

Capacity building through workforce training and community engagement for Surgical, Obstetric, Trauma, and Anaesthesia (SOTA) care: Case studies from South Asia

Shirish Rao^{a,b}, Uma Gupta^a, Aishwarya Ramanujam^a, Abigail Knoble^{c,d}, Isha Gondi^e, Poorvikha Gowda^{a,f}, Chaitanya Reddy^{a,g}, Kashim Shah^c, Archana Amatya^c, Arpana Kalaunee^c, Ruma Rajbhandari^{c,d,h}, Richard Henkar^{i,j}, Mashal Shah^k, Sadaf Khan^k, Gnanaraj Jesudian^{l,m,n}, Kranti Vora^o, Rahul M. Jindal^{p,q,r}, Atul Suroy^s, Dhruva Ghosh^s, Irum Fatima^t, Lovenish Bains^u, Dhananjaya Sharma^v, Siddhesh Zadey^{a,w,x,y,*}, On behalf of the G4 Alliance Asia Working Group

^a Association for Socially Applicable Research (ASAR), Pune, Maharashtra, India

^b Travel Fellow in Primary Care, Tribal Health Initiative, Sittilingi, Tamil Nadu, India

^c Nick Simons Institute, Kathmandu, Nepal

^d Mass General Brigham, Boston, MA, USA

^e Touro University Nevada, Henderson, NV, USA

^f St John's Medical College, Bengaluru, India

^g Smt. Bhikhiben Kanjibhai Shah Medical Institute and Research Center, Vadodara, Gujarat, India

^h Harvard Medical School, Boston, MA, USA

ⁱ Department of Nurse Anesthesia, School of Nursing, University of Pittsburgh, Pittsburgh, PA, USA

^j Global Alliance for Surgery, Obstetric, Trauma and Anaesthesia Care, Washington, DC, USA

^k Centre for Global Surgical Care, Department of Surgery, Aga Khan University, Karachi, Sindh, Pakistan

^l Rural Surgery Innovations Private Limited, Dimapur, Nagaland, India

^m Association of Rural Surgeons of India, India

ⁿ International Federation of Rural Surgeons, India

^o Independent consultant, Gandhinagar, Gujarat, India

^p Uniformed Services University of the Health Sciences, Bethesda, MD, USA

^q Indian Institute of Public Health, Gandhinagar, Gujarat, India

^r Commissioner, Office of Human Rights, MD, USA

^s India Hub, NIHR Global Health Research Unit On Global Surgery, Christian Medical College, Ludhiana, Punjab, India

^t Jhpiego, A Johns Hopkins University Affiliate, Pakistan Country Office, Islamabad, Pakistan

^u Department of General Surgery, Maulana Azad Medical College, New Delhi, India

^v Department of Surgery, Netaji Subash Chandra Bose Government Medical College Jabalpur, Madhya Pradesh, India

^w Department of Epidemiology, Mailman School of Public Health, Columbia University, New York, NY, USA

^x GEMINI Research Center, Duke University School of Medicine, Durham, NC, USA

^y Dr. D. Y. Patil Dental College and Hospital, Dr. D. Y. Patil Vidyapeeth, Pune, Maharashtra, India

Abbreviations: AAs, Anaesthesia Assistants; ARSI, Association of Rural Surgeons of India; ASBAs, Advanced Skilled Birth Attendants; ASHAs, Accredited Social Health Activists; BMETs, Biomedical Equipment Technicians; BSc, Bachelor of Science; CHWs, Community Health Workers; DBEE, Diploma in Biomedical Equipment Engineering; DNB, Diplomate of National Board; GILLS, Gas Insufflation-Less Laparoscopic Surgery; GSU, Global Surgery Unit; HICs, High-Income Countries; HVO, Health Volunteers Overseas; JDWNRH, Jigme Dorjiangchuck National Referral Hospital; KGUMSB, Khesar Gyalpo University of Medical Sciences of Bhutan; LCoGS, Lancet Commission on Global Surgery; LICs, Low-Income Countries; LMICs, Lower-Middle-Income Countries; MBBS, Bachelor of Medicine and Bachelor of Surgery; MD, Doctor of Medicine; MDGPs, Medical Doctors of General Practice; MS, Master of Surgery; NIHR, National Institute for Health and Care Research; NSI, Nick Simons Institute; SATHI, Surgical Accredited and Trained Healthcare Initiative; SOTA, Surgical, Obstetric, Trauma, and Anaesthesia; SOSAS, Surgeons Overseas Assessment of Surgical Needs; SSI, Surgical Site Infections; TSS, Task sharing and shifting; UMICs, Upper-Middle-Income Countries.

