and colleagues, facilitate networking and to monitor patient outcome data. Only a small minority of respondents reported a desire to see the use of more advanced technology such as remote mentoring of procedures (tele-proctoring). Although tele-proctoring has been demonstrated to be useful in endoscopy from a single surgeon case series in Uganda, these findings are in keeping with a recent systematic review that highlighted the adoption of phone calls, video calls and instant messaging as important developments to improve post-operative care. (395,396) However, the adoption of technology for routine use in training or patient care has been unequal geographically.(395,396)

Figure 8-3. *Quadrant graph showing mean importance versus mean performance scores for each skill from Anaesthesia Providers in Somaliland.*



8.4.2 South Africa

The TNA of General Surgeons in South Africa has shown that the HH TNA is also useful in a middle-income country with a high quality, long-standing surgical training programme. Overall, the surgeons surveyed felt their training programme prepared them well for clinical practice. High self-reported performance was reported in most surgical skills, however paediatric inguinal hernia repair, thyroidectomy and trauma thoracotomy were noted to be outliers due to relatively low performance scores, as seen in Figure 4 below. Additionally modified mastectomy and wide local excision for breast cancer were also relatively low scores, identifying breast surgery as a potential area for improvement within the surgical training programmes. Mixed training and organisational improvements were desired in all assessed skills.

Respondents again highlighted the potential benefits of technology in communication, conferencing and webinars but there was also appetite for more advanced use of technology such as in remote supervision of surgical procedures and in simulation training. Additionally, greater use of technology in maintaining patient records, recording clinical outcome data and in conducting surgical research was desired.

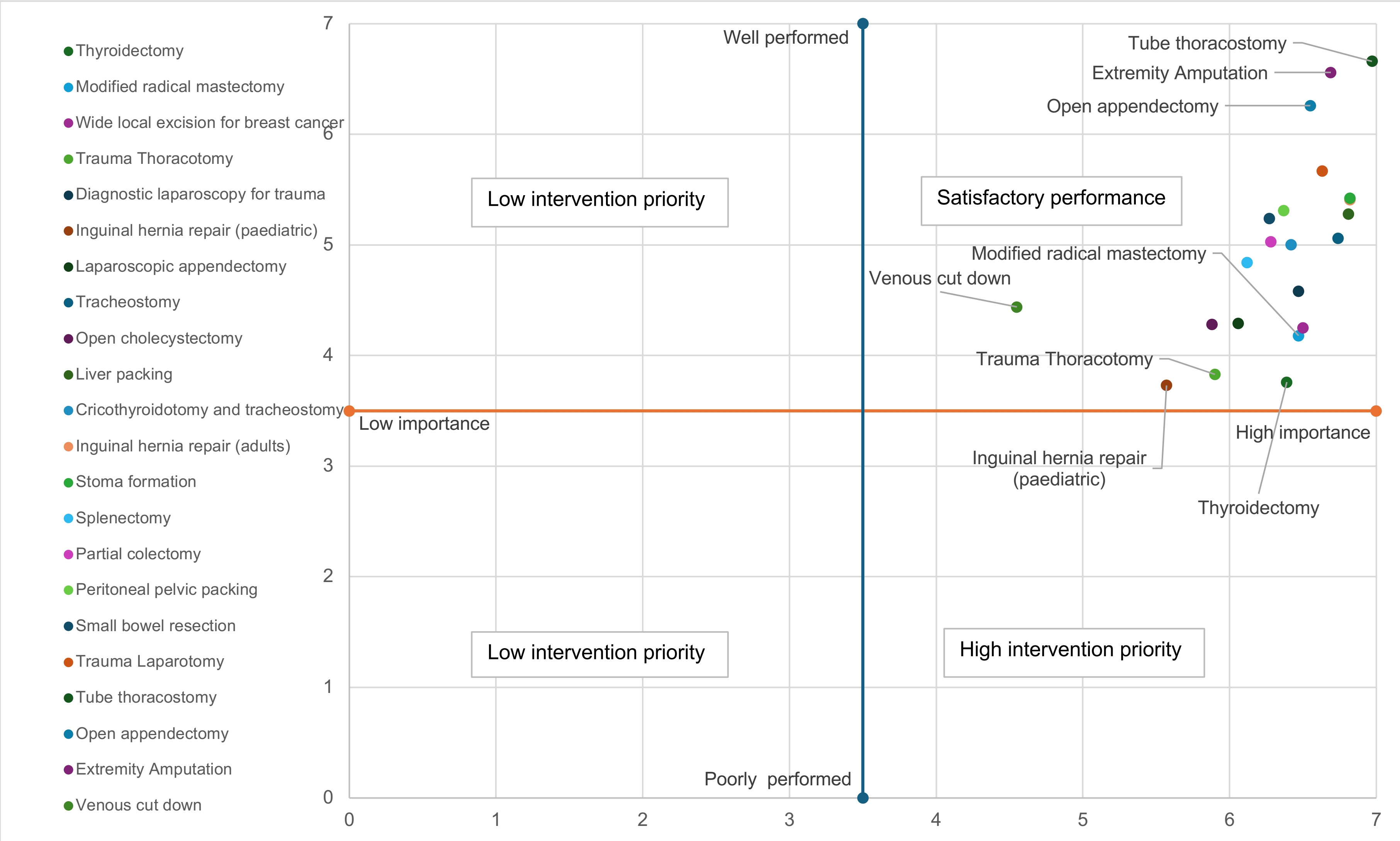
Access to technology for use of and training in minimally invasive surgery (MIS) was a key recurring theme amongst respondents. This finding is in keeping with a recent report on general surgery training in South Africa.(342) The desire for specialist MIS training combined with the broad overall satisfaction with surgical training, raises the possibility of meaningful bi-directional exchanges of surgeons from countries such as South Africa with HICs in North America and Western Europe, as many trainees in HIC settings are reporting reduced confidence in major open surgery and reduced satisfaction with surgical training in general.(397,398) This approach has been adopted on a small scale within vascular surgery in Europe, with senior trainees from high volume endovascular centres exchanging with those from high volume open centres to allow trainees from both centres to gain the benefits of training in both open and endovascular surgery.(399) The national laparoscopic colorectal surgery programme (LAPCO) in England, delivered improvements in mortality and morbidity for patients undergoing elective colorectal cancer resections and a similar model could be used as a basis or a South African programme to develop laparoscopic surgery.(400)

South African university training programmes have been suggested as ideal locations for the training of surgeons from across sub-Saharan Africa.(339) This training model has been shown to have high retention rates of African surgeons and could be used as a model for sub-speciality training from surgeons in nearby countries. Rudolfson and colleagues highlighted that there are also significant patterns of professional migration within southern Africa – particularly into and out of South Africa.(221) This study highlighted that Zimbabwe, the Democratic Republic of Congo and Uganda had a particularly high proportion of their SAO workforce currently working in South Africa. However, the authors also highlight the potential benefits to the healthcare system of SAO providers working temporarily overseas; subspecialist training; professional networking; paying off student debt and incentives for further education are all listed as positive effects of professional migration.

Longer term studies would give more clarity on the relative benefits of professional migration between regions and within them. It could be hypothesised that migration within regions such as Africa is less detrimental to health systems and may encourage health care workers such as surgeons and anaesthetists to return to their country of origin after a period of specialised training abroad in countries such as South Africa. All countries, including HICs, should ensure they produce enough physicians and healthcare workers to staff their own system to reduce the detrimental effects of permanent brain-drain from low-income to high-income countries.

The qualitative analysis also demonstrated that non-technical skills training was an important theme. This highlights that any training intervention or training programme must ensure the wider development beyond the application of technical skills. Wider skills in business management, running a private practice and dealing with organisational politics were also highlighted as areas that the current programme did not prepare surgeons for dealing with. There was also recurring desire for the adoption of a culture of coaching within surgical training. Surgical coaching, although an emerging concept, has been demonstrated to improve surgical trainee performance in HICs.(401,402) A recent systematic review, highlighted that there was no published studies of surgical coaching originating from an LMIC, this represents an area for future study and potential avenue for further surgical system strengthening.(403)

Figure 8-4. *Quadrant graph displaying mean ratings of importance versus mean ratings of performance of each skill by General Surgeons in South Africa.*



8.5 Defining Humanitarian Surgery

The TNA of surgeons in South Africa highlighted their overall satisfaction with training and their high self-reported performance of many key emergency and trauma surgery operations. Also noted was the relatively high number of key trauma procedures reported by respondents, with a median of 50 trauma laparotomies per year. This confidence and experience in the operative management of trauma is in keeping with other published studies and in stark contrast to trends in HICs.(354) This has led to Non-Governmental Organisations (NGOs) such as Médecins Sans Frontières (MSF) recruiting more surgeons from LMICs as their skills and experience are more suited to the breadth of surgical work and importance of trauma care in humanitarian settings.(330,359)

Despite its frequent use in published literature there was no agreed definition of the term 'humanitarian surgery'. The first published definition was agreed using a Delphi methodology, achieving consensus from over 100 experts from 33 separate countries and the working definition can be seen in Figure 5 below.(386)

Figure 8-5. *Working definition of humanitarian surgery.*

> *Humanitarian surgery is an area for study, research and practice that focuses on the co-ordinated provision of emergency surgical care, in accordance with the humanitarian principles, in conflict and post conflict zones, in areas of sudden onset disasters and when the local health system is overwhelmed*.

Agreeing a definition allows comparison of humanitarian surgical activities against agreed international standards and gives clarity on what should and should not be considered humanitarian surgery. This will enable more meaningful collection and comparison of outcome data and is in keeping with other global health fields such as infectious diseases, military global health and paediatrics.(372–374) Furthermore, the definition provides a framework to encourage more professional training and targeted recruitment of appropriate healthcare workers. As the TNA in Chapter 6 has identified, surgeons trained in South Africa have desirable experience and skills for use in humanitarian and conflict zones. This could also be argued to be less ethically problematic than the historic reliance on NGOs and clinicians from HICs in 'the Global North', and recruiting clinicians close to where they are likely to be needed is in keeping with the WHO Emergency Medical Teams mantra of "as local as possible, as international as necessary".(357)

8.6 Future research

The findings reported above have answered the research questions stated at the start of this thesis but have also highlighted the many questions that are yet to be answered. Future research could focus on the suggested questions posed in Table 1 below.

Table 8-1. *Suggestions for future research within the field*

1	What policy interventions have been proven to successfully reduce the burden of surgical disease in low- or middle-income countries?
2	What funding streams have been successfully used to fund these policy interventions?
3	How can the effects of task shifting and task sharing be quantified to ensure high quality clinical care?
4	Should the SAO metric by sub-divided into surgical, anaesthetic and obstetric provider for more granular reporting of the workforce?
5	What is the minimum density of midwives, operating theatre nurses, anaesthetic nurses or biomedical technicians to reduce perioperative mortality?
6	What evidence-based policy interventions have been proven to successfully upscale training of the surgical workforce?
7	How can the surgical workforce be more equitably dispersed within, and between, nations?
8	What methods can be implemented to reduce the effect of the 'brain drain' of surgical workforce from low income to high income countries?
8	What are the factors that can attract healthcare workers to the countries where they are needed most?
10	Is the new definition of humanitarian surgery practical, and does it helpfully discriminate between disaster response and longer-term system strengthening interventions?
11	What are the important metrics to report in humanitarian surgery, and how should they be recorded and reported?
12	Should all organisations that provide humanitarian surgery be mandated to report these metrics?
13	When, and for how long, should humanitarian surgical organisations be deployed?
14	How should humanitarian surgical organisations hand over to the local health system when withdrawing from the field?
15	What are the essential elements of a training programme for humanitarian surgeons to ensure standardisation of skills?
16	What role can the military play in improving global surgery and humanitarian surgery?

17	Is the frequency data reported by the HH TNA survey comparable with objective metrics such as surgical logbooks?
18	Is the performance data reported by the HH TNA survey comparable with objective assessment such as using OSATs?
19	Can the data reported by HH TNA be used to objectively improve the performance of training?
20	What evidence-based solutions exist to improve surgical training in low- and middle-income countries?
21	What evidence-based solutions exist to improve surgical healthcare systems in low- and middle-income countries?
22	Can the HH TNA tool be used to compare both technical and non-technical skills within surgery?
23	What is the evidence base for introducing technology to surgical training in low- and middle-income countries?
24	How can the use of the World Health Organisations' Surgical Safety Checklist be encouraged in low- and middle-income countries?
25	How can the focus of academic surgical research be more equitably distributed across low-and-middle income countries?

8.7 Conclusion

This study has used a number of complimentary research methods to address the key research questions: what are the training needs of surgeon in low resource settings? What tools exist to measure these needs? And, what is the role of technology in improving training within low- and middle-income countries?

The key messages from this study are:

1. The burden of surgical disease in low- and middle-income countries is vast and growing.
2. The surgical workforce is currently inadequate and inequitably distributed.
3. There is an unequal focus of research globally, with some of the regions and nations with the largest burden of disease and the smallest workforce also being the subject of the fewest research studies.
4. Combined together, the burden of disease, the workforce gap and the research interest represent a 3-dimensional lack of equity that applies to many low- and middle-income countries. Those countries with the

greatest need consistently have the least resource to direct to that need. A more equal distribution of workforce, financial and academic resource according to need must be the goal of international health organisations.

5. A modified Hennessy-Hicks Training Needs Analysis (HH TNA) questionnaire can be used to conduct a pragmatic yet meaningful training needs analysis of surgical and anaesthetic providers in low- and middle-income countries.
6. The data generated from the modified HH TNA can be considered reliable and can potentially be used to improve training programmes and to improve healthcare delivery.
7. Anaesthesia Providers (APs) in Somaliland identified emergency cricothyroidotomy as a high intervention priority skill, and there was varied use of oxygen monitoring and the WHO Surgical Safety Checklist.
8. In Somaliland there was desire to see a greater use of technology in improving communication with patients and colleagues and to improve patient outcome data recording. There was minimal appetite for more advanced use of technology such as tele-proctoring.
9. General Surgeons in South Africa felt well prepared for clinical practice, however there were some concerns noted with the performance of paediatric inguinal hernia repair, thyroidectomy and trauma thoracotomy.
10. Amongst General Surgeons in South Africa, respondents reported a desire for increased access to MIS equipment and training, as well as technology for surgical simulation and training in non-technical skills for surgeons.
11. Achieving international consensus on the definition of humanitarian surgery facilitates comparison of activity against international standards and enables meaningful data collection.
12. General Surgeons trained in South Africa have skills and experience that are likely to be applicable to settings of conflict and sudden onset disasters. Meaningful bi-directional exchanges could be established

between HICs and South Africa to ensure both groups of trainees benefit from training in open and minimally invasive surgery.

The novel application of the HH TNA has been demonstrated to be potentially useful and practical across different cultural, political and geographic boundaries and can collect potentially impactful data. This data could be used in combination with other complimentary data sources such as the GBD study and workforce surveys such as the WHO Situational Analysis Tool (SAT) to give a holistic view of the healthcare needs of the local population as well as the density, and training needs, of the local surgical workforce. Further modifications in the application of the HH TNA could also generate long-term data, for example by conducting multiple surveys (akin to 'audit loops') to potentially measure the impact of any training intervention – although the tool is as yet unproven in this regard. Alternatively, by asking all trainees to complete a HH TNA when they finish their training over a number of years, a longer-term assessment of a training programme could be performed. Where possible, the TNA should be used in conjunction with objective data such as from surgical logbooks or OSATS scores to ensure the reported training need is commensurate with the local healthcare needs. Repeating the TNA after an intervention could be a useful way of measuring the impact of an intervention into a training programme – future work could explore the promising results demonstrated in this research.

Furthermore, this TNA has allowed effective and ethical collaboration between HIC and LMIC institutions following best practices in global health research.(18) This collaboration has generated meaningful data to help strengthen surgical training systems in Somaliland and South Africa by enabling researchers from HIC and LMIC institutions to support locally identified training needs. The methodology used in this TNA can be used by researchers in low resource settings without significant financial barriers, especially given the recent proliferation of free software for online surveys. Conducting a TNA allows training interventions to be targeted at the areas of greatest need and can ensure that limited resource is spent where it is needed most to generate the biggest impact for local healthcare workers and their patients. Crucially, any intervention needs to be relevant and specific to the local context rather than a 'standard' course exported from a HIC context to a LMIC without appropriate modification.

The role of technology in improving the training of the surgical workforce is likely to be modest in most settings. Fundamentally, surgery and anaesthesia are craft specialities that require long hours of training in technical skills – technology can augment this process but is unlikely to change the ‘apprenticeship model’ of training. Surgical and anaesthetic providers in Somaliland and South Africa desired greater use of technology in both training and service delivery, however the desired effects were quite different. The focus on more commonplace use of technology such as calls to patients and colleagues in Somaliland likely reflects the barriers to greater use of technology; most frequently reported as an unstable internet connection and lack of access to suitable software. The role of technology in training general Surgeons in South Africa is likely to be greater, and particularly in facilitating access to equipment for, and training in, minimally invasive surgery (MIS). This is reflected by the most frequent barriers reported by South African respondents as lack of access to hardware and lack of software. Greater use of technology can have a positive impact provided it is targeted appropriately. Furter integration of technology cannot address systemic factors such as inadequate administrative support, lack of access to training facilitates and lack of surgical coaching.

Implementation of these findings will be key, and this is a notoriously difficult and often under-appreciated aspect of global health.(387) An implementation science approach should be taken to improve the chances of long term improvements to training programmes.(404) Notable successes such as the WHO Checklist, the ASOS-2 interventional trial, the Lifebox oxygen monitor and Clean-Cut programmes should be encouraged and used as models for the successful implementation of technology and process improvements that have had significant positive impact to patient care.(50,321,405,406) The principles of these successful programmes can be paired with the responsible use of technology to improve training of the surgical workforce to help to address the seismic challenges faced by surgical systems worldwide.

Chapter 9 - Appendices

Appendix 2A - Tables of included studies by WHO regions of the world

Table 9-1. Included studies from African Region.