* Corresponding author at: Association for Socially Applicable Research (ASAR), D2 Sai Heritage, New DP Road, Aundh, Pune, Maharashtra 411007, India.

E-mail address: sidzadey@asarforindia.org (S. Zadey).

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ABSTRACT

South Asia faces a critical deficit in surgical, obstetric, trauma, and anaesthesia (SOTA) care, with over 1.6 billion people lacking access to safe and affordable surgical services. Addressing this inequity requires urgent workforce capacity building beyond traditional specialization. This study, conducted by the G4 Alliance Asia Working Group, employs a Multiple-Case Study design utilizing Cross-Case Synthesis to present six initiatives from Nepal, Bhutan, Pakistan, and India, mapped against a SOTA care workforce capacity building framework. We describe initiatives by training type (programmatic vs. non-programmatic), intent (upskilling vs. reskilling), and workforce outcomes such as task-shifting (delegating tasks to less specialized cadres), task-sharing (multi-cadre collaborative care), and task-creation (developing new cadre roles). Cross-case synthesis revealed distinct pathways for addressing workforce shortage and maldistribution. First, programmatic reskilling initiatives in Nepal, Bhutan, and Pakistan demonstrate how formalizing task shifting to mid-level providers and generalist doctors creates sustainable rural cadres recognized by national health systems. Second, non-programmatic models in India highlight the utility of upskilling existing surgeons to facilitate task sharing, thereby rapidly increasing the functional density of the workforce in resource-limited settings. Crucially, the analysis introduces task creation as a distinct workforce outcome to fill a specific “task-cadre gap” by establishing novel community engagement roles for SOTA care that do not exist in standard hierarchies. The synthesis indicates that while programmatic models support long-term retention through state absorption, non-programmatic interventions offer vital flexibility for immediate service delivery. Indigenously initiated, state-integrated models, providing secure career paths, achieved better sustainability, whereas foreign donor-dependent and non-programmatic models faced challenges. These initiatives underscore that locally driven, context-specific solutions can effectively bridge healthcare disparities. Facilitating cross-learning on the successes and limitations of these diverse models is essential to scale effective interventions and integrate them into national and regional policy plans, thereby ensuring equitable access to SOTA care across South Asia.

1. Introduction

South Asian countries suffer a high disease burden of conditions that can be managed through surgical, obstetric, trauma, and anaesthesia (SOTA) care services [1]. The region contributes 30–50% of the global surgically avertable burden of neonatal and maternal diseases, congenital anomalies, digestive conditions, and injuries [1]. However, most countries in the region fall short of the Lancet Commission on Global Surgery (LCoGS) indicator targets, including the workforce density target [1]. Consequently, the inequitable distribution of the workforce and poor availability of healthcare workers capable of providing SOTA care services remain significant problems in South Asia [1,2]. To address these shortages, the World Health Organization recommends task sharing and shifting (TSS) to increase access to life-saving clinical services by optimizing the roles of less specialized healthcare workers [1–3]. TSS in SOTA has been adopted globally, not only in low and lower middle income countries (LICs and LMICs) to overcome overall workforce shortage, but also in upper middle income (UMIC) and high income countries (HICs) to compensate for distributional inequities that lead to shortages of specialists in rural and remote regions [3–7]. However, the majority of literature on TSS for SOTA care originates from Sub-Saharan Africa, where most countries are LICs facing absolute specialist workforce shortages. Evidence from this region largely focuses on the utility of non-physician clinicians in bridging the gap with a limited surgical workforce [3–7].

While South Asian countries, mostly LMICs and UMICs, share certain challenges in SOTA care workforce availability, distribution, and training with sub-Saharan Africa, there are important differences that merit distinct analysis. South Asian countries, due to their demographic and economic growth trajectories, might have greater healthcare resources, manpower, and domestic spending capacity than Sub-Saharan African countries [1]. South Asian nations operate under complex federal systems where individual states or provinces often match the population size and administrative complexity of entire Sub-Saharan African nations, necessitating different policy integration strategies. Furthermore, training capacity for SOTA care specialists, especially in India and Pakistan, is significantly higher due to a wide range of medical colleges and programs. [8] While Sub-Saharan countries face aggregate workforce shortages, the primary challenge in South Asia is the “paradox of plenty,” characterized by an urban abundance of specialists

and privatization driven by lifestyle and market forces, leading to shortages of rural services [9]. Considering the rural-urban disparities and sectoral differences between private and public providers, TSS priorities in South Asia need to be tailored to the region's needs. Local initiatives in these countries have adopted innovative training models that utilize specialists, non-specialists, non-physicians, and community healthcare workers to provide SOTA care in rural and remote areas. Assessing such local initiatives is crucial for informing specific policy domains, including human resources for health (HRH) planning, surgical financing, and rural workforce retention strategies. We hope that this work will provide insights for Global South-South learning and collaboration.

2. Methodology

2.1. Case studies as a study approach

We conducted this study within the G4 Alliance Asia Working Group to highlight innovative SOTA care workforce training and community engagement initiatives across South Asian countries. The Working Group has previously conducted multiple collaborative research and advocacy activities, including a consensus statement on regional facilitators and barriers to SOTA care access, policy analyses of SOTA care prioritization in national health planning, and issue-focused advocacy pieces on frugal innovations, rural surgical networks, and uptake of safe surgical checklists in Asian LMICs [1,10–13]. Across these, the Working Group has identified several gaps in research, policy, and practice. One such gap is the limited acknowledgement of on-ground implementation work in Asian countries in global academic literature. Reporting such implementation work in the form of case studies has value for shared learning across health systems [14].

Case studies provide detailed descriptions of examples that enable the transfer of learning, replication, adoption, and adaptation across various contexts, making them widely applicable in business, law, public health, and policy [14–17]. This study employed a multiple-case study design [17]. We developed the case studies via purposively reaching out to the G4 Alliance Working Group partners. Case study selection was guided by three criteria: (1) presence of innovative SOTA care workforce training and community engagement models, (2) geographic diversity across South Asian health systems, and (3) availability of primary

implementation data. Data were derived from a complementary triangulation of peer-reviewed research, grey literature (policy documents and internal reports), and first-hand accounts from leaders and champions who developed and implemented SOTA care workforce training and community engagement initiatives. Specifically, peer-reviewed literature was prioritized as the primary source for all data domains, ranging from policy frameworks to ground-level implementation and clinical outcomes. Grey literature and first-hand accounts were utilized strictly as supplementary sources to fill specific data gaps, such as operational mechanisms or recent implementation updates, that were unavailable in published academic records. The case studies cover initiatives started between 2006 and 2024 (See Fig. 1 for a timeline). To analyze these diverse initiatives, we utilized Cross-Case Synthesis, a method of aggregating findings across individual cases to identify systemic patterns [17]. This process was operationalized through Framework Mapping, where data from each case were coded against the theoretical nodes of the SOTA Care Workforce Capacity Building Framework. The synthesis was guided by Replication Logic, which treats each case as an independent experiment to verify the theory [17]. We examined the cases for Literal Replication (where similar interventions produced similar successful outcomes) and Theoretical Replication (where contrasting outcomes were explained by predictable theoretical differences) [17]. By mapping these patterns to our framework, we moved beyond simple description to Analytic Generalization, a method in which empirical results are generalized to a theoretical framework rather than to a statistical population [17]. This allowed us to validate broader theoretical principles regarding workforce capacity building. However, such a theoretical framework for assessing capacity building and Task Sharing and Shifting (TSS) through a case study approach was previously absent. Hence, we developed a specific framework to address this analytical gap.