Study	Region	Country	Source of data	Disease studied	Data	Type of study	GRADE rating
Alkire et al 2011	Africa	Sub-Saharan Africa (2008)	GBD 2006	Cleft lip and palate	Cleft lip: 45,896 (36,103 - 80,493) Cleft palate: 100,747 (79,251 - 176,692) Combined: 146,643 (115,354 - 257,185)	Original research	Moderate
Awedew et al 2022	Africa	Ethiopia	GBD 2019	All cancer	Bladder - 18,470 DALYs (12,520 - 24,100) Brain and CNS - 59,910 DALYS (44,210 - 91,080) Breast - 129,580 (101,090 - 161,690) Cervical - 133,580 (90,860 - 219,610) Colorectal - 79,050 (58,530 - 109,670) Oesophageal - 29,770 (22,790 - 41,210) Gallbladder and biliary tract - 12,740 (9480 - 16,360) Kidney - 16,360 (9490 - 22,070) Larynx - 10,870 (8590 - 14,420) Lip and oral cavity - 24,130 (16,440 - 31,410) Liver - 36,980 (29,050 - 46,870) Malignant skin melanoma - 8260 (6390 - 11,770) Mesothelioma - 2640 (990 - 8100) Nasopharynx - 18,450 (11,650 - 24,530) Non-melanoma skin cancer - 4620 (2250 - 6120) Ovarian - 29,770 (16,110 - 49,910) Pancreatic - 14,860 (9860 - 21,500) Prostate - 43,410 (22,750 - 72,730) Stomach - 73,970 (59,220 - 95,580)	Original research	Moderate

					Testicular - 5110 (3250 - 6670) Thyroid - 28,680 (21,690 - 37,280) Tracheal, bronchus and lung - 55,500 (38,360 - 75,110) Uterine - 9060 (6460- 13,700)		
Awedew et al 2022	Africa	54 African Countries	GBD 2019	Colorectal cancer	Africa 1,300,000 (1,140,000 - 1,460,000) Algeria 57,600 (45,200-72,400) Angola 27,800 (20,700-35,900) Benin 8500 (6500-11,300) Botswana 5200 (3500-7100) Burkina Faso 15,400 (11,900-19,900) Burundi 8900 (6200-12,900) Cote d'Ivoire 23,400 (17,400-30,300) Cabo Verde 1000 (800-1100) Cameroon 30,000 (21,600-40,900) Central African Republic 4000 (2800-5600) Chad 9800 (7400-13,000) Comoros 1000 (700-1300) Congo 7500 (5300-10,200) Democratic Republic of the Congo 56,300 (38,100-83,800) Djibouti 1700 (1200-2500) Egypt 133,000 (95,300-183,300) Equatorial Guinea 1700 (1000-2500) Eritrea 7600 (5700-10,100) Eswatini 1900 (1300-2700) Ethiopia 79,000 (58,500-109,700) Gabon 3700 (2600-4800) Gambia 1500 (1000-2000) Ghana 34,900 (26,500-45,100) Guinea 9400 (7000-12,400) Guinea-Bissau 1700 (1200-2200) Kenya 45,300 (35,300-57,200) Lesotho 3600 (2500-4800)	Original research	Moderate

					Liberia 3200 (2100-4500) Libya 17,100 (12,300-22,500) Madagascar 21,600 (15,500-29,000) Malawi 10,700 (7900-13,900) Mali 16,300 (12,500-21,000) Mauritania 3600 (2600-4700) Mauritius 5100 (4100-6200) Morocco 63,600 (47,400-81,100) Mozambique 22,400 (15,800-29,800) Namibia 2800 (2100-3700) Niger 10,100 (7200-14,000) Nigeria 157,300 (116,500-205,200) Sao Tome and Principe 400 (200-500) Senegal 14,400 (11,000-18,600) Seychelles 600 (500-700) Sierra Leone 5800 (4300-7600) South Africa 111,500 (100,300-126,600) South Sudan 9500 (5900-14,700) Sudan 34,700 (24,000-50,900) Tunisia 26,500 (19,100-36,100) Uganda 43,100 (32,500-54,500) United Republic of Tanzania (59,000 45,100-78,200) Zambia 23,300 (16,600-30,700) Zimbabwe 22,800 (17,100-29,300)		
Badrinath et al 2014	Africa	Uganda	Mulago Hospital Neonatal Surgery Unit database 2012	Surgical neonatal disease	Anorectal malformations - 49,324 DALYs Hirschsprung's Disease - 17,323 DALYs Gastroschisis - 42,552 DALYs Omphalocele - 23,987 DALYs GI atresia - 33,129 DALYs Teratoma - 2,719.2	Original research	Low
Beard et al 2013	Africa	Ghana	National Health and Nutrition Examination	Inguinal hernia	5,000,000 DALYs	Original research	Very low

			Survey (US survey) combined with Operation Hernia (UK NGO) data				
Cairo et al	Africa	Kampala, Uganda	Single centre case series from national referral centre database	Intestinal atresia	16,663.2 DALYs annually	Original research	Low
Ford et al 2016	Africa	Uganda, Malawi, Nigeria, Cote D'Ivoire, South Africa	Retrospective review of neonatal centres, country data extrapolated from single centre data.	Gastroschisis	Uganda 25,617 Malawi 97,646 Nigeria 7946 Côte d'Ivoire 12,298 South Africa 9582	Original research	Very low
Gouda et al 2019	Africa	Sub-Saharan Africa	GBD 2017	Non-communicable diseases	Neoplasms 16 946·7 (15 691·4–18 311·1) Lip and oral cavity cancer 240·4 (222·4–258·0) Nasopharynx cancer 119·9 (107·4–132·8) Other pharynx cancer 80·4 (67·8–89·5) Oesophageal cancer 743·8 (691·6–817·6) Stomach cancer 777·7 (729·5–829·8) Colon and rectum cancer 918·1 (852·0–996·5) Liver cancer 1226·0 (1114·7–1396·2) Gallbladder and biliary tract cancer 122·0 (106·0–155·0) Pancreatic cancer 399·0 (368·2–433·9) Larynx cancer 172·8 (159·9–186·7) Tracheal, bronchus, and lung cancer 934·1 (865·5–1007·3) Malignant skin melanoma 107·9 (83·9–136·7) Non-melanoma skin cancer 105·5 (85·3–116·6) Breast cancer 1701·9 (1475·2–1975·1) Cervical cancer 1706·4 (1457·6–1901·4) Uterine cancer 130·9 (116·2–145·7) Ovarian cancer 312·2 (276·3–348·1) Prostate cancer 903·4 (633·9–1064·1)	Original research	Moderate

					Testicular cancer 20·0 (17·9–23·4) Kidney cancer 190·0 (167·2–214·1) Bladder cancer 203·2 (184·3–221·7) Brain and nervous system cancer 709·4 (557·2–824·0) Thyroid cancer 78·8 (69·5–89·2) Mesothelioma 26·8 (22·6–30·9) Cardiovascular diseases 22 860·8 (21 507·2–24 304·8) Rheumatic heart disease 1036·7 (866·3–1228·8) Non-rheumatic valvular heart disease 162·2 (141·9–188·5) Aortic aneurysm 184·4 (151·5–213·1) Peripheral vascular disease 65·5 (41·7–91·0) Digestive diseases 12 551·0 (10 420·8–14 609·6) Upper digestive system diseases 2916·0 (2265·8–3757·6) Appendicitis 445·4 (350·3–535·4) Paralytic ileus and intestinal obstruction 1887·4 (1398·7–2249·4) Inguinal, femoral, and abdominal hernia 315·4 (239·6–394·7) Inflammatory bowel disease 118·1 (88·1–164·5) Vascular intestinal disorders 135·3 (82·5–164·9) Gallbladder and biliary diseases 329·4 (240·5–399·6) Pancreatitis 293·1 (206·0–416·3) Other digestive diseases 572·0 (412·3–784·8) Decubitus ulcer 43·1 (30·0–63·0) Musculoskeletal disorders 9763·4 (7160·2–12 991·0) Other musculoskeletal disorders 1181·8 (824·1–1605·0) Other non-communicable diseases 28 841·8 (25 069·3–33 049·5) Congenital anomalies 18 512·3 (16 488·0–21 897·3) Urinary diseases and male infertility 1432·3 (1282·8–1600·6) Gynaecological diseases 1161·4 (810·9–1625·0) Oral disorders 1323·0 (782·9–2071·5)		
Habib et al 2015	Africa	16 countries in Western Africa	Systematic review of literature with meta-analysis	Snake bite envenoming	Benin 8376 (6523–10569) Burkina Faso 21283 (16409–26933) Cameroun 18690 (14492–23572)	Systematic review	Low

					Chad 13947 (10770–17475) Cote d'Ivoire 18687(14530–23461) Gambia 2215 (1676–2815) Ghana 22243 (17296–28081) Guinea Bissau 1699 (1318–2129) Guinea Conakry 11344 (8800–14296) Liberia 2659 (2115–3370) Mali 16963 (13106–21375) Niger 18833 (14484–23827) Nigeria 137105 (106800–172261) Senegal 13787 (10667–17309) Sierra Leone 6477 (5048–8149) Togo 5564 (4324–7031) Total 319874(248357–402654)		
Ilbawi et al 2013	Africa	Cameroon	Single centre case series over 3 years. 2004 - 2007.	Surgical disease	DALYs Injuries 281 Infections 183 All abdominal cases 939 Elective abdomen/groin 110 Acute abdomen 829 Obstetrics/Gynaecology 3305 Obstetrics 3137 Gynaecology 168 Congenital anomalies 57 Malignancies and tumors 213 Urology 192 Cutaneous diseases 8 Total 5,178	Original research	Very low
Misganaw et al 2017	Africa	Ethiopia	GBD 2015	257 diseases and injuries	Disease and injuries Age-standardized DALY rates - 2015 Maternal disorders 830.7 (377.6–1786.5) Neonatal disorders 3296.7 (2873.9–3735.8) Other CMNN diseases 983.3 (628.1–1460.4)	Original research	Moderate

					Neoplasms 3192.1 (1857.2–5221.3) Digestive diseases 1094.7 (732.9–1587.6) Neurological disorders 1119.2 (837.4–1433.1) Musculoskeletal disorders 1471.8 (1069–1974.5) Other non-communicable diseases 3423.1 (2615.7–4401.9) Transport injuries 818.3 (520.2–1308.8) Unintentional injuries 2075.3 (1530.5–2833.7) Self-harm and violence 785.8 (438.2–1413.9) War and disaster 101.6 (63.7–153.7)		
Shegaze et al 2020	Africa	Ethiopia	GBD 2016	Cancer	Cause DALY (1000's) All cancer 2012.5 Mouth and oropharynx cancer 55.3 Oesophagus cancer 53 Stomach cancer 51.6 Colon and rectum cancer 127.8 Liver cancer 42.4 Pancreas cancer 17.7 Trachea, bronchus, lung cancer 58.6 Breast cancer 327 Uterine cancer 180.3 Ovarian cancer 97.6 Prostate cancer 35.3 Kidney cancer 71.3 Bladder cancer 26.6 Brain and nervous system cancers 22.4 Gallbladder and biliary tract cancer 22.8 Thyroid cancer 37.5	Original research	Moderate
Ulrich et al 2020	Africa	Uganda	Prospective data base held at Mulago National Referral Hospital	8 most common congenital anomalies	Total - 202,384 DALYs Gastroschisis 42,811 DALYs ARMs 35,294 DALYs Omphalocele 21059 Duodenal obstruction 19024	Original research	Low

					Sacrococcygeal teratoma 2378 Intestinal atresia 33165 Duodenal obstruction 19024 Oesophageal atrasia or tracheoesophageal fistula 30059		

Table 9-2. *Included studies in Region of the Americas*

Study	Region	Country	Source of data	Disease studied	Data extraction	Type of study	GRADE rating
Dominguez et al 2014	Americas	Cuba	National database 2006 (descriptive epidemiological study)	Breast, Endometrial, Cervical, Ovarian cancer	Breast 228 DALYs/100,000 Cervical 224.2 DALYs/100,000 Endometrial 95.5 DALYs/100,000 Ovarian 52 DALYs/100,000	Original research	Very low
Reis et al 2020	Americas	Brazil	GBD 2017	Cervical cancer	238.99 (95% UI 230.45–247.99) DALYs per 100,000 women	Original research	Moderate
Dávila-Cervantes & Pardo-Montaño	Americas	Mexico	GBD 2019	Injuries	3785.6 (3321.8, 4314.3) DALYs/100,000	Original research	Moderate
Dominguez Alonso et al 2009	Americas	Cuba	GBD 2002	Cancers	Site DALY/100,000 Lung 6.23 Breast 4.54 Prostate 3.48 Colorectal 2.58 Endometrium 2.42 Uterus 2.03 Stomach 1.04 Ovary 0.88 Pancreas 1.03 Mouth and oropharynx 0.81 Liver 0.99 Melanoma and other skin 0.69 Esophagus 0.67 Bladder 0.57	Original research	Moderate

Table 9-3. *Included studies from South-East Asian Region*

Study	Region	Country	Source of data	Disease studied	Data	Type of study	GRADE rating
India State-Level Disease Burden Initiative Cancer Collaborators	South-East Asia	India	GBD 2016	All cancers	Stomach - 159·5 DALY/100,000 Breast - 45·7 DALY/100,000 Lung - 133·8 DALY/100,000 Lip and oral cavity - 128·0 DALY/100,000 Pharynx - 120·6 DALY/100,000 Colorectal - 103·5 DALY/100,000 Cervical - 91·9 DALY/100,000 Oesophageal - 76·8 DALY/100,000 Brain and nervous system - 56·7 DALY/100,000	Original research	Moderate
Chatterjee et al 2015	South-East Asia	India	Single centre case series - DALYs averted by surgery	All surgical disease over one year (2010) in one hospital	Abortion 111 Abscess 17 Anal fissure 8 Appendectomy 704 Caesarean section (Elective) 2957 Caesarean section (Emergency) 1095 Calculus of kidney 134 Cataract 156 Cholecystectomy 689 Circumcision 123 Dilation and curettage 164 Ectopic pregnancy 264 ERCP 125 Haematoma 468 Hernia repair 233 Hip replacement 60 Hydrocele 56 Hysterectomy 1177 Injury - Crushing 32	Original research	Very low

					Injury - Face bones 20 Injury - Femur 42 Injury - Head 64 Injury - Patella, tibia and/or fibula 75 Injury - Radius and/or ulna 15 Injury - Scapula, clavicle and/or humerus 110 Injury - Other 73 Joint surgery 228 Mastectomy 34 Otitis media 4 Ovarian cyst 33 TURP 77 Wound debridement 1		
Ghosselin et al 2012	South-East Asia	Bhutan	Single centre case series at national referral centre. Data from 2006.	Injuries (all)	5161 DALYs	Original research	Very low
Kimman et al 2012	South-East Asia	ASEAN Countries	GLOBOCAN 2008	All cancers	Laos - 1941 DALYs/100,000 Vietnam - 1863 DALYs/100,000 Myanmar - 1853 DALYs/100,000 Indonesia - 1841 DALYs/100,000 Philippines - 1411 DALYs/100,000 Singapore - 1492 DALYs/100,000	Original research	Moderate
Kulothungan et al 2022	South-East Asia	India	National Cancer Registry Program 2016	All cancer	1277 DALYs/100,000	Original research	Low
Kunnavil et al 2015	South-East Asia	India	Six population based cancer registries.	Brest cancer	40209 DALYs/100,000	Original research	Low
Menon et al 2019	South-East Asia	India	GBD 2016, India Million Death Study	44 categories of disease	Cancer - 1400 DALYs/100,00 Road traffic accidents - 1200 DALYs/100,00 Musculoskeletal disorders - 1000 DALYs/100,00	Original research	Moderate

Murthy et al 2010	South-East Asia	India	Indian Council of Medical Research Population Based Cancer Registries	Cancer	Oral cavity 1,140,297 Oesophagus 293,997 Stomach 244,101 Colon & Rectum 231,894 Liver 178,907 Pancreas 97,023 Lung 372,259 Melanoma & Other Skin 61,889 Breast 1,253,408 Cervix 539,279 Uterine 61,910 Ovary 276,909 Prostate 76,362 Bladder 77,281	Original research	Moderate
Shrestha et al 2021	South-East Asia	Nepal	GBD 2017	Cancers	Disease DALYs Tracheal, bronchial and lung 54760.72(35829.35–76709.73) Breast cancer 48474.7(35210.61–88091.39) Cervical cancer 30737.74(21361.55–42196.93) Colon and rectum cancer 29359.51(23065.58–37900.19) Oesophageal cancer 27772.23(22568.33–33243.15) Lip and oral cavity cancer 28312.39(22176.93–35115.35) Stomach cancer 42129.89(34853.01–49963.98) Bladder cancer 5390.97(4157.5–8115.11) Brain and nervous system cancer 18258.21(11886.93–30586.76) Gallbladder and biliary tract cancer 14606.16(10796.77–19727.16) Kidney cancer 3764.51(2545.23–5691.44) Larynx cancer 17908.29(14393.78–21738.22) Liver cancer 18087.38(12329.42–28502.49) Malignant skin melanoma 1243.48(821.69–2175.29)	Original research	Moderate

					Mesothelioma 944.14(651.38–1365.7) Nasopharynx cancer 5425.24(4369.06–6514.43) Non-melanoma skin cancer 3064.16(2125.64–3821.52) Ovarian cancer 9405.66(6937.78–12473.28) Pancreatic cancer 12828.49(8887.95–18122.03) Prostate cancer 11072.92(7848.86–14710.17) Testicular cancer 907.02(538.54–1280.61) Thyroid cancer 3913.14(3028.83–5290.95) Uterine cancer 3637.86(2593.66–4938.2)		
Xie & Shang 2022	South-East Asia	Asia	GBD 2019	Oral cancer	Nation DALY 1000s (95%UI) Asia 39548.26(35003.48-44708.67) East Asia 6563.36(5590.63,7748.15) Southeast Asia 4064.3(3373.12,4852.97) Central Asia 416.28(375.67,464.78) South Asia 26898.83(23168.66,31458.19) West Asia 1003.73(867.62,1170.99) Armenia 12.01(9.89-14.41) Afghanistan 47.11(27.84-66.56) Azerbaijan 27.45(21.43-34.42) Bahrain 3.11(2.27-4.10) Bangladesh 1446.51(986.87-2047.83) Bhutan 7.38(5.05-10.47) Brunei Darussalam 2.82(2.43-3.29) Cambodia 87.50(64.55-114.43) China 5758.05(4795.22-6907.43) Democratic People's Republic of Korea 109.43(82.22-147.43) Georgia 32.70(27.06-39.12) India 19226.64(15853.85-23180.25) Indonesia 1131.43(833.76-1533.09) Iran(Islamic Republic of) 124.33(115.07-135.23) Iraq 66.50(49.51-87.04)	Original research	Moderate

					Jordan 18.59(15.21-22.83) Kazakhstan 111.02(95.00-130.72) Kuwait 4.86(3.98-5.89) Kyrgyzstan 21.19(18.07-24.95) Lao People's Democratic Republic 27.04(20.11-35.42) Lebanon 17.19(13.09-22.78) Malaysia 178.80(136.52-229.72) Maldives 1.73(1.41-2.09) Mongolia 16.49(12.38-21.90) Myanmar 259.68(194.13-348.24) Nepal 277.41(210.46-350.56) Pakistan 5940.89(4713.17-7548.97) Palestine 4.84(4.03-5.72) Philippines 434.44(353.93-527.79) Sri Lanka 244.89(175.24-328.03) Tajikistan 13.66(10.82-17.17) Thailand 677.76(490.89-893.14) Timor-Leste 4.05(2.74-5.35) Turkmenistan 27.81(22.01-35.37) Uzbekistan 153.96(128.1-184.82) Viet Nam 998.11(746.9-1283.94)		
Gupta et al 2020	South-East Asia	High burden countries for rheumatic heart disease	GBD 2017	Rheumatic heart disease	Country DALYs (thousands) India 3733.3 Pakistan 296.21 Bangladesh 134.99 Myanmar 52.15 Afghanistan 54.06 Uzbekistan 68.62 Nepal 52.41 Madagascar 45.85 Iraq 25.11 Angola 33.54	Original research	Moderate

					Mozambique 31.05 Niger 30.31 Kazakhstam 14.98 Tajikistan 11.7 Turkmenistan 7.21		

Table 9-4. *Included studies from European Region.*

Study	Region	Country	Source of data	Disease studied	Data	Type of study	GRADE rating
Jankovic et al 2007	European	Serbia	Serbian Burden of Disease study 2003	All diseases (data on surgical diseases extracted)	Disease DALYs Lung, trachea, and bronchial cancer 59 088 Road traffic injuries 30 468 Self-inflicted injuries 27 938 Colon and rectum cancer 26 007 Breast cancer 23 868 Stomach cancer 16 487 Birth asphyxia and birth trauma 13 520 Cervical cancer 8230	Original research	Low

Table 9-5. *Included studies from Eastern Mediterranean Region.*

Study	Region	Country	Data source	Disease	Data	Type of study	GRADE rating
Abbasi-Kangevari et al 2022	Eastern Mediterranean	EMRO	GBD 2019	Prostate Cancer	DALY - 186.8 (147.7-219.5) per 100,000 population	Primary research	Moderate
Al-Hajj et al 2020	Eastern Mediterranean	EMRO	GBD 2017	Injuries in children	61,039,122.3 (UI 57,989,710.8-64,146,588.9) DALYs	Primary research	Moderate
GBD 2015 ENRO Transportation Injuries Collaborators	Eastern Mediterranean	EMRO	GBD 2015	Transportation injuries	8,069,712 (95% UI 7,303,759–8,888,094) DALYs Also includes age standardised DALY rate per 100,000 per country: Eastern Mediterranean Region 1248.9 (1131–1375.1) Afghanistan 3151.7 (2378–4188.6) Bahrain 619.3 (515.8–757.3) Djibouti 1018.8 (530.8–1949.4) Egypt 739.1 (678.2–800.6) Iran 1981.8 (1588.3–2478.4) Iraq 1133.4 (856.4–1486.9) Jordan 826.9 (718.9–940.6) Kuwait 703.1 (602.2–828.2) Lebanon 429.7 (306.3–620.3) Libya 1800.1 (1347.9–2247.5) Morocco 967.1 (745.4–1261.2) Oman 1967.4 (1641.1–2371.3) Pakistan 754.6 (563–1003.5) Palestine 720 (565.3–917.4) Qatar 1455.3 (1136.6–1808.1) Saudi Arabia 1210.7 (1061.2–1355.5) Somalia 1141 (429.8–2657.2) Sudan 2042.4 (1384.1–2978.8) Syria 691.2 (576–791.7) Tunisia 817.7 (665.2–1021.6)	Primary research	Moderate

					United Arab Emirates 1652.4 (1233–2087.7) Yemen 2021.3 (1245.1–3175.3)		
GBD 2015 EMRO Cancer Collaborators 2018	Eastern Mediterranean	EMRO	GBD 2015	All cancer	1.7 million (10.8–12.7 million) DALYs DALYs (in thousands) All cancers groups 11,740 (10,800–12,742) Lip and oral cavity cancer 312 (263–368) Nasopharynx cancer 82 (71–97) Other pharynx cancer 87 (76–99) Esophageal cancer 516 (452–595) Stomach cancer 769 (690–851) Colon and rectum cancer 764 (678–859) Liver cancer 740 (588–823) Gallbladder and biliary tract cancer 148 (124–169) Pancreatic cancer 308 (285–331) Larynx cancer 218 (193–245) Tracheal, bronchial and lung cancer 1330 (1171–1475) Malignant skin melanoma 36 (31–44) Non-melanoma skin cancer 36 (33–39) Breast cancer 1328 (1115–1561) Cervical cancer 251 (192–323) Uterine cancer 193 (157–228) Ovarian cancer 235 (201–271) Prostate cancer 243 (180–297) Testicular cancer 52 (40–68) Kidney cancer 170 (152–190) Bladder cancer 289 (263–320) Brain and nervous system 779 (666–881) Thyroid cancer 49 (42–58) Mesothelioma 34 (30–39) Other neoplasms 953 (840–1103)	Primary research	Moderate
Malekzadeg et al 2015	Eastern Mediterranean	Iran	GBD 2010	GI and liver disease	DALYs (95%UI) Stomach cancer 55751.6 (29309.2 - 81707)	Original research	Moderate