2.2. The SOTA care workforce capacity building framework

We present the case studies within the SOTA Care Workforce Capacity Building Framework, conceptualized by the Working Group (Fig. 2). The framework aligns with global health policy priorities, specifically the World Health Assembly (WHA) Resolution 68.15 on strengthening surgical care, WHA Resolution 76.2 on integrated Emergency, Critical, and Operative (ECO) care, and the WHO Global Strategy on Human Resources for Health: Workforce 2030 [18–20].

Theoretically, the framework integrates fragmented TSS, Community engagement, and non-programmatic training, while relying on existing World Health Organization (WHO) guidelines and human resource development principles. First, it builds on the World Health Organization (WHO) task-shifting and task-sharing guidelines, which advocate for the rational redistribution of tasks to cadres with shorter training [3]. Second, it integrates work-based training as a non-programmatic approach, thereby validating “learning while doing” as a scientifically viable mechanism for skill acquisition in resource-limited clinical environments [21]. Third, it operationalizes the Human Resource of Health (HRH) frameworks and strategies like a) WHO Global Strategy on Human Resources for Health: Workforce 2030, b) WHO Framework for Action for Health Workforce Development 2017–2030, and c) Framework to explore the impacts of public health workforce capacity-building initiatives [20,22,23].

In the framework, SOTA capacity building (Fig. 2) operates in parallel to, but distinct from, Standard Healthcare Education Pathways (Fig. 3). While standard pathways rely on linear, multi-year formal schooling to produce the foundational workforce (doctors, nurses, technicians), the SOTA capacity-building framework uses training and task- and cadre-specific interventions for both existing healthcare workers and community members to address the employment and maldistribution gaps.

As detailed in the framework, these interventions utilize two primary training types:

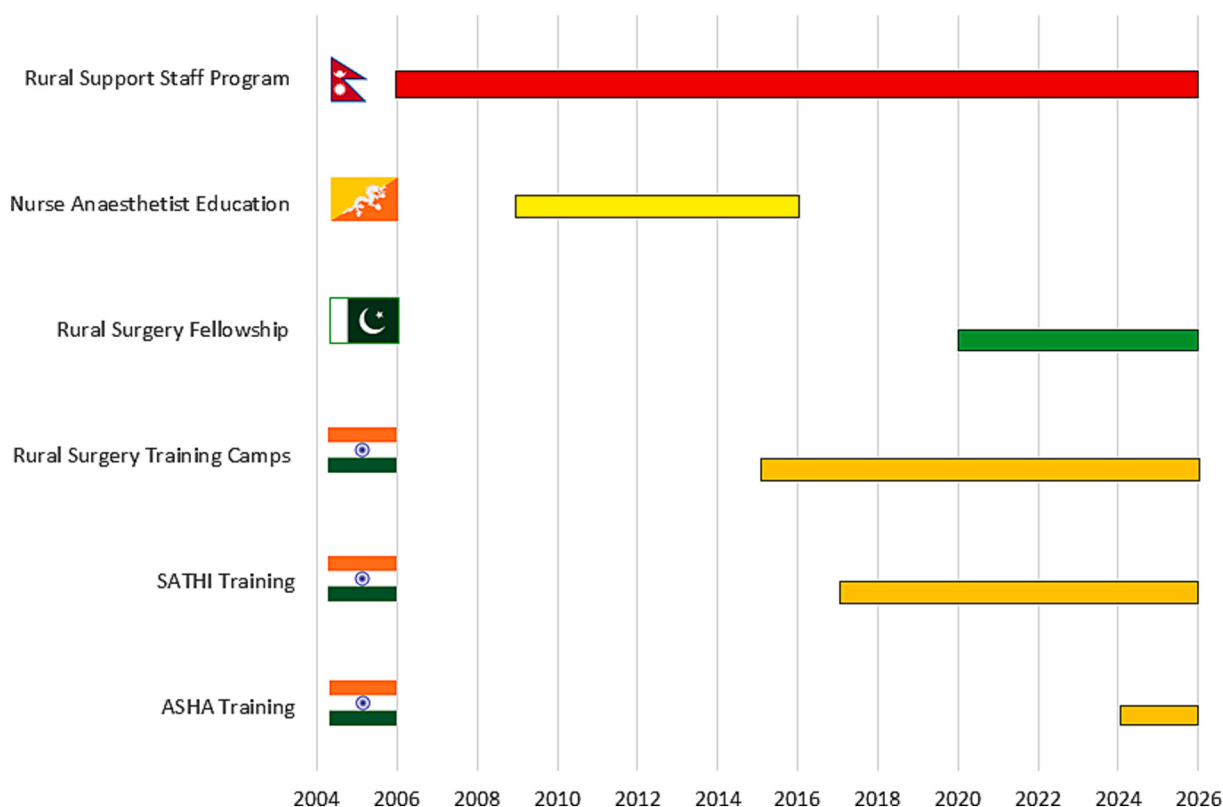


Fig. 1. Timeline of functioning of programmes and initiatives included as Case Studies.