					Oesophageal cancer 23823.5 (15315.1-38285.7) Colorectal cancer 23148.1 (16611.7-30351.9) Other digestive diseases 14693.1 (4827.3-22064.4) Liver cancer hepatitis C 7838.6 (3902.7-11237.6) Liver cancer hepatitis B 6174.9 (3012.5-8948.5) Gallbladder cancer 5255.7 (2515.1- 8977.2) Pancreatic cancer 5066.5 (2970.1- 7831.2) Peptic ulcer 5335.8 (2394.1-11226.5) Liver cancer other 5337.3 (2276.3 - 8436.6) Liver cancer alcohol 2998.4 (1431.5 - 4268.8) Gall bladder diseases 4519.1 (2824.5 -7206) Appendicitis 4074.6 (1712.9 - 6585) Pancreatitis 988.7 (635.2 - 1537.7)		
Modiran et al 2015	Eastern Mediterranean	Iran	GBD 2010	Cancers	Cancers - 1,025,443.19 (Rate 1763.66/100,000) Non-communicable diseases - 13665328.62 (21382.4)	Original research	Moderate
Naghavi et al 2003	Eastern Mediterranean	Iran	Iran Ministry of Health and District Health Department	All	Disease - DALY (1000s) Road traffic injuries - 1963 Natural disasters - 1455 Knee osteoarthritis - 438	Original research	Moderate
Nejadghaderi et al 2022	Eastern Mediterranean	North Africa and Middle East	GBD 2019	Thyroid cancer	North Africa and Middle East region - 74,180 (62,526 to 86,119)	Original research	Moderate
Safiri et al 2022	Eastern Mediterranean	Middle East & North Africa	GBD 2019	Female breast cancer	Region/Country DALYs (95% UI) North Africa and Middle East 1,222,835 (1,053,073, 1,411,009) Afghanistan 48,258 (36,046, 63,895) Algeria 83,225 (62,174, 107,206) Bahrain 3592 (2857, 4487) Egypt 163,089 (112,703, 223,017) Iran (Islamic Republic of) 161,486 (147,227, 177,500) Iraq 109,032 (79,889, 147,823)	Original research	Moderate

					Jordan 23,176 (17,862, 29,882) Kuwait 6066 (4831, 7893) Lebanon 30,575 (23,260, 40,346) Libya 18,190 (12,936, 25,290) Morocco 158,502 (114,796, 219,730) Oman 4235 (3446, 5087) Palestine 11,138 (9150, 13,244) Qatar 3325 (2493, 4364) Saudi Arabia 56,033 (40,441, 75,439) Sudan 50,738 (32,468, 73,398) Syrian Arab Republic 24,006 (16,758, 34,377) Tunisia 33,143 (23,657, 44,761) Turkey 176,292 (138,548, 222,264) United Arab Emirates 17,621 (12,543, 23,549) Yemen 39,870 (28,352, 56,502)		
Safiri et al 2021	Eastern Mediterranean	Eastern Mediterranean region	GBD 2017	Transport related injuries	Eastern Mediterranean Region - 10,784,573 (9,957,150, 11,704,382)	Original research	Moderate
Shokri et al 2022	Eastern Mediterranean	Iran	GBD 2019	Lung cancer	286.8 (266.1–3 07.6) DALYs /100,000	Original research	Moderate
Ramazani et al 2021	Eastern Mediterranean	North Africa and the Middle East	GBD 2017	Gastric Cancer	Country ASR DALY rate Afghanistan 836.08(664.43–1033.46) Algeria 95.84(86.61–105.34) Egypt 78.71(69.84–88.67) Iran 296.79(286.32–308.72) Iraq 68.37(63.23–74.39) Jordan 84.07(74.29–95.25) Lebanon 125.33(112.67–138.95) Libya 142.81(122.41–164.78) Morocco 82.10(68.74–96.95) Palestine 121.36(111.44–132.11) Sudan 322.16(247.22–404.95)	Original research	Moderate

					Syria 87.89(74.64–102.98) Tunisia 97.08(78.85–118.02) Turkey 216.08(193.88–237.32) Yemen 436.93(328.29–555.18) MENA 189.03(178.95–198.92)		
Ben Abdelaziz 2019	Eastern Mediterranean	Algeria, Tunisia, Morrocco	GBD 2017	Cancers	Algeria - 1516 (1404-1611) DALYs/1000,000 Tunisia - 1985 (1636-2386) DALYs/1000,000 Morocco - 1992 (1684-2338) DALYs/1000,000	Original research	Moderate
Naghavi et al 2009	Eastern Mediterranean	Iran	GBD 2002	Injury	21,370 DALYs	Original research	Moderate
Al Saidi et al 2022	Eastern Mediterranean	22 Arabic nations	GBD 2019	Bladder cancer	Country/Region DALYs Algeria 12204.313 Bahrain 589.047 Comoros 218.449 Djibouti 343.694 Egypt 146006.404 Iraq 28575.555 Jordan 4149.817 Kuwait 1486.73 Lebanon 10051.597 Libya 5046.755 Mauritania 960.843 Morocco 13632.953 Oman 682.024 Palestine 1521.84 Qatar 375.706 Saudi Arabia 5811.828 Somalia 3166.278 Sudan 10810.029 Syrian Arab Republic 4789.598 Tunisia 9647.67 United Arab Emirates 5504.675	Original research	Moderate

					Yemen 7400.041 Global 4392583.341 High SDI 1247727.376 High-middle SDI 1329958.706 Middle SDI 1032346.548 Low-middle SDI 505458.044 Low SDI 274570.451		
Bawazir 2017	Eastern Mediterranean	Yemen	GBD 2010, Aden Cancer Centre, GLOBOCAN 2012	Breast cancer	344,925 DALYs	Original research	Moderate

Table 9-6. *Included studies reporting data from Western Pacific Region.*

Study	Region	Country	Source of data	Disease studied	Data	Type of study	Grade of evidence
Qiu et al 2021	Western Pacific	China	GLOBOCAN 2020	All cancers	Disease - DALYs \All cancers 67,340,309 Tracheal, bronchus, and lung cancer 17,128,584 Stomach cancer 9,824,993 Colon and rectum cancer 6,394,918 Oesophageal cancer 5,759,997 Liver cancer 5,325,461 Breast cancer 2,957,454 Pancreatic cancer 2,805,178 Other malignant neoplasms 2,071,051 Brain and central nervous system cancer 2,053,424 Cervical cancer 1,622,242 Prostate cancer 1,002,595 Nasopharynx cancer 912,107 Ovarian cancer 835,056 Bladder cancer 816,119 Gallbladder and biliary tract cancer 763,584 Kidney cancer 642,799 Lip and oral cavity cancer 575,805 Larynx cancer 497,928 Uterine cancer 364,277 Non-melanoma skin cancer 324,379 Thyroid cancer 187,319 Malignant skin melanoma 150,117 Mesothelioma 79,117 Testicular cancer 51,146	Original research	Moderate
Sun et al 2020	Western Pacific	China	GLOBOCAN 2018	Cancer	Disease DALYs/100,00 Lung 1079.9	Original research	Moderate

					Liver 789.6 Stomach 553.3 Oesophagus 316.1 Colorectal 301.2 Breast 186.8 Brain, CNS 138.7 Pancreas 133.9		
Yan et al 2022	Western Pacific	China	Chinese Cancer Registry Report 2015	Breast cancer	22,515,000 DALYS	Original research	Moderate
Yang et al 2021	Western Pacific	China, Mongolia	GBD 2019	Gastric cancer	China 98.25 Mongolia 2.77 East Asia & Pacific 123.1 World 222.2	Original research	Moderate
Yang et al 2021	Western Pacific	China	GBD 2017	Oral cancer	509,746.1 (478,229.8, 538,113.9) DALYs	Original research	Moderate
Zhang et al 2022	Western Pacific	China	GBD 2019	Lip and oral cancer	40.48266785 DALYs/100,000	Original research	Moderate
Zhang et al 2022	Western Pacific	China	GBD 2019	Cancer	Morphology All-age DALYs, no. 103(95% UI) All neoplasms 65269.26 (53487.48,77903.09) Tracheal, bronchus, and lung cancer 17128.58 (14340.49,20231.34) Stomach cancer 9824.99 (8191.72,11632.86) Colorectal cancer 6394.92 (5462.29,7408.70) Esophageal cancer 5760.00 (4581.77,6999.57) Liver cancer 5325.46 (4425.69,6374.59) Cervical cancer 1622.24 (892.58,2090.86) Breast cancer 2957.45 (2408.51,3590.17) Pancreatic cancer 2805.18 (2368.77,3276.55) Brain and central nervous system cancer 2053.42 (1584.34,2524.97) Prostate cancer 1002.59 (794.01,1322.63)	Original research	Moderate

					Ovarian cancer 835.06 (612.56,1063.25) Nasopharynx cancer 912.11 (760.83,1081.93) Bladder cancer 816.12 (691.35,967.38) Gallbladder and biliary tract cancer 763.58 (566.76,920.49) Uterine cancer 364.28 (286.56,503.57) Kidney cancer 642.8 (533.66,763.98) Lip and oral cavity cancer 575.81 (479.52,690.74) Larynx cancer 497.93 (411.84,600.18) Non-melanoma skin cancer 324.38 (272.52,376.46) Thyroid cancer 187.32 (156.24,219.11) Malignant skin melanoma 150.12 (93.91,189.54) Other pharynx cancer 145.47 (117.12,176.32) Testicular cancer 51.15 (42.02,61.19) Mesothelioma 79.12 (65.07,94.57)		

Table 9-7. *Included studies from multiple WHO regions or with a global focus.*

Study	Region	Country	Data source	Disease	Data	Type of study	GRADE ranking
Allahqoli et al 2022	Global	Global	GBD - 2019	Female breast cancer	Global - 473.83 (437.3 - 510.51) /100,000, AFRO - 58.1.45 (487.56 - 680.12), Americas - 496.90 (467.77 - 528.93), SE Asia - 460 (386.42 - 543.77), EMRO - 780.99 (659.45-936.68), WESTPAC - 331.65 (288.07-379.58)	Primary research	Moderat e
GBD 2019 Colorectal Cancer Collaborators	Global	Global	GBD 2019	Colorectal cancer	Global - 24 284 087 (22 614 920–25 723 221), Andean & Latin America - 125 578 (101 753–151 796), Caribbean - 172 016 (147 186–200 175), Central Asia - 199 841 (182 012–219 941), central sub-Saharan Africa - 100 988 (75 749–131 447), East Asia - 6 712 862 (5 774 277–7 735 907), Eastern sub-Saharan Africa - 356 433 (301 931–425 606), North Africa and Middle East - 1 013 634 (896 161–1 146 526), Oceana - 16 315 (12 915–20 556), South Asia - 2 419 098 (2 078 019–2 782 570), Southeast Asia - 2 142 434 (1 780 490–2 482 287), Southern Latin America - 366 436 (347 729–385 441), Southern sub-Saharan Africa - 147 780 (132 439–165 539), Tropical Latin America - 660 129 (625 562–687 740), Western sub-Saharan Africa - 353 242 (295 571–420 704)	Primary research	Moderat e
GBD 2019 Respiratory Tract Cancer Collaborators	Global	Global	GBD 2019	Respiratory cancers	Larynx cancer - 3,260,000 (3,030,000 to 3,510,000) DALYs Tracheal, bronchus and lung cancer - 45,900,000 (42,300,000 to 49,300,000) DALYs	Primary research	Moderat e
Bai et al 2020	Global	Global	GBD 2017	Kidney cancer (all subtypes)	Overall 3284.32 (3085.56–3393.16) Socio-demographic factor High-middle SDI 843.42 (798.96–879.28) Middle SDI 620.20 (575.96–660.73) Low-middle SDI 332.52 (305.98–357.67)	Primary research	Moderat e

					Low SDI 189.05 (160.88–214.37) Region Andean Latin America 25.82 (22.59–28.92) Australasia 31.61 (28.62–34.96) Caribbean 20.95 (18.80–25.11) Central Asia 52.34 (49.29–55.11) Central Europe 175.47 (155.5–184.35) Central Latin America 126.95 (120.72–133.94) Central Sub-Saharan Africa 20.76 (16.72–25.24) East Asia 472.46 (417.97–507.41) Eastern Europe 318.58 (304.82–330.17) Eastern Sub-Saharan Africa 66.59 (54.91–79.91) High-income Asia Pacific 149.03 (134.76–159.4) High-income North America 407.78 (387.52–435.78) North Africa and Middle East 140.56 (120.36–150.18) Oceania 2.28 (1.78–2.92) South Asia 251.84 (225.69–265.85) Southeast Asia 176.89 (149.46–192.46) Southern Latin America 80.86 (73.15–90.63) Southern Sub-Saharan Africa 19.10 (16.97–21.29) Tropical Latin America 107.71 (102.44–112.13) Western Europe 553.19 (510.18–582.26) Western Sub-Saharan Africa 83.55 (70.63–98.56)		
Bencheikh et al 2023	Global	Global	GBD 2019	Vascular disease (aortic aneurysm, ischaemic stroke peripheral, arterial disease)	Low Income: Aortic Aneurysms 131,777 Ischemic Stroke 2,455,709 Peripheral Artery 57,467 Low middle income: Aortic Aneurysms 794,568 Ischemic Stroke 18,608,312 Peripheral Artery Disease 246,933	Primary research	Moderate

					Upper Middle income: Aortic Aneurysms 1,177,024 Ischemic Stroke 33,246,046 Peripheral Artery Disease 526,001		
Choi et al 2023	Global	Global	GBD 2019	Primary liver cancer	High-middle SDI - 2,502,034 (2,214,723 - 2,839,723) Middle SDI - 5,463,765 (4,736,439 - 6,221,172) Low-middle SDI - 1,616,488 (1,469,159 - 1,785,003) Low SDI - 663,784 (570,133 - 758,108)	Primary research	Moderate
Deng et al 2017	Global	Global	GBD 2017	Thyroid cancer	Characteristics DALY (No. ×103 (95% UI)) Global 1,133.17 (1,073.44 - 1,227.49) Socio-demographic index High SDI 220.44 (205.12 - 239.51) High-middle SDI 204.21 (190.73 - 220.65) Low SDI 153.32 (136.63 - 169.90) Low-middle SDI 236.77 (214.78 - 270.13) Middle SDI 314.77 (294.66 - 346.94) Region Andean Latin America 12.82 (11.19 - 14.27) Australasia 4.77 (4.17 - 5.44) Caribbean 7.07 (6.36 - 7.87) Central Asia 7.63 (7.09 - 8.23) Central Europe 22.23 (20.81 - 23.89) Central Latin America 39.54 (37.35 - 42.02) Central Sub-Saharan Africa 5.74 (4.64 - 7.68) East Asia 184.14 (170.57 - 203.49) Eastern Europe 44.72 (41.69 - 48.39) Eastern Sub-Saharan Africa 52.65 (44.75 - 61.71) High-income Asia Pacific 52.27 (47.68 - 57.63) High-income North America 60.84 (56.16 - 66.36) North Africa and Middle East 63.08 (57.86 - 72.30) Oceania 1.67 (1.36 - 2.13) South Asia 297.71 (269.76 - 332.09)	Primary research	Moderate

					Southeast Asia 134.52 (122.89 - 156.20) Southern Latin America 10.04 (9.12 - 11.10) Southern Sub-Saharan Africa 6.32 (5.74 - 7.01) Tropical Latin America 28.57 (27.18 - 30.04) Western Europe 82.73 (76.83 - 90.09) Western Sub-Saharan Africa 14.10 (12.27 - 16.32)		
Deng et al 220	Global	Global	GBD 2017	Larynx cancer	DALY No. ×103 (95% UI) Global 3279.46 (3191.43 - 3375.12) Socio-demographic index High-middle SDI 677.61 (659.41 - 697.58) Middle SDI 827.46 (791.22 - 891.84) Low-middle SDI 785.51 (734.75 - 843.69) Low SDI 532.99 (485.24 - 577.35) Region Andean Latin America 8.72 (7.89 - 9.67) Australasia 6.30 (5.58 - 7.12) Caribbean 36.56 (32.95 - 40.31) Central Asia Central Latin America 56.48 (52.93 - 59.85) Central Sub-Saharan Africa 34.85 (32.80 - 36.90) East Asia 489.64 (465.71 - 513.79) Eastern Europe 187.82 (181.83 - 194.25) Eastern Sub-Saharan Africa 64.32 (57.67 - 71.76) North Africa and Middle East 179.67 (168.03 - 190.51) Oceania 3.74 (3.16 - 4.46) South Asia 1236.89 (1170.38 - 1309.34) Southeast Asia 209.25 (189.65 - 256.62) Southern Latin America 27.82 (24.84 - 31.22) Southern Sub-Saharan Africa 25.06 (23.56 - 26.72) Tropical Latin America 132.27 (128.63 - 136.5) Western Sub-Saharan Africa 61.19 (51.78 - 73.34)	Original research	Moderat e

Deng et al 2020	Global	Global	GBD 2017	Tracheal, bronchial and lung cancer	Characteristics DALYs (No.) 2017 (No. × 103) (95%UI) Global 40928.67 (40016.96–41855.08) Socio-demographic index High-middle SDI 12131.49 (11619.86–12612.67) Low SDI 1744.38 (1639.2–1857.13) Low-middle SDI 3086.99 (2902.02–3297.12) Middle SDI 11522.03 (10949.76–12140.59) Region Andean Latin America 111.23 (100.12–122.25) Australasia 209.62 (190.97–227.96) Caribbean 221.59 (204.91–239.15) Central Asia 313.61 (298.93–328.26) Central Latin America 492.36 (472.52–514.08) Central sub-Saharan Africa 123.99 (102.07–158.17) East Asia 15905.05 (15198.33–16566.97) Eastern Europe 1784.52 (1743.68–1825.11) Eastern sub-Saharan Africa 267.66 (247.43–295.11) North Africa and Middle East 1511.45 (1428.41–1590.68) Oceania 44.10 (35.58–60.27) South Asia 3131.09 (2942.45–3331.08) Southeast Asia 3005.25 (2747.8–3294.35) Southern Latin America 356.99 (328.99–388.02) Southern sub-Saharan Africa 213.18 (202.83–224.31) Tropical Latin America 750.05 (732.31–769.16) Western sub-Saharan Africa 329.25 (283.13–388.81)	Original research	Moderate
Di Pardo et al 2016	Global	Global	GLOBOCAN 2008	Oesophageal cancer	Global - 3,955,919 DALYs DALYs (Rate/100,000) China 1,885,642 (1.4) India 531,101 (0.44) Bangladesh 100,641 (0.62) Pakistan 82,966 (0.46) Brazil 81,717 (0.42)	Original research	Moderate

He et al 2020	Global	Global	GBD 2017	Bladder cancer	Socio-demographic index High-middle SDI 83.23 (80.03–87.57) Low SDI 23.83 (21.78–27.57) Low-middle SDI 51.97 (47.97–56.86) Middle SDI 67.02 (63.16–73.49) Region Andean Latin America 1.32 (1.17–1.49) Australasia 2.25 (2.03–2.48) Caribbean 2.41 (2.22–2.62) Central Asia 3.32 (3.14–3.51) Central Latin America 5.79 (5.53–6.06) Central Sub-Saharan Africa 2.51 (2.01–3.29) East Asia 62.14 (58.52–71.54) Eastern Europe 21.37 (20.57–22.22) Eastern Sub-Saharan Africa 7.17 (6.18–8.05) North Africa and Middle East 29.45 (26.75–33.62) Oceania 0.28 (0.23–0.33) South Asia 40.22 (37.35–44.86) Southeast Asia 21.41 (18–23.93) Southern Latin America 4.42 (4.04–4.87) Southern Sub-Saharan Africa 3.03 (2.68–3.31) Tropical Latin America 9.31 (9–9.62) Western Sub-Saharan Africa 7.6 (6.37–8.76)	Original research	Moderate
He 2021	Global	Global	GBD 2019	Gastric cancer	2019 (No.×1000) (95% UI) Global 22220.98 (20301.49,24071.76) China 9824.99 (8191.72,11632.86) Low SDI 1233.25 (1093.36,1390.35) Low-middle SDI 3773.51 (3441.56,4132.70) Middle SDI 8273.27 (7276.66,9296.06) High-middle SDI 6352.75 (5662.39,7023.40) Andean Latin America 263.03 (212.83,321.88) Australasia 38.91 (35.98,41.63)	Original research	Moderate