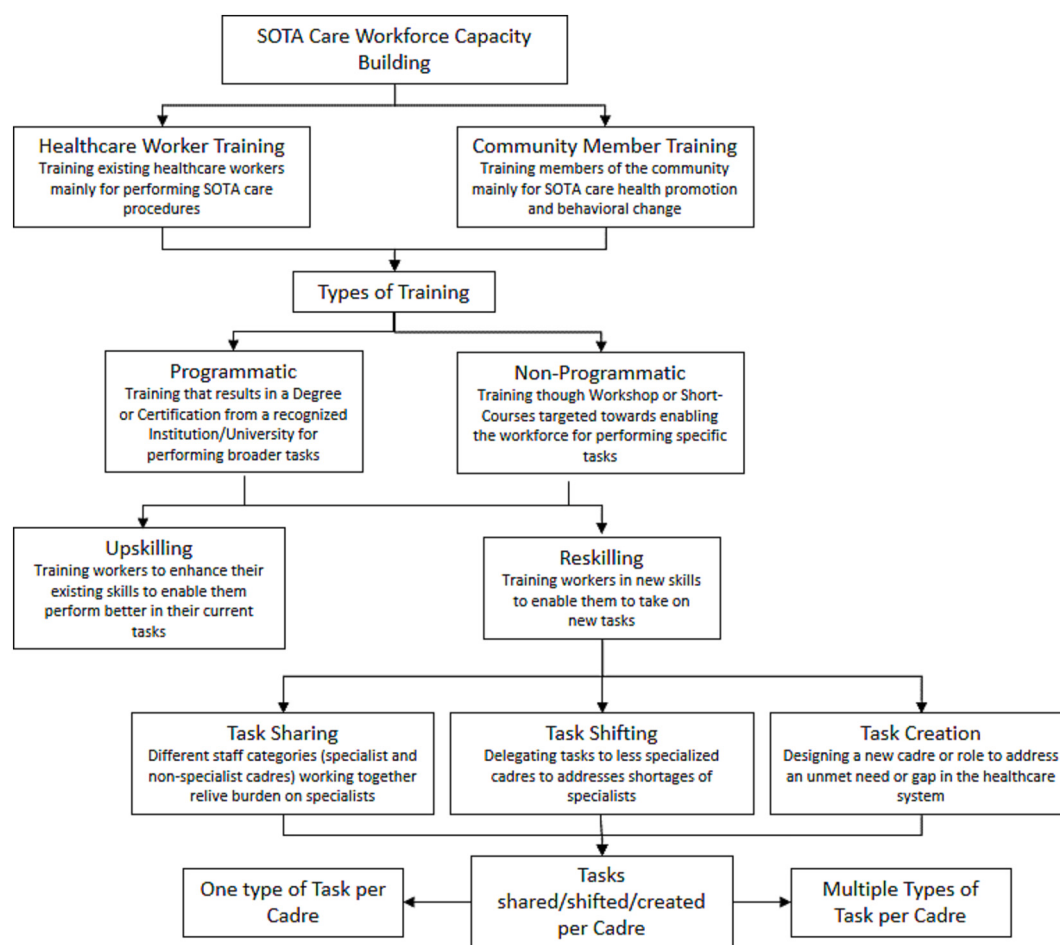


Fig. 2. Framework for SOTA Care Workforce Capacity Building.

1. **Programmatic Training:** Education that results in a formal Degree or Certification from a recognized institution, enabling broader scopes of practice. This aligns with the “Workforce 2030” objective of institutionalizing training to ensure quality assurance and portability [20].
2. **Non-Programmatic Training:** Short courses, workshops, or work-based training focused on specific competencies. This modality prioritizes feasibility and rapid deployment over broad academic certification [21].

Regardless of the modality, these initiatives are intended for the Upskilling or Reskilling of the cadres [24,25].

1. **Upskilling** enhances workers' existing skills (e.g., a surgeon learning gasless laparoscopy) to perform better in their current roles.
2. **Reskilling** involves learning entirely new skills to take on new tasks (e.g., a nurse learning spinal anaesthesia).

These pathways lead to three distinct workforce outcomes:

1. **Task Sharing:** Different cadres working together to relieve specialist burden [26].
2. **Task Shifting:** Delegating tasks to less specialized cadres to address shortages [26].
3. **Task Creation:** Defining novel roles for tasks that do not currently exist in the routine system (e.g., community navigation for surgery) or allotting a dedicated cadre to tasks that previously lacked a specific workforce assignment.

Depending on the specific pathway, this framework enables a flexible workforce in which one cadre can perform multiple tasks or a particular task can be shared across various cadres, thereby increasing the overall efficiency of the health system.

3. Case Studies

3.1. Case study 1: rural support staff program by Nick Simons Institute in Nepal

The Nick Simons Institute (NSI) is a non-governmental philanthropic organization founded in 2006 that works to develop solutions to improve rural healthcare through training, hospital support, and advocacy for healthcare workers in collaboration with the government of Nepal [27]. In 2006, only 20% of district hospitals could perform cesarean sections, prompting NSI and the Ministry of Health to train TSS healthcare workers to improve surgical care in rural areas through the Rural Support Staff Program [28–31].

3.1.1. Medical doctors of general practice (MDGPs)

The MDGP program, launched in Nepal in the 1980s, includes programmatic training in preventive and emergency care, as well as essential surgeries such as cesarean sections and appendectomies. It is a 3-year residency program for graduate doctors provided by NSI in affiliation with Kathmandu University [27]. This equips MDGPs to meet the diverse healthcare needs of rural communities, where specialists are rare, through TSS [32]. The Rural Staff Support Program addresses retention and performance challenges by offering MDGPs attractive incentives, including scholarships, competitive pay, and improved