					Caribbean 97.7 (82.77,113.47) Central Asia 324.97 (294.10,359.73) Central Latin America 647.87 (550.78,763.65) Central Sub-Saharan Africa 125.5 (97.76,157.85) East Asia 10102.78 (8469.06,11888.73) Eastern Europe 1081.23 (971.54,1201.16) Eastern Sub-Saharan Africa 345.78 (298.17,399.76) North Africa and Middle East 1011.45 (904.54,1132.98) Oceania 28.67 (21.58,36.73) South Asia 2774.51 (2413.91,3168.20) Southeast Asia 987.32 (874.36,1105.38) Southern Latin America 209.27 (198.03,220.24) Southern Sub-Saharan Africa 95.72 (86.52,106.65) Tropical Latin America 556.71 (530.26,581.24) Western Europe 1097.49(1030.85,1149.17) Western Sub-Saharan Africa 396.23 (337.14,463.23)		
Higashi et al 2015	Global	LMICs	GBD 2010	Surgical digestive diseases	DALYs 1000s Appendicitis 1,419 Intestinal obstruction without hernia 3,390 Inguinal or femoral hernia 703 Gallbladder and bile duct disease 1,906	Original research	Moderat e
Higashi et al 2015	Global	Global	GBD 2015	Injuries	Road Injury Region DALY East Europe/Central Asia 779,308 Sub-Saharan Africa 3,507,638 North Africa/Middle East 1,093,122 South Asia 4,692,999 East Asia Pacific 4,336,877 Latin America/Caribbean 1,691,314 Total 16,101,257 Other transport injury	Original research	Moderat e

					Region DALY East Europe/Central Asia 47,120 Sub-Saharan Africa 270,686 North Africa/Middle East 66,709 South Asia 340,760 East Asia Pacific 309,928 Latin America/Caribbean 59,125 Total 1,094,328 Falls Region DALY East Europe/Central Asia 772,809 Sub-Saharan Africa 934,208 North Africa/Middle East 346,824 South Asia 2,031,692 East Asia Pacific 3,902,220 Latin America/Caribbean 524,038 Total 8,511,792 Fire, heat, and hot substance injuries Region DALY East Europe/Central Asia 270,469 Sub-Saharan Africa 3,010,660 North Africa/Middle East 291,629 South Asia 5,559,069 East Asia Pacific 403,174 Latin America/Caribbean 173,684 Total 9,708,685 Unintentional injury Region DALY East Europe/Central Asia 1,041,996		

					Sub-Saharan Africa 2,251,169 North Africa/Middle East 542,139 South Asia 3,778,108 East Asia Pacific 2,111,317 Latin America/Caribbean 943,515 Total 10,668,244 Interpersonal violence Region DALY East Europe/Central Asia 461,613 Sub-Saharan Africa 1,378,702 North Africa/Middle East 206,024 South Asia 1,043,360 East Asia Pacific 761,912 Latin America/Caribbean 2,381,028 Total 6,232,639 Injury totals Region DALY East Europe/Central Asia 3,373,316 Sub-Saharan Africa 11,353,064 North Africa/Middle East 2,546,447 South Asia 17,445,988 East Asia Pacific 11,825,428 Latin America/Caribbean 5,772,703 Total 52,316,945		
Higashi et al 2015	Global	Global	GBD 2010	Congenital anomalies (Cleft, congenital heart defects, neural tube defects	Clefts Region DALYs East Europe and Central Asia 8841 Sub-Saharan Africa 62 872 North Africa and Middle East 16 302 South Asia 128 182	Original research	Moderat e

					East Asia Pacific 94 435 Latin America and Caribbean 18 235 Total 328 867 Congenital heart anomalies Region DALYs East Europe and Central Asia 663 797 Sub-Saharan Africa 63 602 North Africa and Middle East 1 692 728 South Asia 979 165 East Asia Pacific 2 774 235 Latin America and Caribbean 1 123 160 Total 7 296 687 Neural tube defects Region DALYs East Europe and Central Asia 109 897 Sub-Saharan Africa 983 066 North Africa and Middle East 119 238 South Asia 2 923 628 East Asia Pacific 444 018 Latin America and Caribbean 203 057 Total 4 782 904 Total of all 3 anomalies Region DALYs East Europe and Central Asia 782 535 Sub-Saharan Africa 1 109 540 North Africa and Middle East 1 828 268 South Asia 4 030 975 East Asia Pacific 3 312 688 Latin America and Caribbean 1 344 452		

					Total 12 408 458 LMICs Clefts 555 094 Congenital heart anomalies 14 755 312 Neural tube defects 6 294 486		
Ji et al 2020	Global	Global	GBD 2017	Breast Cancer	Characteristic DALY SDI High-middle 3536312 (3,259,624–3,720,805) Middle 4,433,924 (3,996,316–4,723,874) Low-middle 3,569,694 (3,178,209–4,459,868) Low 1,819,824 (1,680,310–1,980,751) Region Central Asia 198,308 (185,440–212,929) East Asia 2,824,713 (2,409,605–3,047,356) South Asia 3,487,738 (2,996,165–4,220,998) Southeast Asia 1,706,010 (1,574,939–1,845,127) Australasia 104,618 (91,721–118,054) Oceania 30,998 (22,602–44,128) Carribbean 144,948 (124,816–168,503) Andean Latin America 95,827 (83,870–110,884) Central Latin America 473,911 (448,947–499,652) Southern Latin America 219,614 (195,247–248,453) Tropical Latin America 565,785 (548,115–583,686) Eastern Europe 876,136 (845,015–910,073) Central Sub-Saharan Africa 168,772 (126,775–222,327) Eastern Sub-Saharan Africa 524,137 (457,901–605,323) North Africa and Middle East 969,604 (900,819–1,070,338) Southern Sub-Saharan Africa 160,614 (147,118–174,089) Western Sub-Saharan Africa 848,382 (649,940–1,116,388)	Original research	Moderat e
John & Ross 2010	Global	Global	GBD 2004	Cancer	Country DALY ('000) China 19302	Original research	Moderat e

					India 8,487 Russia 3109 Indonesia 2406 Brazil 2159 Nigeria 1203 Bangladesh 1123 Ukraine 980 Pakistan 972 Thailand 913 Mexico 816 Turkiye 760 Philippines 683 Vietnam 666 Egypt 595		
Kang et al 2021 (GBD OG Cancer Collaborators)	Global	Western Pacific and South-East Asia	GBD 2019	Brain and nervous system cancer	Region DALYs South East Asia 1 532 948 ((1 153 447 to 1 796 140) Western Pacific 2 470 092 (1 887 397 to 2 919 034)	Original research	Moderat e
Karimkhani et al 2015	Global	Global	GBD 2015	Melanoma	Region DALYs/100,000 Eastern Europe 7·8326 (6·2571–9·8118) 65·2106 (50·9055–84·6727) Central Europe 8·3560 (6·4831–10·5992) 57·7440 (43·5435–72·6766) Southern Sub-Saharan Africa 6·3628 (4·9125–7·8282) 33·6285 (25·9907–39·0645) Southern Latin America 5·2630 (3·8651–7·1943) 32·5423 (23·5926–45·1229) Tropical Latin America 5·5221 (4·1212–6·5629) 27·6028 (20·9512–30·5295) Central Asia 3·6565 (3·1654–4·5980) 20·3091 (17·9108–25·5949) Central Latin America 3·2885 (2·4786–4·3273) 17·7484 (13·3281–23·6114) Andean Latin America 2·8237 (2·3764–3·5472) 16·6716 (14·4629–20·9201) Oceania 2·5894 (1·8818–3·8080) 15·8802 (11·3658–24·2364)	Original research	Moderat e

					Caribbean 2·8244 (2·4326–3·6637) 14·6916 (12·7388–18·8543) Central Sub-Saharan Africa 2·1923 (1·4123–3·2689) 12·6024 (8·4114–19·7562) Eastern Sub-Saharan Africa 2·1221 (1·6561–2·6536) 11·5941 (9·0618–14·4732) Western Sub-Saharan Africa 2·2212 (1·7434–3·0505) 10·6301 (8·5621–14·7869) North Africa and Middle East 1·6660 (1·4458–2·2201) 10·4575 (9·2637–14·3409) East Asia 1·4307 (1·0586–1·7655) 10·2859 (7·5003–11·5445) Southeast Asia 1·3100 (1·0986–1·7015) 9·2136 (7·8837–11·9697) Asia Pacific 0·7130 (0·5524–0·9494) 7·7359 (5·7688–10·8982) South Asia 1·1088 (0·8943–1·4254) 6·4210 (5·5115–8·3923)		
Kocarnik et al 2022	Global	Global	GBD 2019	All cancers	SDI DALYs (millions) Low - 18 (15.9-20.2) Low-middle - 40.2 (36.8-43.7) Middle - 76.3 (69.7-83.2) High-middle - 63.5 (58.6-68.2)	Original research	Moderate
Lippi & Mattiuzzi 2020	Global	Global	GBD 2017	Pancreatic cancer	SDI DALYs Low - 753 per million Low-Middle - 1424 per million Middle - 3160 per million	Original research	Low
Liu et al 2022	Global	East Asia and Pacific	GBD 2019	Breast cancer	Region/Country - DALYs (1000s) East Asia and Pacific - 20,625.31 (19,043.05–22,174.4) China - 2957.45(2408.51– 3590.17)	Original research	Moderate
LV et al 2022	Global	Global	GBD 2019	Breast cancer	World Bank Income Status - DALYs (1000's) Low income - 1,102.66 (917.42–1,330.13) Lower Middle income - 7,951.67 (6,978.48–8,885.18) Upper middle income - 6,556.36 (5,880.50–7,289.31)	Original research	Moderate
Momenimovahed et al 2022	Global	Global	GBD 2019	Cervical cancer	Region DALY World bank income level	Original research	Moderate

					Low income 1 325 105 (996969-1670798) Low middle income 3 404 838 (2879036-4266168) Upper middle income 3 371 381 (2536703-3905565) WHO Regions African Region 1 878 932 (1455936_2310125) Eastern Mediterranean region 331 307 (254792_407536) South East Asia 2 258 636 (1842723_2972147) Western Pacific 2 135 723 (1333747_2632365) Americas 1 412 411 (1274478_1573926)		
Mubarik et al 2022	Global	Global	GBD 2017	Female breast cancer	South Asia - 3,432,683 (2941453, 4164191) Central Sub-Saharan Africa - 165,332 (123344, 218998) Western Sub-Saharan Africa - 841,439 (643411, 1109259) Southern Sub-Saharan Africa - 157,518 (144145, 170965) Caribbean - 143,012 (122890, 166457) Oceania - 30,752 (22374, 43891) North Africa and Middle East - 958,621 (889519, 1059683) Andean Latin America - 4,683 (82634,109651) Central Latin America - 470,478 (445493, 496143) Tropical Latin America - 557,150 (539687, 574935) Southern Latin America - 217566.5(193204, 246424) Central Asia - 196,394 (183615, 210934) South-East Asia - 1,684,759 (1553411,1823089) Eastern Europe - 866,215 (834927, 899837)	Original research	Moderate
Murray et al 2013	Global	Global	GBD 2010	291 diseases and injuries	Condition - DALYs (thousands) Communicable maternal, neonatal, and nutritional disorders - 868 024 (818 934–921 489) Maternal disorders - 16 104 (12 972–18 912) Neonatal disorders - 201 959 (182 138–221 901) Neoplasms - 188 487 (174 452–199 037) Cardiovascular diseases - 295 036 (273 061–309 562) Digestive diseases (excluding cirrhosis) - 32 691 (29 153–35 898)	Original research	Moderate

					Musculoskeletal disorders - 169 624 (129 771–212 734) Injuries - 278 665 (253 532–305 786)		
Pan et al 2022	Global	Global	GBD 2019	Early onset colorectal cancer (EO-CRC)	Cases (95% UI) Age-standardized DALY per 100 000 population (95% UI) Middle SDI 1,550,467 (1,388,571 to 1,717,229) Low-middle SDI 766,284 (672,536 to 870,105) Low SDI 288,192 (245,104 to 338,714) Region 100,788 (93,094 to 108,937) High-income Asia Pacific High-income North America 224,187 (212,140 to 237,605) Western Europe 207,340 (193,916 to 221,500) Australasia 16,851 (14,264 to 19,864) Andean Latin America 27,087 (20,040 to 35,742) Tropical Latin America 140,322 (130,057 to 151,074) Central Latin America 129,267 (109,626 to 152,485) Southern Latin America 50,371 (43,173 to 58,593) Caribbean 27,802 (22,083 to 34,737) Central Europe 88,960 (75,933 to 103,094) Eastern Europe 168,658 (147,831 to 192,396) Central Asia 49,744 (43,004 to 57,382) North Africa and Middle East 273,698 (231,829 to 322,390) South Asia 616,964 (520,893 to 727,009) Southeast Asia 522,972 (427,068 to 624,755) East Asia 1,366,228 (1,152,737 to 1,609,615) Oceania 5723 (4069 to 7991) Western Sub-Saharan Africa 97,086 (76,476 to 121,008) Eastern Sub-Saharan Africa 115,961 (93,351 to 143,938) Central Sub-Saharan Africa 30,537 (20,886 to 43,251) Southern Sub-Saharan Africa 37,028 (28,480 to 46,855)	Original research	Moderate
Patel et al 2019	Global	Global	GBD 2016	Brain and other CNS cancer	Region - DALYs Low SDI - 448 065 (390 748 to 505 097) Low-middle SDI - 1 485 406 (1 331 597 to 1 698 842)	Original research	Moderate

					Middle SDI - 2 714 483 (2 381 230 to 3 017 478) Also has country specific DALYs		
Pourshams et al 2019	Global	Global	GBD 2017	Pancreatic cancer	Region - DALYs Middle SDI - 1847413 (1756278, 1922329) Low-middle SDI - 912709 (862808, 981014) Low SDI - 416395 (387858, 446127) Also has individual country breakdown	Original research	Moderate
Qiu et al 2021	Global	China	GLOBOCAN 2020	All cancers	All cancers 67,340,309 Tracheal, bronchus, and lung cancer 17,128,584 Stomach cancer 9,824,993 Colon and rectum cancer 6,394,918 Oesophageal cancer 5,759,997 Liver cancer 5,325,461 Breast cancer 2,957,454 Pancreatic cancer 2,805,178 Other malignant neoplasms 2,071,051 Brain and central nervous system cancer 2,053,424 Cervical cancer 1,622,242 Prostate cancer 1,002,595 Nasopharynx cancer 912,107 Ovarian cancer 835,056 Bladder cancer 816,119 Gallbladder and biliary tract cancer 763,584 Kidney cancer 642,799 Lip and oral cavity cancer 575,805 Larynx cancer 497,928 Uterine cancer 364,277 Non-melanoma skin cancer 324,379 Thyroid cancer 187,319 Malignant skin melanoma 150,117 Mesothelioma 79,117 Testicular cancer 51,146	Original research	Moderate

Ramsey et al 2019	Global	High burden of nasopharyngeal cancer	GBD 2015	Nasopharyngeal cancer	DALYs/100,000 Malaysia (90.04) Tunisia (51.39) China (49.91) Thailand (39.87) Myanmar (63.03) Philippines (54.91) Laos (46.71) Cambodia (44.93) Vietnam (44.02) Afghanistan (22.57) Yemen (14.93) Sudan (12.94) Syrian Arab Republic (5.44) Malta (25.63) Romania (23.11) Venezuela (44.02) Tonga (36.96) Samoa (29.28) Grenada (24.79) Saint Lucia (23.41) Vanuatu (41.25) Kenya (32.92) India (24.18) Pakistan (24.05) Nepal (22.60) Solomon Islands (40.14) Papua New Guinea (37.21) Uganda (34.33) Djibouti (23.85) Eritrea (23.15)	Original research	Moderate

Ren et al 2020	Global	Global	GBD 2017	Oral cancer	Location Estimate 95% CI Region South Asia 180.83 (165.54–195.14) Eastern Europe 73.14 (70.38–76.17) Oceania 69.01 (56.69–96.47) Southern Sub-Saharan Africa 62.74 (58.35–67.47) Tropical Latin America 57.34 (55.18–59.39) Southeast Asia 55.91 (52.51–59.59) Eastern Sub-Saharan Africa 54.45 (49.93–59.22) Caribbean 53.72 (49.54–58.17) Central Sub-Saharan Africa 50.43 (43.68–57.17) Central Asia 45.14 (42.67–47.56) Western Sub-Saharan Africa 31.48 (27.50–35.77) Southern Latin America 30.72 (27.78–33.84) East Asia 28.17 26.69–29.54) Andean Latin America 25.1 (22.44–27.80) Central Latin America 23.13 (22.12–24.14) North Africa and the Middle East 19.02 (18.15–20.02) SDI category Low-middle-SDI 125.94 (114.22–138.75) Low-SDI 99.61 (92.48–106.91) Middle-SDI 57.09 (53.35–59.96) High-middle-SDI 38.63 (37.28–39.94)	Original research	Moderat e
Safiri et al 2021	Global	Global	GBD 2019	Tracheal, Bronchus and Lung Cancer	GBD Region DALY (95% UI) Southern Latin America 442,045 (418,326, 465,335) Eastern Europe 1,980,197(1,746,364, 2,218,058) Central Asia 387,448 (349,153, 429,746) Central Latin America 620,446 (525,145, 734,892) Andean Latin America 139,023 (110,696, 171,936) Caribbean 254,120 (215,965, 298,930) Tropical Latin America 887,599 (843,776, 929,377) East Asia 17,614,063 (14,810,292, 2,072,1521)	Original research	Moderat e

					Southeast Asia 3,429,720 (2,859,905, 3,965,337) Oceania 41,926 (31,280, 59,685) North Africa and Middle East 1,870,025 (1,648,815, 2,118,436) South Asia 3,089,930 (2,617,375, 3,550,873) Southern Sub-Saharan Africa 271,196 (244,455, 304,088) Western Sub-Saharan Africa 426,667 (354,157, 511,658) Eastern Sub-Saharan Africa 298,323 (247,993, 365,706) Central Sub-Saharan Africa 195,463 (126,063, 339,448)		
Song et al 2022	Global	Global	GBD 2019	Stomach cancer	Region DALYs (95%UI) Andean Latin America 263,028 (212,831 to 321,879) Caribbean 97,702 (82,770 to 113,470) Central Asia 324,971 (294,104 to 359,728) Central Europe 428,299 (374,968 to 482,886) Central Latin America 647,870 (550,777 to 763,649) Central Sub-Saharan Africa 125,499 (97,759 to 157,846) East Asia 10,102,781 (8,469,057 to 11,888,734) Eastern Europe 1,081,234 (971,542 to 1,201,164) Eastern Sub-Saharan Africa 345,779 (298,174 to 399,764) North Africa and Middle East 1,011,450 (904,537 to 1,132,984) Oceania 28,669 (21,580 to 36,725) South Asia 2,774,513 (2,413,908 to 3,168,197) Southeast Asia 987,321 (874,362 to 1,105,379) Southern Latin America 209,269 (198,034 to 220,237) Southern Sub-Saharan Africa 95,721 (86,515 to 106,655) Tropical Latin America 556,713 (530,256 to 581,239) Western Sub-Saharan Africa 396,231 (337,138 to 463,233)	Original research	Moderate
Stewart et al 2014	Global	Global	GBD 2010	Surgical disease requiring emergency surgery	Low- and middle-income countries DALYs/100,000 Hernia 11 Ileus and obstruction 54 Peptic ulcer disease 104 Biliary disease 30 Appendicitis 23	Original research	Moderate

					Soft tissue infections 47 Peripheral arterial disease* 10 Aortic aneurysm 34 Mesenteric ischaemia 9 Urolithiasis 15 Acute urinary retention† 7 Total 343		
Stewart et al 2016	Global	Sierra Leone and Nepal	Surgeons OverSeas Surgical Assessment Survey (SOSAS) conducted in 2014	Fractures	Country - DALYs 100,000s Sierra Leone - 597 (520 - 687) Nepal - 741 (527 - 853)	Original research	Moderat e
Wu et al 2023	Global	Global	GBD 2019	Colorectal cancer	Age-standardized DALY rate (per 100,000) Sociodemographic index – Low 166.10(148.36,185.88) Low-middle 209.51(189.36,231.12) Middle 273.61(247.05,299.90) High-middle 356.65(330.60,382.58) Region – Andean Latin America 220.77(179.05,266.30) Caribbean 333.31(285.19,387.92) Central Asia 256.81(234.43,281.07) Central Europe 512.56(448.72,577.87) Central Latin America 223.68(193.13,259.51) Central sub-Saharan Africa 169.27(129.19,220.17) East Asia 325.17(280.71,373.18) Eastern Europe 423.70(384.00,469.26) Eastern sub-Saharan Africa 193.87(165.98,229.61) North Africa and middle East 218.67(194.05,246.53)	Original research	Moderat e

					Oceania 203.57(163.60,252.47) South Asia 165.06(141.74,189.86) Southeast Asia 333.97(276.63,386.37) Southern Latin America 447.56(424.73,470.53) Southern sub-Saharan Africa 250.43(225.14,279.33) Tropical Latin America 268.30(253.73,279.78) Western sub-Saharan Africa 176.11(149.04,206.17)		
Yang et al 2021	Global	Global	GBD 2017	Ovarian cancer	DALYs 1000s (95% uncertainly interval) SDI regions Low SDI 383 555.36 (339 679.00–445 455.23) Low-middle SDI 865 011.38 (778 222.21–1 001 875.10) Middle SDI 1 136 410.19 (1 089 471.89–1 187 124.79) High-middle SDI 986 760.61 (952 272.85–1 019 769.80) World regions Southern Latin America 50 527.67 (44826.08–57410.96) Central Europe 187 239.44 (178 365.29–196 495.32) Eastern Europe 295 736.82 (283 204.90–309 029.89) Caribbean 28 550.19 (25 565.06–32 903.11) South Asia 914 746.18 (831 993.27–1 021 946.91) Central Latin America 155 322.74 (147 467.14–163 153.77) Andean Latin America 31 362.26 (27 282.35–35 978.62) Southern sub-Saharan Africa 38 581.00 (34 998.81–41 974.82) Central Asia 51 433.47 (48 383.12–54 704.35) Tropical Latin America 133 767.91 (128 306.99–139 953.26) Central sub-Saharan Africa 29 846.18 (22 907.10–38 229.36) Southeast Asia 423 816.27 (372 397.79–494 855.41) North Africa and Middle East 213 119.43 (200 760.11–226 896.70) East Asia 735 854.83 (692 701.74–779 500.45) Western sub-Saharan Africa 102 686.80 (81 410.92–129 013.42) Oceania 5104.47 (3904.78–6837.97) Eastern sub-Saharan Africa 141 096.86 (118 322.03–161 449.68)	Original research	Moderate

Yang et al 2022	Global	Global	GBD 2019	Primary liver cancer	Regions Andean Latin America 44,340 (35,812 to 54,428) Caribbean 41,276 (33,562 to 50,616) Central Asia 172,830 (148,859 to 200,042) Central Europe 156,614 (133,681 to 182,107) Central Latin America 197,475 (171,637 to 231,238) Central Sub-Saharan Africa 51,448 (38,555 to 67,260) East Asia 5,491,479 (4,590,535 to 6,534,290) Eastern Europe 234,701 (205,032 to 273,291) Eastern Sub-Saharan Africa 187,944 (149,325 to 232,670) North Africa and Middle East 731,622 (578,678 to 923,575) Oceania 7093 (5872 to 8495) South Asia 1,085,515 (943,943 to 1,244,802) Southeast Asia 1,149,098 (943,489 to 1,384,243) Southern Latin America 43,534 (40,967 to 46,273) Southern Sub-Saharan Africa 122,195 (108,238 to 137,902) Tropical Latin America 142,719 (135,353 to 150,317) Western Sub-Saharan Africa 308,593 (252,949 to 365,495)	Original research	Moderate
Yang et al 2022	Global	Global	GBD 2019	Appendicitis	Characteristics Numbers in 2019 (95% UI) SDI High-middle 109,306(92,726–132,526) Middle 317,880(265,061–369,324) Low-middle 614,999(495,566–709,957) Low 392,572(284,827–505,022) Region Andean Latin America 24,903(19,692–31,923) Caribbean 19,774(14,156–27,771) Central Asia 9,684(7,864–12,463) Central Latin America 79,612(63,718–97,580) Central Sub-Saharan Africa 43,183(24,388–69,515) East Asia 68,712(55,191–84,652) Eastern Europe 21,213(17,341–30,074)	Original research	Moderate

					Eastern Sub-Saharan Africa 124,840(74,786–195,219) North Africa and Middle East 70,903(51,605–87,877) Oceania 1,674(940–2,395) South Asia 703,819(557,425–836,936) Southeast Asia 102,875(75,572–121,780) Southern Latin America 8,121(6,663–10,668) Southern Sub-Saharan Africa 14,079(11,730–17,255) Tropical Latin America 49,542(38,112–58,203) Western Sub-Saharan Africa 84,249(53,617–120,589)		
Yi et al 2021	Global	Global	GBD 2019	Breast, ovarian, cervical and uterine cancer	Region Numbers in 2019 (95% UI) Breast High-middle 4507.16 (4147.35~4888.83) Middle 5823.38 (5223.62~6455.65) Low-middle 4128.62 (3554.63~4720.57) Low 1789.1 (1554.12~2051.72) Cervical High-middle 1543.7 (1236~1729.87) Middle 2817.25 (2223.19~3217.72) Low-middle 2282.24 (1948.33~2722.93) Low 1632.49 (1271.61~2044.29) Ovarian High-middle 1378.23 (1191.05~1526.4) Middle 1453.63 (1199.32~1696.72) Low-middle 922.65 (740.01~1169.38) Low 373.32 (311.09~462.23) Uterine High-middle 667.94 (606.21~735.23) Middle 584.64 (475.79~674.77)	Original research	Moderat e

					Low-middle 332.22 (280.87~404.9) Low 145.26 (117.9~181.52)		
Zhai et al 2017	Global	Global	GBD 2017	Thyroid cancer	Characteristics DALYs No. ×1000 (95% UI) Socio-demographic index Low 153.32 (136.63–169.90) Low-middle 236.77 (214.78–270.13) Middle 314.77 (294.66–346.94) Middle-high 204.21 (190.73–220.65) Region Oceania 1.67 (1.36–2.13) Andean Latin America 12.82 (11.19–14.27) Caribbean 7.07 (6.36–7.87) Central Asia 7.63 (7.09–8.23) Central Latin America 39.54 (37.35–42.02) Central Sub-Saharan Africa 5.74 (4.64–7.68) East Asia 184.14 (170.57–203.49) Eastern Europe 44.72 (41.69–48.39) Eastern Sub-Saharan Africa 52.65 (44.75–61.71) North Africa and Middle East 63.08 (57.86–72.30) South Asia 297.71 (269.76–332.09) Southeast Asia 134.52 (122.89–156.20) Southern Latin America 10.04 (9.12–11.10) Southern Sub-Saharan Africa 6.32 (5.74–7.01) Tropical Latin America 28.57 (27.18–30.04) Western Sub-Saharan Africa 14.10 (12.27–16.32)	Original research	Moderate
Zhang et al 2022	Global	10 most populous countries	GBD 2019	Oral cancer	Nation DALY No.*102 (95%UI) 2019 Russian 163,106.13 (136,536.75–192,130.02) China 575,805.4 (479,521.98–690,743.25) Indonesia 113,143.08 (83,375.61–153,308.74) Mexico 27,215.25 (23,357.09–31,173.64) Brazil 148,871.92 (141,013.9–157,204.72) India 1,922,663.79 (158,5385.47–2,318,025.04)	Original research	Moderate

					Bangladesh 144,651.02 (98,686.77–204,783.04) Pakistan 594,088.79 (471,317.46–754,897.27)		
Zhang et al 2021	Global	Global	GBD 2019	Cervical cancer	DALYs 1000s (95% UI) Low SDI 1632.49 (1271.61–2044.29) Low-middle SDI 2282.24 (1948.33–2722.93) Middle SDI 2817.25 (2223.19–3217.72) High-middle SDI 1543.7 (1236–1729.87) East Asia 1696.32(972.55–2166.63) South Asia 1833.69 (1466.66–2370.91) Southeast Asia 808.25 (653.21–1088.29) Central Asia 119.72 (103.95–138.54) Oceania 24.91 (16.09–34.06) Eastern Europe 308.61 (255.79–369.57) Andean Latin America 129.59 (99.42–165.4) Central Latin America 436.92 (361.75–538.52) Caribbean 114.71 (86.8–145.02) Tropical Latin America 365.28 (340.28–419.75) Southern Latin America 127.49 (105.4–140.05) Eastern Sub- Saharan Africa 758.61(557.09–1022.32) Southern Sub-Saharan Africa 213.94 (173.97–254.95) Western Sub-Saharan Africa 672.6 (524.74–854.86) North Africa and Middle East 221.93 (169.2–268.19) Central Sub-Saharan Africa 261.63 (176.04–360.43)	Original research	Moderate
Zhang et al 2022	Global	Global	GBD 2019	Nasopharyngeal cancer	Low SDI 201,745.62 (177,985.02,227,158.41) Low − middle SDI 494,501.67 (446,244.80,550,735.30) Middle SDI 914,422.51 (819,013.03,1,020,649.33) High − middle SDI 563,897.97 (492,007.88,643,059.41) Region Central Asia 12,210.65 (10,777.21,13,872.25) Eastern Europe 30,887.84 (27,091.29,35,026.51) Southern Latin America 4266.69 (3909.63,4660.98)	Original research	Moderate

					Andean Latin America 2547.40 (2027.19,3163.50) Caribbean 7758.81 (6532.90,9118.29) Central Latin America 13,191.46 (11,099.86,15,758.87) Tropical Latin America 18,584.82 (17,416.29,19,698.19) North Africa and Middle East 102,673.53 (89,157.11,118,580.07) South Asia 508,458.22 (449,582.10,583,995.83) East Asia 958,330.81 (810,442.81,112,4171.87) Oceania 3566.34 (2561.39,4740.58) Southeast Asia 364,165.80 (316,977.85,418,042.49) Central Sub-Saharan Africa 11,212.57 (8559.10,14,139.98) Eastern Sub-Saharan Africa 90,076.91 (67,599.25,110,874.75) Southern Sub-Saharan Africa 9266.35 (8256.2,210,360.57) Western Sub-Saharan Africa 48,177.41 (36,971.51,59,608.31)		
Zhao et al 2021	Global	Global	GBD 2017	Cervical cancer	DALYs (95%UI) Low SDI 1710473 (1541497 to 1882373) Low-middle SDI 1894281 (1713065 to 2137452) Middle SDI 2456312 (2009841 to 2581203) High-middle SDI 1227689 (1073166 to 1290650) Region Central Asia 97090 (90080 to 104919) Eastern Europe 242922 (233739 to 252335) Southern Latin America 121469 (107025 to 137962) Andean Latin America 102588 (87071 to 117597) Caribbean 96573 (79167 to 113794) Central Latin America 353069 (333387 to 373695) Tropical Latin America 316023 (305123 to 329010) North Africa and Middle East 187684 (159194 to 208843) East Asia 1423547 (923640 to 1544767) Oceania 32058 (22840 to 42233) Southeast Asia 806446 (674759 to 906591) Central sub-Saharan Africa 265271 (193429 to 332876) Eastern sub-Saharan Africa 646308 (549919 to 769675)	Original research	Moderat e

					Southern sub-Saharan Africa 182929 (162744 to 199885) Western sub-Saharan Africa 611846 (480371 to 753733)		
Zhou et al 2021	Global	Global	GBD 2017	Ovarian cancer	DALYs x 1000 (95%UI) Low SDI 150.70 (114.44-223.63) Low-middle SDI 258.87 (248.30-359.55) Middle SDI 398.06 (372.24-448.21) High-middle SDI 619.01 (584.87-650.41) Region Central Asia 26.91 (23.54-37.76) Eastern Europe 297.05 (274.68-329.81) Southern Latin America 33.43 (30.88-36.20) Andean Latin America 6.17 (6.93-5.47) Caribbean 5.59 (4.99-6.57) Central Latin America 47.50 (46.20-48.84)+ Tropical Latin America 57.85 (55.67-60.30) North Africa and Middle East 79.12 (67.42-106.24) East Asia 279.83 (257.75-319.49) Oceania 1.51 (1.12-2.05) Southeast Asia 172.75 (146.62-224.15) Central sub-Saharan Africa 12.39 (8.98-16.59) Eastern sub-Saharan Africa 70.94 (57.05-94.27) Southern sub-Saharan Africa 17.59 (15.89-19.26) Western sub-Saharan Africa 35.84 (28.58-49.00)	Original research	Moderat e
Liu et al 2023	Global	Global	GBD 2019	Colorectal cancer	Region - DALY No. *103 (95% UI)) Socio-demographic index High middle SDI 7174.86 (6649.07-7693.26) Middle SDI 6990.43 (6308.9-7671.29) Low middle SDI 2998.33 (2703.93-3314.97) Low SDI 942.42 (835.79-1059.27) Region Andean Latin America 125.58 (101.75-151.8) Caribbean 172.02 (147.19-200.17)	Original research	Moderat e

					Central Asia 199.84 (182.01-219.94) Central Europe 1052.15 (922.92-1184.25) Central Latin America 539.64 (465.2-627.07) Central Sub-Saharan Africa 100.99 (75.75-131.45) East Asia 6712.86 (5774.28-7735.91) Eastern Europe 1419.1 (1287.54-1571.37) Eastern Sub-Saharan Africa 356.43 (301.93-425.61) North Africa and Middle East 1013.63 (896.16-1146.53) Oceania 16.31 (12.92-20.56) South Asia 2419.1 (2078.02-2782.57) Southeast Asia 2142.43 (1780.49-2482.29) Southern Latin America 366.44 (347.73-385.44) Southern Sub-Saharan Africa 147.78 (132.44-165.54) Tropical Latin America 660.13 (625.56-687.74) Western Sub-Saharan Africa 353.24 (295.57-420.7)		
GBD 2017 Colorectal Cancer Collaborators	Global	Global	GBD 2017	Colorectal cancer	Region DALY Southern Latin America 262320 (241353, 284521) Eastern Europe 1233374 (1198127, 1275464) Central Asia 149884 (142576, 158028) Central Latin America 421623 (404702, 437765) Andean Latin America 91524 (82564, 100036) Caribbean 138301 (127898, 150530) Tropical Latin America 535234 (518062, 551007) East Asia 4539232 (4296171, 4749878) Southeast Asia 1360792 (1286955, 1449817) Oceania 16944 (13657, 24444) North Africa and Middle East 792334 (752239, 837918) South Asia 2129682 (1902148, 2300720) Southern sub-Saharan Africa 115680 (106259, 123470) Western sub-Saharan Africa 321228 (273859, 381991) Eastern sub-Saharan Africa 375287 (346163, 399939) Central sub-Saharan Africa 105862 (87267, 133328)	Original research	Moderate

Mock et al 2015	Global	All Low- and Middle-Income Countries	Essential Surgery, Disease Control Priorities, Third Edition	Surgically avertable conditions	Condition DALYs (1000s) Maternal disorders 19,000 Birth asphyxia 78,000 Cataracts 7000 Peptic ulcer disease 7000 Appendicitis 2000 Skin diseases 16,000 Cleft lip and palate <1000 Oral disorders 13000 Road traffic crash 72,000 Other unintentional injury 96,000 Intentional injury 34,000 Burden from surgically avertable disorders 340,000	Original research	Low
Khanali et al 2021	Global	Global	GBD 2017	Gallbladder and biliary tract cancers	GBD Region DALY Central Asia 18637 (16809 to 19845) Central Europe 123704 (118345 to 131431) Eastern Europe 96759 (92262 to 101664) Andean Latin America 39793 (34820 to 48131) Caribbean 13400 (11516 to 19174) Central Latin America 109743 (103955 to 129452) Tropical Latin America 114774 (110696 to 118156) North Africa and Middle East 128903 (111197 to 152265) South Asia 923070 (707826 to 1038260) Central Sub-Saharan Africa 14143 (11618 to 17415) Eastern Sub-Saharan Africa 46641 (38395 to 58433) Southern Sub-Saharan Africa 8961 (7012 to 10451) Western Sub-Saharan Africa 47645 (38937 to 64830) East Asia 619726 (474276 to 679363) South East Asia 250697 (192488 to 274930) Oceania 2265 (1720 to 2771)	Original research	Moderate
Safiri et al 2020	Global	Global	GBD 2017	Kidney cancer	GBD Region DALY Central Asia 52,337 (49,287, 55,105)	Original research	Moderate

					Central Europe 175,474 (155,504, 184,347) Eastern Europe 318,581 (304,822, 330,166) Andean Latin America 25,816 (22,594, 28,915) Caribbean 20,946 (18,796, 25,112) Central Latin America 126,948 (120,716, 133,945) Tropical Latin America 107,712 (102,442, 112,126) North Africa and Middle East 140,564 (120,365, 150,183) South Asia 251,842 (225,690, 265,848) Central Sub-Saharan Africa 20,758 (16,716, 25,241) Eastern Sub-Saharan Africa 66,589 (54,910, 79,913) Southern Sub-Saharan Africa 19,099 (16,966, 21,292) Western Sub-Saharan Africa 83,548 (70,625, 98,563) East Asia 472,461 (417,968, 507,412) South East Asia 176,890 (149,465, 192,463) Oceania 2,285 (1784, 2,917)		
Massenburg et al 2020	Global	Global	GBD 2017	Orofacial cleft	Region DALYs per 100,000 Population (UI) Global 8.53 (5.38–14.49) Low SDI 22.00 (9.31–53.30) Low-middle SDI 8.98 (5.96–13.28) Middle SDI 5.33 (3.87–7.27) High-middle SDI 4.67 (3.36–6.35) High SDI 3.24 (2.19–4.65) East Asia and Pacific 5.55 (4.00–7.42) Europe and Central Asia 3.21 (2.20–4.55) Latin America and Caribbean 4.24 (3.08–5.67) Middle East and North Africa 6.33 (4.61–8.55) North America 2.99 (2.00–4.30) South Asia 8.42 (5.74–12.07) Sub-Saharan Africa 25.29 (9.29–61.61)	Original research	Moderate
Mock et al 2015 (Essential	Global	Global	WHO Global Health Estimates	Disease addressed by surgery	Category DALYs (1000s) Maternal conditions 19,000 Birth asphyxia and birth trauma 78,000	Original research	Low

Surgery Chapter 1)					Cataracts 7000 Peptic Ulcer Disease 7000 Appendicitis 2000 Skin diseases 16,000 Cleft lip and palate <1000 Oral conditions 13,000 Road traffic crash 72,000 Other unintentional injuries 96,000 Intentional injuries 34,000 Total surgical burden 340,000		
Blake et al 2015 (Essential Surgery Chapter 21)	Global	Global	WHO Global Health Estimates 2013	Cleft lip and palate	Region DALYs per 1000 East Asia and Pacific 7.99 Europe and Central Asia 6.73 Latin America and the Caribbean 6.23 Middle East and North Africa 8.20 South Asia 17.85 Sub-Saharan Africa 16.37	Original research	Low
Farmer et al 2015 (Essential Surgery chapter 8)	Global	Global	WHO Global Health Estimates 2013	Congenital anomalies	Anomaly DALYs (100s) Cardiac 20760.00 Neural tube 10075.00 Down syndrome 2939.00 Cleft lip 709.00 Ither chromosomal 2941.00 Other congenital 20272.00 Total 57,696	Original research	Low
Beard et al 2015 (Essential Surgery Chapter 9)	Global	Global	Beard et al 2013 and US Census Database	Inguinal hernia	Region DALYs (100,000s) World 15,230 Africa 3,770 Americas 1,430 Eastern Mediterranean 1,420 Europe 1,510	Original research	Very low

					Southeast Asia 4,430 Western Pacific 2,650		
Niederman et al 2015 (Essential Surgery Chapter 10)	Global	Global	WHO Global Health Estimates	Dental disease	Disease DALYs (1000s) All oral conditions 15,152 Untreated caries 5,031 Peridontitis 5,501 Tooth loss 4,620	Original research	Low
Johnson et al 2015 (Essential Surgery Chapter 5 Obstetric Surgery)	Global	Global	GBD 2010	Obstetric conditions	Condition DALYs (1000s) Maternal disorders 16,104 (12,972-18,912) Maternal haemorrhage 3,289 (2,619-3860) Maternal sepsis 1,309 (1,059-1,585) Hypertensive disorders of pregnancy 2,797 (2,254-3,357) Obstructed labour 1,792 (1,249-2,806) Abortion 2,138 (1,731-2,592) Other maternal disorders 4,778 (3,819-5,512)	Original research	Moderate

Appendix 2B – Systematic review 1 search strategy

2B.1 MEDLINE (Ovid) search terms

1. (cost? adj2 (illness or disease or sickness)).tw.
2. limit 1 to humans
3. (burden? adj2 (illness or disease? or condition? or economic*)).tw.
4. ("quality-adjusted life years" or "quality adjusted life years" or QALY?).tw.
5. "cost of illness"/
6. Health expenditures/
7. (out-of-pocket adj2 (payment? or expenditure? or cost? or spending or expense?)).tw.
8. (expenditure? adj3 (health or direct or indirect)).tw.
9. ((adjusted or quality-adjusted) adj2 year?).tw.
10. or/1-9
11. exp surgery/
12. exp operating room/
13. Operative.mp. or Surgical Procedures, Operative/ [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word]
14. surg*.ti,ab.
15. operative.ti,ab.
16. operation.ti,ab.
17. operating room.ti,ab.
18. trauma.ti,ab.
19. cancer.ti,ab.
20. ortho*.ti,ab.
21. surgical procedures.ti,ab.
22. 11 or 12 or 13 or 14 or 15 or 16 or 17 or 18 or 19 or 20 or 21
23. Developing Countries.sh,kf.