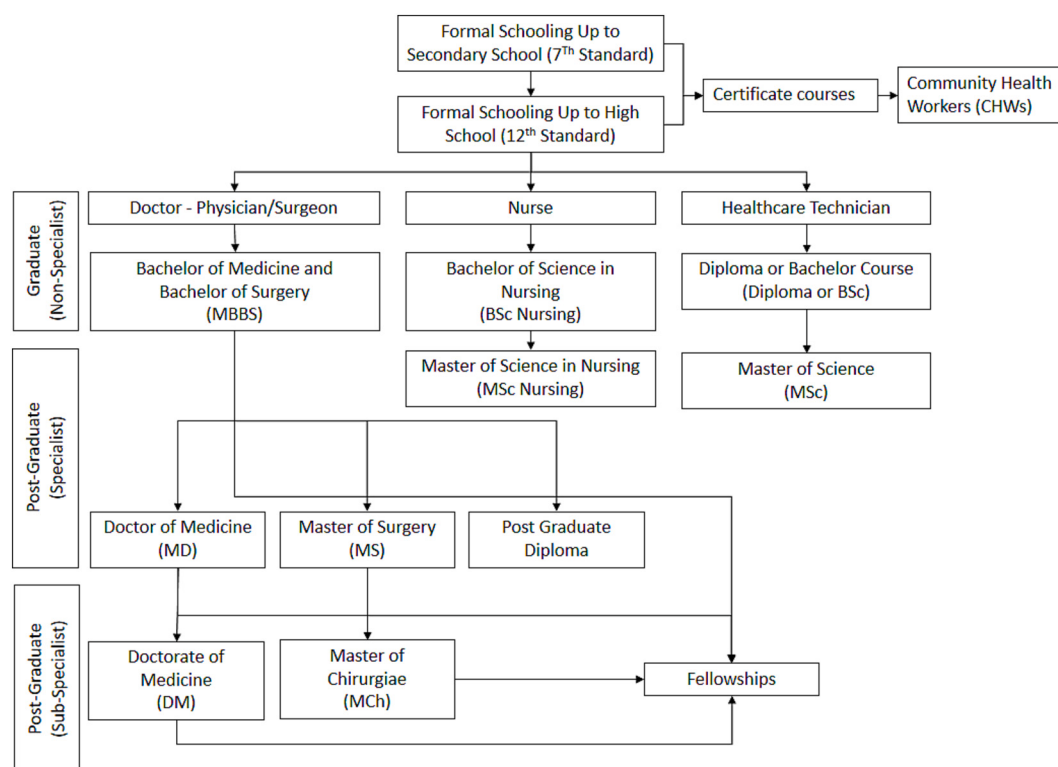


Fig. 3. Standard Healthcare Education Pathways in South Asian Countries.

working conditions such as internet access, quality housing, and continued training. By integrating MDGP-led teams into rural hospitals, NSI has expanded these facilities' capacity to provide emergency and surgical care [28,32]. In 2016–17, there were 22 MDGPs in 18 hospitals across 15 districts, with anaesthesia assisted by AAs, MOs, or another MDGP. 40.7% of all appendectomies and major operations were performed by MDGP-led teams [28].

3.1.2. Advanced skilled birth attendants (ASBAs)

In 2013, NSI partnered with the National Health Training Center to develop the ASBA program to train non-specialist medical officers with an MBBS degree to provide safe cesarean sections through task-shifting at rural hospitals [33]. The 70-day ASBA reskilling-focused training prepares medical officers to handle obstetric emergencies, focusing on performing cesarean sections and other critical procedures like managing shock, ectopic pregnancies, and blood transfusions that they can then perform under the supervision of an MDGP [34]. By 2020, around 234 ASBAs had been trained. A 2022 program evaluation found that 92.7% of ASBA graduates performed cesarean sections immediately following their training, and 65.6% continued to perform cesarean sections for more than eight years post-training, demonstrating the lasting impact on improving access to cesarean sections [35]. As of 2023, four ASBA training sites, three supported by NSI, aim to train 40 medical officers annually. Training is free, but NSI-supported graduates are bonded for one year and are typically placed to serve in rural hospitals [34].