24. (Africa or Asia or Caribbean or West Indies or South America or Latin America).mp. or Central America.hw,kf,ti,ab,cp,in. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word]

25. (Afghanistan or Angola or Armenia or Armenian or Bangladesh or Benin or Bhutan or Bolivia or Burkina Faso or Burkina Fasso or Burundi or Cambodia or Central African Republic or Chad or Comoros or Congo or Cote d'Ivoire or Ivory Coast or Djibouti or Egypt or El Salvador or Eritrea or Ethiopia or Gambia or Gaza or Georgia or Ghana or Guatemala or Guinea or Guam or Haiti or Honduras or India or Indonesia or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Lao PDR or Lesotho or Liberia or Madagascar or Malawi or Mali or Mauritania or Moldova or Mongolia or Morocco or Mozambique or Myanmar or Myanma or Nepal or Nicaragua or Niger or Nigeria or Pakistan or Paraguay or Philippines or Philipines or Phillipines or Phillippines or Rwanda or Ruanda or Sao Tome or Senegal or Sri Lanka or Solomon Islands or Somalia or Sudan or Swaziland or Tajikistan or Tanzania or Timor-Leste or Tokelau or Togo or Tuvalu or Uganda or Ukraine or Uzbekistan or Vanuatu or Vietnam or Viet Nam or West Bank or Yemen or Zambia).mp. or Zimbabwe.hw,kf,ti,ab,cp,in. [mp=title, book title, abstract, original title, name of substance word, subject heading word, floating sub-heading word, keyword heading word, organism supplementary concept word, protocol supplementary concept word, rare disease supplementary concept word, unique identifier, synonyms, population supplementary concept word, anatomy supplementary concept word]

26. ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or world)).ti,ab.

27. ((developing or less* developed or under developed or underdeveloped or middle income or low* income) adj (economy or economies)).ti,ab.

28. (low* adj (gdp or gnp or gross domestic or gross national)).ti,ab.

29. (low adj3 middle adj3 countr*).ti,ab.

30. (lmic or lmics or third world or lami countr*).ti,ab.

31. transitional countr*.ti,ab.

32. ((high burden or high-burden or countdown) adj countr*).ti,ab.

33. 23 or 24 or 25 or 26 or 27 or 28 or 29 or 30 or 31 or 32

34. 10 and 22 and 33

2B.2 The ScHARR LMIC geographic search filter: full copies of the search filter used for each database

Terms used for Ovid MEDLINE:

1 Developing Countries.sh,kf.

2 (Africa or Asia or Caribbean or West Indies or South America or Latin America or Central America).hw,kf,ti,ab,cp,in.

3 (Afghanistan or Angola or Armenia or Armenian or Bangladesh or Benin or Bhutan or Bolivia or Burkina Faso or Burkina Fasso or Burundi or Cambodia or Central African Republic or Chad or Comoros or Congo or Cote d'Ivoire or Ivory Coast or Djibouti or Egypt or El Salvador or Eritrea or Ethiopia or Gambia or Gaza or Georgia or Ghana or Guatemala or Guinea or Guam or Haiti or Honduras or India or Indonesia or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Lao PDR or Lesotho or Liberia or Madagascar or Malawi or Mali or Mauritania or Moldova or Mongolia or Morocco or Mozambique or Myanmar or Myanma or Nepal or Nicaragua or Niger or Nigeria or Pakistan or Paraguay or Philippines or Philipines or Phillipines or Phillippines or Rwanda or Ruanda or Sao Tome or Senegal or Sri Lanka or Solomon Islands or Somalia or Sudan or Swaziland or Tajikistan or Tanzania or Timor-Leste or Tokelau or Togo or Tuvalu or Uganda or Ukraine or Uzbekistan or Vanuatu or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe).hw,kf,ti,ab,cp,in.

4 ((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or world)).ti,ab.

5 ((developing or less* developed or under developed or underdeveloped or middle income or low* income) adj (economy or economies)).ti,ab.

6 (low* adj (gdp or gnp or gross domestic or gross national)).ti,ab.

7 (low adj3 middle adj3 countr*).ti,ab.

8 (lmic or lmics or third world or lami countr*).ti,ab.

9 transitional countr*.ti,ab.

10 ((high burden or high-burden or countdown) adj countr*).ti,ab.

11 or/1-11

Appendix 3A - Tables of included studies by WHO regions of the world

Table 9-8. *Included studies from African Region.*

Study	Country	Source of data	Clinician studied	Data	Type of study	GRADE Rating
Albutt et al 2018	Uganda	WHO TSAAEESC survey	Surgeons, Anaesthetist, Obstetrician & Gynaecologists	Surgeons - 38 Anaesthetists - 11 Obs & Gynae - 34	Original research	Low
Bruno et al 2017	Madagascar	Hospital surveys and semi-structred interviews with adminstrative staff in each region	SAO Providers	Surgeons - 94, 0.55 Anesthetists - 26, 0.5 Obs&Gynae - 14, 0.08 SAO total - 134, 0.78	Original research	Low
Chao et al 2012	Ethiopia	Hospital surveys	SAO providers	Physicians - 243 SAO - 59 Nurses - 982 Anaesthesia technicians - 45 Midwives - 100	Original research	Moderate
Iddriss et al 2011	Gambia	WHO TSAAEESC survey - WHO Tool for Situation Analysis to Assess Emergency and Essential Surgical Care survey	SAO providers	Surgeon physician 14 Anaesthesiologist physician 4 Obstetrician/gynaecologist 8 General doctors providing surgery 3 General doctors providing anaesthesia 1 Non-physician anaesthetists 14 Surgical technician 7 Paramedics/midwives 88	Original research	Low
Dahir et al 2020	Somaliland	WHO TSAAEESC survey, Hospital Walkthrough and geospatial mapping.	SAO providers	Surgical providers - 15 Anaesthesiologists - 3 Obstetricians - 14 Total workforce - 32 0.8/100,000	Original research	Moderate

Epiu et al 2017	East Africa (Uganda, Kenya, Tanzania, Rwanda, Burundi)	Survey of 5 main referral hospitals, interviews and UNICEF data	Anaesthetists (physicians and non -physicians)	Uganda - 30 physicians (0.08/100,000), 400 non-physicians Kenya - 168 physicians (0.39), 800 non-physicians Tanzania - 22 physicians (0.05), 400 non-physicians Rwanda - 15 physicians (0.13), 350 non-physicians Burundi - 2 physicians (0.02), 328 non-physicians	Original research	Low
Ethiopian Public Health Institute, 2022	Ethiopia	Ethiopian MNH Exemplar Study	Nurses, midwives, health officers, GPs + Sepcialists	Nurses - 6.8/10,000 Midwives - 2.0/10,000 Health Officers - 1.6 GPs + Specialists - 1.2	Original research	Moderate
Feysia et al 2012	Ethiopia	MOH 2007, WHO 2006	Physician, Nurse, Midwife, Surgeon, Anaesthetist/Anaesthesiologist, Anaesthesia Provider, Health Officer, Orthopaedic Surgeons	Physicians - (0.55/1000) Specialist physicians - 714 Midwives - 1,059 Nurses - 20,109 (0.26/1000) Health Officer - 1,606 (0.02/1000) Surgeon - 522 Orthopaedic Surgeons - 265 Anaesthesiologist - 114 Anaesthesia provider - 981	Original research	Low
Henry et al 2015	Malawi	PIPES Survey	Surgeon, Anaesthetist/Anaesthesiologist, Surgical Provider, Anaesthesia Provider	General Surgeon - 27 (1.21 per 100,000) Physicians performing surgery - 28 (1.26/100,000) Surgical Clinical Officers - 27 (1.21/100,000) Anaesthetist - 5 (0.22 per 100,000) Anaesthetic Clinical Officers - 40 (1.80/100,000)	Original research	Moderate
Kouo-Ngamby et al 2015	Cameroon	WHO TSAAEESC Survey 2009	Physician, Nurse, Midwife, Surgeon, Anaesthetist/Anaesthesiologist, Surgical Provider, Anaesthesia Provider, Obstetrician & Gyanecologists	Surgeons - 8.25 per 1,000,000 Anaesthesiologists - 1.33/1,000,000 Obs & Gyane - 7.26/1,000,000 Physicians providing surgery - 9.85/1,000,000 Physicians providing anaesthesia - 5.10/1,000,000 Anaesethesia providers (Nurse, Clinical Officers) - 15.41/1,000,000	Original research	Low

				Surgical providers (Clinical officers) - 13.13/1,000,000 Midwives - 306.85/1,000,000		
Rwanda Ministry of Health 2021	Rwanda	Rwanda Health Management Information System (2021)	Physician, Nurse, Midwife, SAO Providers	Physician - 1,614 Nurse - 11,083 Midwife - 1,604 SAO Provider - 13 per 100,000	Original research	Low
Odinkemelu et al 2021	Liberia	Survey - WFSA Anaestsia Facility Assessment Tool (AFAT)	Surgeon, Anaesthetist/Anaesthesiologist, Anaesthesia Provider, Obstetrician & Gyanecologists, SAO Physicians	Surgeons - 29 Anaesthesiologists - 1 (0.02/100,000) Nurse anaesthetists - 72 (1.56/100,000) Obs & Gayne - 24 SAO - 54 (1.25/100,000)	Original research	Moderate
Shirley & Wamai	Kenya	World Bank Development Indicators	SAO Providers	SAO providers - 2.35/100,000	Original research	Low
Tiwari et al 2021	South Africa	Health Professionals Council of South Africa database	Surgeon, Anaesthetist/Anaesthesiologist, Obstetrician & Gyanecologists	Surgeons - 3191 (10.5/100,000) General Surgeons - (1.40/100,000) Prthopaedic Surgeons - (1.60/100,000) Anaesthesiologists - 1846 /3.0/100,000) Obs & Gynae - 1292 (2.2/100,000) SAO Providers - 6329 (10.5/100,000)	Original research	Moderate
Walker et al 2010	Uganda	Survey	Surgeon, Anaesthetist/Anaesthesiologist, Surgical Provider, Anaesthesia Provider	Specialist Surgeon (all sub-specialities including OB/GYN)- 0.7/100,000 Medical Officer (performing surgery) - 1.0/100,000 Anaesthetist - 0.1/100,000 Anaesthetic officer and anaesthetic assistants (performing anaesthesia) - 0.9/100,000 All anaesthesia providers - 1.1/100,000	Original research	Moderate
WHO Regional Office for Africa 2021	All African nations	WHO HRH Survey	Physician, Nurse, Midwife, Specialist medical practitioners	Regional Physicians - 0.20/1000 (2005) Physicians - 0.31 (2018) Nurses + midwives - 1.06/1000 (2005) Nurses + midwives - 1.23/1000 (2018)	Original research	Moderate

				Full data per nation in Excel sheet		
Juventine et al 2023	8 CANECSA countries	CANSECSA database, national medical council registers, anaesthesia society registers, Zambia College of Medicine and Surgery records. Validated by approaching individuals.	Anaesthetist/Anaesthesiologist, Anaesthesia Provider	Eswatini - 0.34/100,000 (4) Kenya - 0.33 (176) Malawi - 0.02 (4) Rwanda - 0.25 (32) Tanzania - 0.06 (36) Uganda - 0.15 (66) Zambia - 0.46 (67) Total - 0.19 (411)	Original research	Low
Penoyar et al 2012	Tanzania	WHO TSAAEESC survey (2010)	Anaesthetist/Anaesthesiologist, Anaesthesia Provider	GPs performing surgery - 113 Non-physician surgical provider - 122 Surgeons - 64 Midwives - 4017 GPs performing anaesthesia - 16 Non-physician anaesthesia providers - 176 Anaesthetists - 11 Obs & Gyane - 74 (World Bank population 2011 44.7 million)	Original research	Moderate
Sherman et al 2011	Liberia	WHO TSAAEESC survey	Midwife, Surgeon, Anaesthetist/Anaesthesiologist, Surgical Provider, Anaesthesia Provider	Surgeon - 3 Anaesthetists - 0 Obs & Gyane - 2 GP surgical provider - 20 GP anaesthetic provider - 1 Non-physician anaesthesia provider - 19 Non-physician surgical provider - 5 Midwives - 88	Original research	Moderate
Kingham et al 2008=9	Sierra Leone	WHO TSAAEESC survey (2008)	Surgeon, Anaesthetist/Anaesthesiologist, Surgical Provider, Anaesthesia	Surgeon - 14 Anaesthetist - 2 Obs & gyane - 8	Original research	Low

			Provider, Obstetrician & Gyanecologists	General Surgeon - 4.5 GP anaesthetic provider - 3 Non-physician anaesthetic provider - 19 Non-physician surgical provider - 18		
Rudolfson et al 2023	South Africa	Health Professions Council of South Africa and WHO global surgery workforce database	Physician, Surgeon, Anaesthetist/Anaesthesiologist, Specialist medical practitioners, Obstetrician & Gyanecologists	Surgeons - 3658 Anaesthetists - 1749 Obstetricians - 1236 SAO Specialists - 6670 SAO density - 12.1/100,000	Original research	Low
Osebo et al 2024	Ethiopia	Systematic review	Surgeon, Surgical Provider, Specialist medical practitioners	SAO density - 0.54-5.19/100,000	Systematic review	Low
Meshesha, 2022	Ethiopia	WHO-PGSSC Surgical Assessment Tool (SAT)	Specialist medical practitioners	SAO density - 5.19/100,000	Original research	Moderate

Table 9-9. Included studies in Region of the Americas

Study	Country	Source of data	Clinician studied	Data	Type of study	GRADE Rating
Jiminez et al 2015 (World Bank)	Peru	Ministry of Health, General Director's Office for Management of Human Resources Development (2013)	Physician, Nurse, Midwife, Surgeon, Anaesthetist/Anaesthesiologist, Obstetrician & Gyanecologists	Physician - 33,669 Nurse - 33,491 Midwife - 11,533 Anaesthetist - 601 General Surgeon - 708 Obs & Gyane - 1066	Original research	Moderate
LeBrun et al 2012	Bolivia	WHO TSAAEESC Survey 2011, Key Informant Interviews with Ministry of Health and Sports	Physician, Nurse, Surgeon, Anaesthetist/Anaesthesiologist, Obstetrician & Gyanecologists	Physicians - 13,329 (12.2/10,000) Obs & Gynae - 1,270 General Surgeons - 730 Sub-speciality Surgeons (including Ortho, ENT, Opth, Plastic, Thoracic, Paeds, Neuro, Urologist, GI, Oncological) - 1,077 Anaesthesiologists - 500 Nurses - 9,291	Original research	Low
Solis et al 2013	Nicaragua	WHO TSAAEESC survey	Physician, Nurse, Surgeon, Anaesthetist/Anaesthesiologist, Specialist medical practitioners, Obstetrician & Gyanecologists	Physicians - 10,559 (17.4/10,000) Surgeons - 986 (1.6/10,000) Anaesthetists - 250 (0.4/10,000) Obs & Gynae - 580 - (1/10,000) Orthopaedic surgeons - 235 (0.4/10,000) General Surgeons - 390 (0.6/10,000) Paediatric Surgeons - 57 (0.1/10,000) Nurses - 5104 (8.4/10,000)	Original research	Low
Tran et al 2015	Haiti	WHO TSAAEESC survey	Midwife, Surgeon, Anaesthetist/Anaesthesiologist, Surgical Provider, Anaesthesia Provider, Obstetrician & Gyanecologists	Surgeon - 239 Anaesthesiologist - 170 Obs & Gynae - 187 Non-physician anaesthesia provider - 77 Midwife - 314	Original research	Moderate

Vansell et al 2015	Guyana	WHO TSAAEESC survey	Anaesthetist/Anaesthesiologist, Anaesthesia Provider	Anaesthesiologists - 5 Nurse anaesthetists - 17	Original research	Low

<u>Table 9-10.</u> Included studies from South-East Asian Region

Study	Country	Source of data	Clinician studied	Data	Type of study	GRADE rating
Kolehmainen-Aitken & Srestha 2009	Nepal	MoH HR information system, field study	Nurse, Anaesthetist/Anaesthesiologist, Obstetrician & Gyanecologists	Anaesthesiologist - 8 Obs & Gyane - 11 Medical Officer - 102 Nurse - 328 Population - 27.03 million	Original research	Low
Ross et al 2023	Nepal	WHO-PGSSC Surgical Assessment Tool (SAT)	Specialist medical practitioners, gSAO	SAO - 0.4/100,000 gSAO - 3.1/100,000	Original research	Very low

Table 9-11. Included studies from European Region.

Study	Country	Source of data	Clinician studied	Data	Type of study	GRADE rating
Katsaga et al 2012 (European Health Observatory)	Kazakhstan	Ministry of Health 2011, Medinform 2011	Physicians, surgeons, nurses, midwives	Physicians - 388 (403/100,000) Surgeons - 44/100,000 Nurses - 625 (870/100,000) Midwives - 59 (42/100,000)	Original research	Low
Richardson 2013	Belarus	Ministry of Health 2011	Physicians, surgeons, Midwives, Nurses	Physicians - 39,194 (379/100,000) Surgeons - 1,373 Midwives - 4,716 Nurses - 73,862 (1,062/100,000)	Original research	Low
Bjegovic-Mikanovic et al 2019	Serbia	IPH Batut, Commonwealth of Independent States (CIS) and South-eastern Europe Health Network (SEEHN)	Physician, Specialist Physicians, Nurses, Midwives	Physicians - 307.08/100,000 (CIS, SEEHN) Nurses - 628.80/100,000 (CIS, SEEHN) Specialist physicians - 210/100,000 (IPH Batut) Nurses - 605/100,000 (IPH Batut) Midwives - 36/100,000 (IPH Batut) General Surgeons - 5% (IPH Batut) Anaesthesiologists - 5% (IPH Batut) Obstetricians & Gynaecologists - 7.6% (IPH Batut)	Original research	Low
Dimova et al 2018 (European Observatory on Health)	Bulgaria	Eurostat 2018, WHO Regional Office for Europe 2018	Physician, Nurse, Midwife, Surgeon, Specialist medical practitioners	Physicians - 29,038 (4.16/1000 - Eurostat, 400/100,000 - WHO) Nurses - 31,397 (4.37/1000 - Eurostat, 486/100,000 - WHO) Midwives - 3,274 Specialist medical practitioners - 24,521 General Surgeons - 0.23/1000	Original research	Low
Dimova et al 2012	Bulgaria	WHO regional Office for Europe 2010	Physician, Nurse, Midwife, Surgeon, Obstetrician & Gyanecologists	Physicians - 3.60/1000 Nurses - 4.24/1000	Original research	Low

				Surgeons - 1.6/10,000 Gynaecologists - 1.8/10,000		

Table 9-12. Included studies from Eastern Mediterranean Region.

Study	Country	Source of data	Clinician studied	Data	Type of study	GRADE rating
Ashraf et al 2022	Pakistan	Pakistan: Human Resources for Health Vision, Khan TH. Job satisfaction in Pakistani anesthesiologists. Anaesth Pain Intensive Care. 2011;15(2):93–101. (2018–30).	Physician, Nurse, Midwife, Anaesthetist/Anaesthesiologist	Physician - 0.96/100,000 Anaesthetists - 300 (200 trainees) Nurses + midwives - 0.49/100,000 194.5 million	Systematic review	Low
Siddiqi et al 2020	Pakistan (Focussed on rural areas)	WHO TSAAEESC survey	SAO Providers	0.5/100,000	Original research	Low

Table 9-13. *Included studies reporting data from Western Pacific Region.*

Study	Country	Source of data	Clinician studied	Data	Type of study	GRADE rating
WHO Regional Office for the Western Pacific - Vanuatu 2013	Vanuatu	MoH 2012	Physician, Nurse, Midwife, Surgeon, Anaesthetist/Anaesthesiologist, Specialist medical practitioners	Physicians - 32 (0.13/1000) Nurses - 289 (1.23/1000) Midwives - 51 (0.21/1000) Surgeons - 8 (0.03/1000) Obs & Gynae - 5 (0.02/1000) Anaesthetists - 4 (0.02/10000 (population - 239,631)	Original research	Low
WHO Regional Office for he Western Pacific - Tonga 2015	Tonga, Fiji, Kiribati, Samoa, Solomon Islands, Vanuatu	WHO Global Health Observatory Data Repository 2013	Physician, Nurse, Surgeon, Anaesthetist/Anaesthesiologist, Specialist medical practitioners, Obstetrician & Gyanecologists	Tonga Physician - 55 (0.53/1000) Specialist medical practitioners - 20 Surgeons - 5 Anaesthetists - 3 Obs & Gynae - 3 Nurses and midwives - 3.01/1000 Fiji Physician - 0.43/1000 Nurses and midwives - 2.24/1000 Kiribati Physician - 0.38/1000 Nurses and midwives - 3.71/1000 Samoa Physician - 0.48/1000 Nurses and midwives - 1.85/1000 Soloman Islands	Original research	Low

				Physician - 0.22/1000 Nurses and midwives - 2.05/1000 Vanuatu Physician - 0.12/1000 Nurses and midwives - 1.7/1000		
WHO Regional Office for the Western Pacific - Marshall Islands 2014	Marshall Islands	MoH 2011	Nurse, Specialist medical practitioners	Specialist medical practitioners - 15 (0.28/1000) Nurses - 188 (2.56/1000) Midwives - 12 (0.23/1000)	Original research	Low
Zhang et al 2021	China	Cross sectional survey of all hospitals providing anaesthesia in China.	Nurse, Anaesthetist/Anaesthesiologist	Anaesthesiologists - 0.67/100,000 Anaesthesia nurses - 0.20/100,000	Original research	Moderate
Natuzzi et al 2011	Soloman Islands	WHO TSAAEESC survey 2010	Surgeon, Anaesthetist/Anaesthesiologist, Surgical Provider, Anaesthesia Provider, Obstetrician & Gyanecologists	Surgeon - 5 Anaesthetist - 3 Obs & Gynae - 4 MO Surgeon - 13 MO Anaesthesia - 12 Non-physician Anaesthetic provider - 1	Original research	Moderate
Speigel et al 2011	Mongolia	WHO TSAAEESC survey	Midwife, Surgeon, Anaesthetist/Anaesthesiologist, Surgical Provider, Anaesthesia Provider	Surgeons - 0 Anaesthetists - 0 GPs performing surgery - 7 GPs providing anaesthesia - Non-physician anaesthesia providers - 10 Non-physician surgical providers - 13 Midwives - 282	Original research	Very low

Table 9-14. *Included studies from multiple WHO regions or with a global focus.*

Study	Country	Source of data	Clinician studied	Data	Type of study	GRADE rating
Gupta et al 2014	Global	Systematic review of studies using one of two surveys (WHO TSAAEESC or PIPES)	Physician, Surgeon, Anaesthetist/Anaesthesiologist	Surgeons Afghanistan - 11 Bolivia - N/A Gambia - 14 Ghana - 7 Liberia - 3 Mongolia - 0 Nigeria - 26 Rwanda - 50 Sierra Leone - 14 Solomon Islands - 4 Sri Lanka - N/A Tanzania - 64 Uganda - 43 Zambia - 44 Anaesthesiologists Afghanistan - 4.6 Bolivia - N/A Gambia - 4 Liberia - 0 Mongolia - 0 Nigeria - 6 Rwanda - 13 Sierra Leone - 2 Solomon Islands - 3 Sri Lanka - 1 Tanzania - 11 Uganda - 9	Systematic review	Low

				Zambia - 25 Physicians Afghanistan - 0.2/1000 (all data 2010 unless stated) Bolivia - N/A Gambia - 0.0 Liberia - 0.1 Mongolia - 2.8 Nigeria - 0.4 Rwanda - 0.1 Sierra Leone - 0.0 Solomon Islands - 0.2 Sri Lanka - 0.5 Tanzania - 0.0 Uganda - 0.1 Zambia - 0.1 (2009 data)		
World Health Organisation 2017 - Surgical care systems strengthening: developing NSOAPs	Uganda, Madagascar, India	WHO TSAAEESC survey	SAO provider	Uganda - 0.3/100,000 Madagascar - 0.78/100,000 India - 11.9/10,000	Original research	Low
Kempthorne et al 2017	Global	WFSA Global Anesthesia Workforce Study	Anaesthetist/Anaesthesiologist, Anaesthesia Provider	See Excel sheet for data	Original research	Moderate
LeBrun et al 2014	Global (8 countries)	WHO TSAAEESC survey 2012	Physician, Surgeon, Anaesthetist/Anaesthesiologist, Obstetrician & Gyanecologists	Physicians Bangladesh - 3.0/10,000 Bolivia - 12.2 Ethiopia - 0.2 Lberia - 0.2 Nicaragua - 17.4	Original research	Low

				Rwanda - 0.2 Uganda - 1.2 Surgeons + Obstetricians Bangladesh - 0.2/10,000 Bolivia - 3.0 Ethiopia - <0.1 Lberia - 0.1 Nicaragua - 2.7 Rwanda - <0.1 Uganda - 0.1 Obstetricians Bangladesh - 0.1/10,000 Bolivia - 1.2 Ethiopia - <0.1 Lberia - Nicaragua - 1.0 Rwanda - Uganda - <0.1 Anaesthesiologists Bangladesh - 0.1/10,000 Bolivia - 0.5 Ethiopia - <0.1 Lberia - <0.1 Nicaragua - 0.4 Rwanda - <0.1 Uganda - <0.1 SAO Drs Bangladesh - <0.1/10,000		

				Bolivia - 1.0 Ethiopia - <0.1 Lberia - <0.1 Nicaragua - 0.1 Rwanda - <0.1 Uganda - <0.1		
Dubowitz et al 2009	Global	Survey	Anaesthetist/Anaesthesiologist, Anaesthesia Provider	Anaesthetists Democratic Republic of Congo - 0.02/100,000 Zimbabwe - 0.3/100,000 Senegal - 0.2 Benin - 0.2 Eswatini - 0.155 Cote D'Ivoire - 0.155 Cameroon - 0.15 Rwanda - 0.055 Zambia 0.04 Uganda - 0.04 Afghanistan - 0.025 All anaesthesia providers - Eswatini - 1.4/100,000 Zimbabwe - 0.9/100,000 Aghanistan - 06 Tanzania - 0.1 Yemen - 0.07	Original research	Very low
WHO Global Health Observatory data repository	Global	National reporting to WHO GHO Data repository	Physician, Nurse, Midwife, Surgeon, Anaesthetist/Anaesthesiologist, Obstetrician & Gyanecologists	See full publication	Original research	Moderate
WHO National Health Workforce	Global	Nationally reported data	Physician, Nurse, Midwife, Specialist medical practitioners	See full publication	Original research	Moderate

Accounts Data Portal						
The World Bank - Specialist Surgical Workforce	Global	LCoGS, WHO Collaborating Centre for Surgery and Public Health, national Ministries of Health, OECD, WHO Health for All database, BMJ Global Health	Specialist Surgical Workforce	See full publication	Original research	Moderate
Holmer et al 2015	Global	Ministries of Health, WHO country offices, professional societies, members of the WHO Global Initiative for Emergency & Essential Surgical Care, and from publicly available sources	Surgeon, Anaesthetist/Anaesthesiologist, Obstetrician & Gyanecologists	Country Income Bracket SAO Density (per 100,000) Rwanda LIC 1.69 Sierra Leone LIC 0.23 Uganda LIC 1.57 Kenya L-MIC 2.65 Nigeria L-MIC 1.64 Pakistan L-MIC 6 Zimbabwe L-MIC 2.48 Colombia UMIC 20.33 Fiji UMIC 8.54 Malaysia UMIC 15.58 Maldives UMIC 15.96 Maur	Original research	Moderate
Bouchard et al 2020	11 Countries across the 6 WHO regions.	Online medical licensing registries, WHO Global Surgical Workforce Database	SAO providers, Surgoens, Obstetricians, Anaesthesia Providers	Country Income Bracket SAO Density (per 100,000) Rwanda LIC 1.69 Sierra Leone LIC 0.23 Uganda LIC 1.57 Kenya L-MIC 2.65 Nigeria L-MIC 1.64 Pakistan L-MIC 6 Zimbabwe L-MIC 2.48 Colombia UMIC 20.33	Original research	Moderate

				Fiji UMIC 8.54 Malaysia UMIC 15.58 Maldives UMIC 15.96 Mauritius UMIC 34.57 Peru UMIC 41.77 South Africa UMIC 10.11		

Appendix 3B – Systematic review 2 search strategy

3B.1 MEDLINE (Ovid) search terms

Table 9-15 *- Search terms for MEDLINE (Ovid), combination of workforce AND disease AND setting used.*

	Provider	**Workforce density**	**Setting**
1	Surgeon.ti,ab	(workforce adj3 density).mp.	Developing Countries.sh,kf.
2	Anaesthetist OR anaesthesiologist OR anaesthetist OR anesthesiologists.ti,ab	(staffing adj2 levels)	Africa or Asia or Caribbean or West Indies or South America or Latin America or Central America.hw,kf,ti,ab,cp,in.
3	Obstetrician.ti,ab	Workforce gap	Afghanistan or Angola or Armenia or Armenian or Bangladesh or Benin or Bhutan or Bolivia or Burkina Faso or Burkina Fasso or Burundi or Cambodia or Central African Republic or Chad or Comoros or Congo or Cote d'Ivoire or Ivory Coast or Djibouti or Egypt or El Salvador or Eritrea or Ethiopia or Gambia or Gaza or Georgia or Ghana or Guatemala or Guinea or Guam or Haiti or Honduras or India or Indonesia or Kenya or Kiribati or Korea or Kosovo or Kyrgyzstan or Lao PDR or Lesotho or Liberia or Madagascar or Malawi or Mali or Mauritania or Moldova or Mongolia or Morocco or Mozambique or Myanmar or Myanma or Nepal or Nicaragua or Niger or Nigeria or Pakistan or Paraguay or Philippines or Philipines or Phillipines or Phillippines or Rwanda or Ruanda or Sao Tome or Senegal or Sri Lanka or Solomon Islands or Somalia or Sudan or Swaziland or Tajikistan or Tanzania or Timor-Leste or

			Tokelau or Togo or Tuvalu or Uganda or Ukraine or Uzbekistan or Vanuatu or Vietnam or Viet Nam or West Bank or Yemen or Zambia or Zimbabwe.hw,kf,ti,ab,cp,in.
4	Gynaecologist OR gynecologist.ti,ab	NSOAP OR “National Surgical Obstetric Anaesthesia Plan”	((developing or less* developed or under developed or underdeveloped or middle income or low* income or underserved or under served or deprived or poor*) adj (countr* or nation? or population? or world)).ti,ab.
5	Surgical provider.ti,ab	Surgical capacity	((developing or less* developed or under developed or underdeveloped or middle income or low* income) adj (economy or economies)).ti,ab.
6	Anaesthetic provider OR anesthetic provider.ti,ab	OR/1-5	(low* adj (gdp or gnp or gross domestic or gross national).ti,ab.
7	SAO adj3 provider.ti,ab		(low adj3 middle adj3 countr*).ti,ab.
8	surgical practitioner.ti,ab		(lmic or lmics or third world or lami countr*).ti,ab.
9	OR/1-8		transitional countr*.ti,ab.
10			((high burden or high-burden or countdown) adj countr*).ti,ab.
11			or/1-10

3B.2 Grey literature review strategy

List of health organisations websites to search as part of the grey literature review

- Overton – Grey literature database.
- World Health Organization
- World Bank
- USAID
- World Journal of Surgery
- College of Surgeons of East, Central and Southern Africa
- G4Alliance
- WHO/World Bank global surgical workforce database
- The National health Workforce Accounts database, WHO.
- Word Federation of Neurosurgical Societies World Neurosurgery Map
- World Federation of Societies of Anaesthesiologists
- BMJ Global Health
- The Lancet Global Health
- The World Journal of Surgery

3B.3 Search strategy for Google grey literature search

Search terms used for grey literature search using Google search engine: “workforce” OR “surgeon” OR “surgical provider” OR “obstetrician” OR “gynaecologist” or “anaesthetist” OR ”anaesthesiologist” OR “anaesthesia provider” AND “surgery” OR “injury” AND “surgical” AND “low income” OR “low-middle income” OR “LMIC”.

The search was performed both with and without limiting the domains to .org .edu .gov .ac.uk and .int.

3B.4 Search strategy for Overton

(surgeon OR anaesthetist OR anaesthesiologist OR anesthetist OR anesthesiologist OR obstetrician OR gynaecologist OR gynecologist OR "surgical provider" OR "anaesthetic provider" OR "anesthetic provider" OR "physician associate" OR "SAO provider" OR "surgical practitioner") AND ("workforce density" OR "staffing levels" OR "workforce gap" OR NSOAP OR "national surgical obstetric anaesthesia plan"

OR "surgical capacity") AND (developing countries OR LMIC OR "developing nation” OR “Low income”~3 OR “middle income”~3)

Appendix 4A – Somaliland Essential Surgery & Obstetrics Survey

Royal College of Surgeons of England

Somaliland Essential Surgery & Obstetrics Training Needs Survey

This survey is part of a national Training Needs Analysis that will help to to identify the most important areas for further training and systems improvement in Somaliland. By completing this survey you will help to shape the developments of training and professional development in your own workplace.
The Somaliland Medical Association (SMLA) is working with the Partnerships for Surgical Systems Strengthening (PaSSS) initiative through this survey to improve surgical, obstetric, trauma and anaesthesia care in Somaliland. This work is supported by the Ministry of Health Development (MOHD) and the National Professions Council (NHPC). PaSSS Partners include:

- InciSioN Somaliland
- the Somaliland Nursing Anaesthesia Network (SNAN)
- Somaliland Nursing & Midwifery Association (SNMA)
- Somaliland Medical Laboratory Association (SOMLA)
- Hargeisa Group Hospital (HGH)
- Burco Regional Hospital (BRH)
- Medicine Africa
- The Royal College of Surgeons of England (RCS England)

1

DATA PROTECTION STATEMENT & CONSENT

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2. The data will be anonymised and stored securely in accordance with the Data Protection Act 2018, the General Data Protection Regulation (GDPR) and RCS England's Privacy Policy. It will be used only in connection with the purposes for which you originally provided the information. For the avoidance of any doubt, the information will be shared with members of the PaSSS Somaliland Partnership, the Somaliland Ministry of Health Development (MOHD), National Health Professions Council (NHPC), donors and researchers working with or on behalf of RCS England and/or the PaSSS Somaliland Partnership.
3. Within this survey there is an option for you to provide us information which may identify you personally. We will not collect this data unless you specifically and willingly choose to provide us with such information. If you do, we will use such details only for the purposes of (a) keeping you updated on the progress and results of the survey; (b) inviting you to participate in focus groups or interviews in connection with the survey and its findings; (c) determining what percentage of health workers completing the survey have an NHPC registration number. Access to your personal data will be restricted and will not be shared widely without your express written consent.
4. Should you wish to find out more about how we handle your information or to discuss any services provided by RCS England, please contact global@rcseng.ac.uk.

*

○ By ticking this box, I give consent for RCS England to share my personal data being stored and/or processed for the purposes and in the manner described above. I understand that at any point I am free to withdraw this consent by contacting humanitarian@rcseng.ac.uk

Demographics

Sex *

○ Male
○ Female

2

Age *

- 18 - 24
- 25 - 34
- 35 - 44
- 45 - 54
- 55 - 64
- Above 65
- Prefer not to say

What is your profession? *

- Doctor/Physician
- Anaesthesia provider
- Obstetrician/Gynaecologist
- Surgeon (Doctor with formal post-graduate training in surgery)

What stage of training are you? *

- Medical student
- Qualified doctor
- Specialist physician/surgeon/anaesthetist with postgraduate training in your speciality

In which region do you work?

- Awdal
- Gabiley
- Marodijeeh
- Sahil
- Togdheer
- Sanaag
- Sool

What is the setting of your workplace? *

- Rural
- Urban

What type of healthcare facility do you work in? *

- Primary care/community facility
- Secondary care/WHO Level 1 hospital
- Tertiary care/WHO Level 2 or 3 hospital

How many years of postgraduate medical experience do you have? *

- Less than 3 years
- 3 - 5 years
- 6 - 10 years
- 11 - 15 years
- 16 - 20 years
- More than 20 years

Describe your previous surgical training *

- [ ] Formal postgradute qualification (Membership of Surgical College, Post Graduate Certificate, Masters or Higher Degree)
- [ ] Training course
- [ ] Online training course or webinar
- [ ] Informal 'on the job' training
- [ ] Other

If other please describe:

Surgical Training Needs Analysis

Surgical & Obstetric skills

You will see listed below a range of procedures, many of which you may undertake in performing your job. Look at each of these activities and then rate each one by writing the appropriate number in the box.
The first column (A) asks **how important** the procedure is to the successful performance of your job.
The second column (B) asks **how well you currently perform** this procedure.
The third column (C) asks **how many times per year** do you perform this procedure?
The fourth column (D) asks **how important is improving training** alone, in improving your performance at this procedure.
The fifth column (E) ask **how important is improving your work situation**, in improving your performance at this procedure.

We understand that some clinicians will only use some of these skills - just complete the rows for the skills that are relevant to you, and tick the last column if you no longer perform this skill or you have not completed this rotation yet.

Please answer each these questions by choosing a number from 1-7 (1-not important/not well, 7-extremely important/extremely well)

	A - How important is this for your patient care?	B - How well do you consider that you currently perform this activity?	C - How many times per year do you perform this skill?	D - How important is improving training alone in improving your performance of this skill?	E - How important are changes to your work situation (systems, infrastructure, equipment) to improving your performance of this skill?	I no longer perform this operation or I have not completed this rotation in training.
Trauma laparotomy						
C-section						
Cataract surgery						
Inguinal hernia repair						
Stoma formation						
Tracheostomy						
Open appendectomy						
Partial colectomy						
Modified radical mastectomy						
Trauma thoracotomy						
Extremity amputation						
Small bowel resection						
Hysterectomy						
External fixation femur						
Uterine evacuation						

Partial mastectomy

Splenectomy

Trauma craniotomy

External fixation tibia

Tube thoracostomy

Laparoscopic cholecystectomy

Obstetric fistula repair

Internal fixation femur

Laparoscopic appendectomy

Pediatric colostomy

Salpingectomy

Imperforate anus repair

Open cholecystectomy

Coronary artery bypass graft

Percutaneous coronary angioplasty

Cleft lip/palate repair

Thyroidectomy

7

Use of technology

Is technology currently used in either your clinical practice (such as video calls to a patient or colleague) or training (such as an online webinar or watching a video recording of an operation *

- Yes
- No

What technology is currently used? (Tick all that apply) *

- Video calls to colleague
- Video calls to patient
- Videoconferences
- Sending clinical photographs or videos
- Webinars for training or continued professional development (CPD)
- Online conferences
- Remote supervision or mentoring of procedures
- Watching video recording of an operation or procedure
- Online smart phone app for surgical trianing
- Website
- Online lectures
- Online logbook of operations or procedures
- Other

If other please describe:

17

What are the barriers to using technology in your current place of work? *

- ☐ Lack of hardware (computer, smart phone etc)
- ☐ Lack of access to software
- ☐ Unaware of technology available
- ☐ Unsure which technology is most appropriate
- ☐ Unstable internet connection
- ☐ Unreliable power source
- ☐ Other

If other please give more detail:

How could technology best be used to improve training or patient care in your place of work?

Further training

If you would like us to keep you informed with the Training Needs Analysis or you would be willing to participate in an interview or focus group in connection with the PaSSS Somaliland Initiative please enter your email address below:

example@example.com

Submit

Do you hold a licence with the NHPC? *

- ◯ Yes
- ◯ No
- ◯ Don't know

Do you use the World Health Organisation Surgical Safety Checklist? *

- ◯ Always
- ◯ Often
- ◯ Rarely
- ◯ Never
- ◯ I don't know what this is

Do you keep a logbook or record of the operations or procedures that you have performed either individually or collectively at your hospital? *

- ◯ I do not keep a log book
- ◯ I keep an individual logbook for my own operations or procedures
- ◯ We have a logbook at our hospital/institution

What technology would you like to see introduced in future? (Tick all that apply) *

- ☐ Video calls to colleague
- ☐ Video calls to patient
- ☐ Videoconferences
- ☐ Sending clinical photographs or videos
- ☐ Webinars for training or continued professional development (CPD)
- ☐ Online conferences
- ☐ Remote supervision or mentoring of procedures
- ☐ Watching video recording of an operation or procedure
- ☐ Online smart phone app for surgical trianing
- ☐ Website
- ☐ Online lectures
- ☐ Online logbook of operations or procedures
- ☐ Other

Is your facility public or private? *

- ◯ Public/Government facility
- ◯ Private facility
- ◯ Non-governmental organisation (NGO) or charity facility
- ◯ Other

Do you have any other suggestions on how to improve surgical care in Somaliland?

Where did you undertake your training? *

- Somaliland
- Other

Appendix 4B - Somaliland Essential Anaesthesia Survey

Royal College of Surgeons of England

Somaliland Essential Anaesthesia Training Needs Survey

This survey is part of a national Training Needs Analysis that will help to identify the most important areas for further training and systems improvement for anaestehsia providers in Somaliland. By completing this survey you will help to shape the development of training and professional development in your own workplace.
To do this, the Somaliland Nursing Anaesthesia Network (SNAN) is working with the **Partnerships for Surgical Systems Strengthening (PaSSS)** initative to improve surgical, obsttric, trauma and anaesthesia care in Somaliland. This work is being supported by the **Ministry of Health Development** (MOHD) and the **National Health Professions Council** (NHPC). PaSSS partners include:

- InciSioN Somaliland
- Somaliland Medical Association (SMLA)
- Somaliland Nursing & Midwifery Association (SNMA)
- Somaliland Medical Laboratory Association (SOMLA)
- Hargeisa Group Hospital (HGH)
- Burco Regional Hospital (BRH)
- Medicine Africa
- The Royal College of Surgeons of England (RCS England)

1

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3. Within this survey there is an option for you to provide us information which may identify you personally. We will not collect this data unless you specifically and willingly choose to provide us with such information. If you do, we will use such details only for the purposes of (a) keeping you updated on the progress and results of the survey; (b) inviting you to participate in focus groups or interviews in connection with the survey and its findings; (c) determining what percentage of health workers completing the survey have an NHPC registration number. Access to your personal data will be restricted and will not be shared widely without your express written consent.
4. Should you wish to find out more about how we handle your information or to discuss any services provided by RCS England, please contact global@rcseng.ac.uk.

*

- ◯ By ticking this box, I give consent for RCS England to share my personal data being stored and/or processed for the purposes and in the manner described above. I understand that at any point I am free to withdraw this consent by contacting humanitarian@rcseng.ac.uk

Demographics

Sex *

- ◯ Male
- ◯ Female

2

Age *

- 18 - 24
- 25 - 34
- 35 - 44
- 45 - 54
- 55 - 64
- Above 65
- Prefer not to say

What is your profession? *

- Nurse
- Doctor/Physician
- Anaesthesia provider

What stage of training are you? *

- Student healthcare worker (medical student, student nurse/anaestheisa provider/)
- Qualified healthcare worker (doctor, nurse, anaesthesia provider)
- Specialist physician/anaesthetist with postgraduate training in your speciality

In which region do you work?

- Awdal
- Gabiley
- Marodijeeh
- Sahil
- Togdheer
- Sanaag
- Sool

3

What is the setting of your workplace? *

- Rural
- Urban

What type of healthcare facility o you work in? *

- Primary care/community facility
- Secondary care/WHO Level 1 hospital
- Tertiary care/WHO Level 2 or 3 hospital

How many years of postgraduate medical experience do you have? *

- Less than 3 years
- 3 - 5 years
- 6 - 10 years
- 11 - 15 years
- 16 - 20 years
- More than 20 years

4

Anaesthetic training needs analysis

Anaesthetic skills

You will see listed below a range of procedures, many of which you may undertake in performing your job. Look at each of these activities and then rate each one by writing the appropriate number in the box. The first column (A) is concerned with how **important the activity is** to the successful performance of your job; the second column (B) is concerned with **how well you currently perform** that activity; the third column (C) asks how **many times per year do you perform this activity?**.

We understand that some clinicians will only use some of these skills - **just complete the rows for the skills that are relevant to you, ignore the skills that are not relevant to you.**

9

Please answer each these questions by choosing an option form the dropdown menu (1-not important/not well, 7-extremely important/extremely well)

	A - How important is this for your patient care?	B - How well do you consider that you currently perform this activity?	C - How often do you perform this skill?
Administration of a general anaesthetic			
Administration of regional anaesthesia			
Administration of spinal anaesthesia			
Endotracheal intubation			
Emergency front of neck access (cricothyroidotomy)			
Management of peri-operative complications			
Pre-operative assessment of a patient for surgery			
Peri-operative analgesia			
Neonatal resuscitation			
Paediatric anaesthesia			
Geriatric anaesthesia			
Medical management of co-morbidities			

The following columns are concerned with the scope for improving performance either through **D - training alone** or through **E - changes in your work situation.**
We understand that some clinicians will only use some of these skills - **just complete the rows for the skills that are relevant to you, ignore the skills that are not relevant to you.**

10

Please answer each these questions by choosing a number from 1-7 (1 - Not at all important, 7 - Extremely important to improving performance)

	D - How important is improving training alone in improving your performance of this skill?	E - How important are changes to your work situation (systems, infrastructure, equipment) to improving your performance of this skill?
Administration of a general anaesthetic		
Administration of regional anaesthesia		
Administration of spinal anaesthesia		
Intubation		
Emergency front of neck access (cricothyroidotomy)		
Management of peri-operative complications		
Pre-operative assessment of a patient for surgery		
Peri-operative analgesia		
Neonatal resuscitation		
Paediatric anaesthesia		
Geriatric anaesthesia		
Medical management of co-morbidities		

Use of technology

Is technology currently used in either your clinical practice (such as video calls to a patient or colleague) or training (such as an online webinar or watching a video recording of an operation *

- Yes
- No

What technology is currently used? (Tick all that apply) *

- ☐ Video calls to colleague
- ☐ Video calls to patient
- ☐ Videoconferences
- ☐ Sending clinical photographs or videos
- ☐ Webinars for training or continued professional development (CPD)
- ☐ Online conferences
- ☐ Remote supervision or mentoring of procedures
- ☐ Watching video recording of an operation or procedure
- ☐ Online smart phone app for surgical trianing
- ☐ Website
- ☐ Online lectures
- ☐ Online logbook of operations or procedures
- ☐ Other

If other please describe:

If other please describe:

What are the barriers to using technology in your current place of work? *

- ☐ Lack of hardware (computer, smart phone etc)
- ☐ Lack of access to software
- ☐ Unaware of technology available
- ☐ Unsure which technology is most appropriate
- ☐ Unstable internet connection
- ☐ Unreliable power source
- ☐ Other

If other please give more detail:

How could technology best be used to improve training or patient care in your place of work?

Further training

If you would like us to keep you informed with the Training Needs Analysis or you would be willing to participate in an interview or focus group in connection with the PaSSS Somaliland Initiative please enter your email address below:

example@example.com

Submit

Do you hold a licence with the NHPC? *

- Yes
- No
- Don't know

Do you use the World Health Organisation Surgical Safety Checklist? *

- Always
- Often
- Rarely
- Never
- I don't know what this is

Where did you undertake your training? *

- Somaliland
- Other

Is your facility public or private? *

- Public/government facility
- Private facility
- Non-governmental organisation (NGO) or charity facility

Do you have regular access to a reliable oxygen saturation monitor or probe for use intra-operatively?

What technology would you like to see introduced in future? (Tick all that apply) *

- Video calls to colleague
- Video calls to patient
- Videoconferences
- Sending clinical photographs or videos
- Webinars for training or continued professional development (CPD)
- Online conferences
- Remote supervision or mentoring of procedures
- Watching video recording of an operation or procedure
- Online smart phone app for surgical trianing
- Website
- Online lectures

- Online logbook of operations or procedures
- Other

Appendix 4C – South Africa Essential Surgery Survey

Essential General Surgical Skills Training Needs Analysis

This survey is part of a national Training Needs Analysis that will help to to identify the most important areas for further training and systems improvement across South Africa. By completing this survey you will help to shape the developments of training and professional development in your own workplace. This project is a collaboration between the Association of Surgeons of South Africa (ASSA) Surgical Research Society of Southern Africa (SRSSA) the South African Society of Surgeons in Training (SASSIT) and the Global Surgery Policy Unit from the London School of Economics and the Royal College of Surgeons of England.

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3. Within this survey there is an option for you to provide us information which may identify you personally. We will not collect this data unless you specifically and willingly choose to provide us with such information. If you do, we will use such details only for the purposes of (a) keeping you updated on the progress and results of the survey; (b) inviting you to participate in focus groups or interviews in connection with the survey and its findings. Access to your personal data will be restricted and will not be shared widely without your express written consent.
4. Should you wish to find out more about how we handle your information or to discuss any services provided by RCS England, please contact global@rcseng.ac.uk.

*

○ By ticking this box, I give consent for RCS England to share my personal data being stored and/or processed for the purposes and in the manner described above. I understand that at any point I am free to withdraw this consent by contacting humanitarian@rcseng.ac.uk

1

1 - Demographics

Gender *

○ Male
○ Female

Age *

○ 18 - 24
○ 25 - 34
○ 35 - 44
○ 45 - 54
○ 55 - 64
○ Above 65
○ Prefer not to say

What is the setting of your workplace? *

○ Rural
○ Urban

What type of healthcare facility do you work in? *

○ Primary care/community facility
○ Secondary care/WHO Level 1 hospital
○ Tertiary care/WHO Level 2 or 3 hospital

Do you use the World Health Organisation Surgical Safety Checklist? *

○ Always
○ Often
○ Rarely
○ Never
○ I don't know what this is

Do you keep a logbook or record of the operations or procedures that you have performed either individually or collectively at your hospital? *

○ I do not keep a log book
○ I keep an individual logbook for my own operations or procedures
○ I do not keep a personal log book but there is a logbook at our hospital/institution/operating theatre

2

What stage of your career are you? *

- ◯ Registrar/Postgraduate trainee
- ◯ Consultant/Attending

2a - Trainees

What year of training are you currently in? *

- ◯ 1
- ◯ 2
- ◯ 3
- ◯ 4
- ◯ 5
- ◯ 6
- ◯ 7
- ◯ 8

Where are you undertaking your training? *

- ◯ South Africa
- ◯ Other

What is your career intent? *

- ◯ Public practice
- ◯ Private practice
- ◯ Academic surgery
- ◯ Mixture of public and private
- ◯ Other

If you selected 'Other', please describe below:

2b - For Consultant/Attending Surgeons

How many years have you been practicing as a Consultant? *

- 1
- 2
- 3
- 4
- 5
- More than 5

Where did you complete your surgical training? *

- South Africa
- Other

If other please state which country:

Is your facility public or private? *

- Public/Government/Academic facility
- Private facility
- Non-governmental organisation (NGO) or charity facility
- Other

On a scale of 1 - 7, how well did your surgical training prepare you for consultant practice?

Please Select

What skills or clinical situations were you not adequately prepared for in your surgical training? *

3 - Surgical Training Needs Analysis

You will see listed below a range of procedures, many of which you may undertake in performing your job. Look at each of these activities and then rate each one by writing the appropriate number in the box.
The first column (A) asks **how important the procedure is** to the successful performance of your job.
The second column (B) asks **how well you currently perform this procedure**.
The third column (C) asks **how many times per year do you perform this procedure**?
The fourth column (D) asks **how important is improving training** alone, in improving your performance at this procedure.
The fifth column (E) ask **how important is improving your work situation**, in improving your performance at this procedure.

We understand that some clinicians will only use some of these skills - **just complete the rows for the skills that are relevant to you,** and **tick the last column if you no longer perform this skill or you have not completed this rotation yet.**

Please answer each these questions by choosing a number from 1-7 (1-not important/not well, 7-extremely important/extremely well)

	A - How important is this for your patient care?	B - How well do you consider that you currently perform this activity?	C - How many times per year do you perform this skill?	D - How important is improving training alone in improving your performance of this skill?	E - How important are changes to your work situation (systems, infrastructure, equipment) to improving your performance of this skill?	I no longer perform this operation or I have not completed this rotation in training.
Trauma laparotomy						
Trauma thoracotomy						
Extremity amputation						
Splenectomy						
Tube thoracostomy						
Diagnostic laparoscopy for trauma						
Cricothyroidotomy and tracheostomy						
Venous cut down						

Peritoneal pelvic packing
Liver packing
Stoma formation
Partial colectomy
Small bowel resection
Open appendectomy
Laparoscopic appendectomy
Laparoscopic cholecystectomy
Open cholecystectomy
Thyroidectomy
Inguinal hernia repair (adults)
Inguinal hernia repair (paediatric)
Wide local excision for breast cancer
Modified radical mastectomy
Tracheostomy

7

4 - Use of technology

If other please describe:

8

What technology would you like to see used in future in: A - your clinical practice? And B - your training?

	In clinical practice	In training
Video calls to colleague		
Video calls to patient		
Videoconferences		
Specialist telemedicine software e.g. Proximie		
Sending clinical photographs or videos		
Webinars for training or continued professional development (CPD)		
Online conferences		
Remote supervision or mentoring of procedures		
Watching video recording of an operation or procedure		
Online smart phone app for surgical trianing		
Website		
Online lectures		
Online logbook of operations or procedures		
Other		

If other please describe:

What are the barriers to using technology in your current place of work?

	In clinical practice	In training
Lack of hardware (computer, smart phone etc)		
Lack of access to software		
Unaware of technology available		
Unsure which technology is most appropriate		
Unstable internet connection		
Unreliable power source		
Cost/finances		
Other		

If other please give more detail:

How could technology best be used to improve training in your place of work?

Further training

Please specify the areas of your job in which you would like to receive further training. Please list these in order of importance.

Do you have any other suggestions on how to improve surgical training in South Africa?

If you would like us to keep you informed with the Training Needs Analysis or you would be willing to participate in an interview or focus group in connection with the Global Surgery Policy Unit (GSPU) please enter your email address below:

example@example.com

Submit

Essential General Surgical Skills

What technology is currently being used in: A - your clinical practice? And B - your training?

	In clinical practice	In training
Video calls to colleague	☐	☐
Video calls to patient	☐	☐
Videoconferences	☐	☐
Specialist telemedicine software e.g. Proximie	☐	☐
Sending clinical photographs or videos	☐	☐
Webinars for training or continued professional development (CPD)	☐	☐
Online conferences	☐	☐
Remote supervision or mentoring of procedures	☐	☐
Watching video recording of an operation or procedure	☐	☐
Online smart phone app for surgical trianing	☐	☐
Website	☐	☐
Online lectures	☐	☐
Online logbook of operations or procedures	☐	☐
Other	☐	☐

11

12

Appendix 5A – Good Reporting of a Mixed Methods Study (GRAMMS) guideline for Chapter 5

Table 9-16. Good Reporting of a Mixed Methods Study (GRAMMS) guideline for Chapter 5.

Item	Guideline	Paragraph reported
1	Describe the justification for using a mixed methods approach to the research question	4.2 Methods
2	Describe the design in terms of the purpose, priority and sequence of methods	4.2 Methods & 5.2 Methods
3	Describe each method in terms of sampling, data collection and analysis	4.2.4 Organisational analysis and study locations, 5.2 Methods & 5.3 Results
4	Describe where integration has occurred, how it has occurred and who has participated in it	4.2 Methods & 5.2 Methods
5	Describe any limitation of one method associated with the present of the other method	5.5.1 Limitations
6	Describe any insights gained from mixing or integrating methods	5.5 Discussion & 5.6 Conclusion

Appendix 6A – Good Reporting of a Mixed Methods Study (GRAMMS) guideline for Chapter 6

Table 9-17. Good Reporting of a Mixed Methods Study (GRAMMS) guideline for Chapter 6.

Item	Guideline	Paragraph reported
1	Describe the justification for using a mixed methods approach to the research question	4.2 Methods
2	Describe the design in terms of the purpose, priority and sequence of methods	4.2 Methods & 6.2 Methods
3	Describe each method in terms of sampling, data collection and analysis	4.2.4 Organisational analysis and study locations, 6.2 Methods & 6.3 Results
4	Describe where integration has occurred, how it has occurred and who has participated in it	4.2 Methods & 6.2 Methods
5	Describe any limitation of one method associated with the present of the other method	6.4.4 Limitations
6	Describe any insights gained from mixing or integrating methods	6.4 Discussion & 6.5 Conclusion

Appendix 7A – Standards for Reporting Qualitative Research (SRQR) guideline

Table 9-18. Standards for Reporting Qualitative Research (SQSR) guideline

Domain	Item
Title	Defining Humanitarian Surgery; An International Delphi Process.
Abstract	Included in manuscript.
Problem formulation	Included in Introduction section.
Research question	What is the definition of the term Humanitarian Surgery?
Qualitative approach and research paradigm	Delphi process.
Researcher characteristics and reflexivity	Full demographics are reported and full reflexivity statement is included in the manuscript.
Context	Inclusion and exclusion criteria included in methods section.
Sampling strategy	Targeted sampling of authors of Global Surgery papers as well as the research authors' networks. Snowball sampling used to increase response rate from LMICs.
Ethical issues	Approved by London School of Economics Research Ethics Committee.
Data collection methods	Included in Methods section.
Data collection instruments and technologies	Included in Methods section.
Units of study	Included in Results section.
Data processing	Included in Methods and Results sections.
Data analysis	GM performed thematic analysis on data from Round 1, confirmed with the senior author. Further data analysis reported in Methods and Results sections.
Techniques to enhance trustworthiness	Reported using appropriate descriptive statistics. Median and IQR selected as these are more robust measures of group agreement and consensus.
Synthesis and interpretation	Included in Results section.
Links to empirical data	Demographic data and summary of Likert scales included in manuscript.
Integration with prior work	Included in Discussion.
Limitations	Included in Discussion.
Conflicts of interest	None.
Funding	This project has been funded by UK aid from the UK government; however, the views expressed do not necessarily reflect the UK government's official policies.

Appendix 7B – Guidance for Reporting Involvement of Patients and Public - Short Form (GRIPP2-SF)

Table 9-19. Guidance for Reporting Involvement of Patients and Public - Short Form (GRIPP2-SF)

Section and topic	Item	Reported on page no.
1: Aim	Report aim of Patient and Public Involvement (PPI) in this study.	249
2: Methods	Provide a clear description of the methods used for PPI in this study.	249
3: Study results	Outcomes – Report the results of PPI in the study, including both positive and negative outcomes.	251 - 258
4 Discussion and conclusions	Outcomes – Comment on the extent to which PPI influenced the study overall. Describe positive and negative effects.	258 - 262
5: Reflections/critical perspective	Comment critically on the study, reflecting on the things that went well and those that did not, so other can learn from this experience.	261 - 262

Appendix 7C - List of respondents

Jared Wohlgemut
Fabien Mantilla
Soham Bandyopadhyay
Henry de Berker
Monalisa Faulkner
Simon Horne
Ali Saeed
Mahmoud
Waeel Hamouda
Mahmoud Al Quran
Stephen Chadwick
Paul Hage
Andy Leather
Raoof Saleh
Ammar
James Glasbey
Younos
Mohammed Alyousofi
Håkon Bolkan
Tim Tientcheu
Lesley Hunt
Osama Abidi
Mansoor Khan
Ibrahim Ali Abdulkareem
Ali Alburaihi
Dimitri Pournaras
Thomas Hampton
Mariam Dahir
Christoph McAllen
Barayka
Abdullah Mohammed
Abdullah Abbas Alameri
Naveen Cavale
Harald Veen
Amila Ratnayake
Estevao Plentz
Tom Bashford
Wasingya Kasereka
Lucien

Chukwuemeka Anyikwa
Tony Redmond
Deirdre Mangaoang
Benard Langat
Ali Ghelai
Qasem
Murgong Erick
Bronte Martin
Fadi Hakim
Aref Mohammed Hassan
Ali Daoud
Shaheed
Mohamed Aamer
Jonathan Herron
Kokila Lakhoo
Elsie Awino
Sherry Wren
Emma Upchurch
Saladin Sawan
Mandeep Pathak
Mohana Amirtharajah
JM RAMIA
Jyotsna Rani
Ahmed Almaqadma*
Mubarak Elkarsany
June Jach
Wadih Hassan Ali
Ekuwam David
Hanna Kaade
Judy Mella
Momcilo Trajkovic
Syed Muhammad Ali
Mahfooz Alsenwi
Mohammad Alqadi
Rajeev Naik
Rebekka Troller
Chris Lavy
Leonid Aya
Muaadh

Emma Sidebotham
Deepa Bose
Samer Jabbour
Felicia Sande
Vasileios Sakalis
Rachel Fletcher
Abdullah Alhajj
Timothy Love
Ismail Lawani
Abdonaser
Peter Anderson
Andy Kent
Fadhel Mutahar
Bashama Naji Atiya Saleh
Arjuna Aluwihare
Michael Odesoji
Akhila Annamreddi
Vishal Kumar
Claire Durkin
Ewen Harrison
Mohammed
Moez Zeiton
Matt Doe
Kota Itamoto
William Bolton
Syrian Medical Medical Society
Wail Ahmed
Waleed al Alimi
Selmy Awad
Dubem Ejikeme Orakwe
Lionelle Tchokam
A Haitham
Timothy Das
June Jach (PPI member)

*tragically killed in Gaza – March 2024

Appendix 7D - List of publications and presentations undertaken during the period of research

Published papers

McKnight, Friebel, Marks, Almaqadma, Seleem, Tientcheu, Saleh, Ryan-Coker, Emodi, Seida, Barden, Redmond, Amirtharajah, Wren, Leather, Hargest.
Defining humanitarian surgery: international consensus in global surgery, British Journal of Surgery, Volume 111, Issue 2, February 2024, znae024, https://doi-org.abc.cardiff.ac.uk/10.1093/bjs/znae024

Khomenko, Lurin, Gumeniuk, McKnight, Makarov, Nehoduyko, Khoroshun, Tertyshnyi.
Telemedicine support aids lower limb reconstruction after combat injury in Ukraine, *Journal of Surgical Case Reports*, Volume 2023, Issue 7, July 2023, rjad403, https://doi-org.abc.cardiff.ac.uk/10.1093/jscr/rjad403

Presentations

Training Needs Analysis of surgical teams in Somaliland. McKnight, Daoud, Orr, Friebel, Hargest. The Travelling Surgical Society, London September 2024.

Clinical Reach back to Ukraine. McKnight, Tertyshnyi, Chaychenko, Booker, Bowley, Makarov. Australasian Military Medicine Association Conference. Perth, Australia, October 2023.

Clinical Reach back to Ukraine. McKnight, Tertyshnyi, Chaychenko, Booker, Bowley, Makarov. Military Health Systems Research Symposium, Orlando, USA. August 2023.

Defining Humanitarian Surgery; an international Delphi process. McKnight, Friebel, Hargest Surgical Research Society of South Africa, Durban, South Africa. July 2023.

Defining Humanitarian Surgery; an international Delphi process. McKnight, Friebel, Hargest. NIHR Global Surgery Research Day, RCS England. Oct 2022

Defining Humanitarian Surgery: an international Delphi process. McKnight, Friebel, Hargest. Surgical Research Society Annual Meeting. March 2023

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