3.1.3. Anaesthesia assistants (AAs)

In 2006, the Department of Health Services, Ministry of Health, and Population formalized a six-month AA reskilling course for nurses and paramedics at four hospitals under the National Health Training Center. [31] Later, in 2011, NSI partnered closely with the National Academy of Medical Sciences to upgrade the AA training to a 12-month course aligned with international standards for non-physician anaesthesia providers and developed a distance-learning program to upgrade those

with the 6-month training. From 2011 to 2012, 14 AAs assisted with 4143 cases, providing insights into the caseload and quality of anaesthesia care provided by AAs and showcasing successful task-shifting [36,37]. Despite no anaesthetists working at the rural district level and very few at the provincial level, 83.1% of district hospitals can provide cesarean sections as of the 2023–24 financial year, a 31.3% increase from just eight years prior [38]. A 2024 internal survey at the NSI showed that AAs are working in almost all districts (Fig. 4).

3.1.4. Biomedical equipment technicians (BMETs)

To address the need for sustainable maintenance of medical devices in rural Nepal, NSI, in partnership with the National Health Training Center, Ministry of Health and Population, introduced a training program that created a new cadre for rural hospitals—the Biomedical Equipment Technician [39]. The BMET program was a 48-week training course covering laboratory maintenance, computer skills, and hands-on practical experience. In 2014, the program was upgraded to a Diploma in Biomedical Equipment Engineering, and in 2015, the Public Service Commission created BMET posts within the government system, ensuring long-term success [29]. A 2018 service tracking survey reported that 48% of BMET graduates were employed in government hospitals, and by 2020, approximately 245 BMETs had completed the program [39,40]. An evaluation of the BMET conducted in 2022 found that hospitals with BMETs had significantly fewer non-functional pieces of equipment requiring simple and advanced repairs across all equipment categories (general, lab, operation theatre, and X-ray), compared to government hospitals without a BMET [39,41]. Further, provincial BMET labs are being implemented to provide a hub-and-spoke model that reduces reliance on the central BMET lab in Kathmandu.

3.2. Case study 2: nurse anaesthetist education in Bhutan

Access to surgical and obstetric care was limited in Bhutan due to a shortage of anaesthesia providers [42]. Nurse anaesthetists were introduced by a team called Health Volunteers Overseas (HVO). Fig. 5

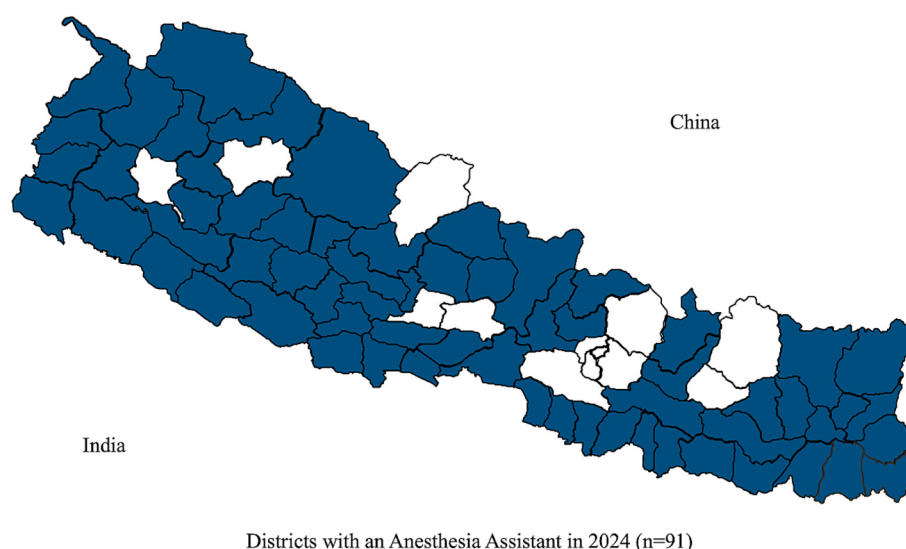


Fig. 4. Districts with an Anaesthesia Assistant in 2024 ($n = 91$). Map lines delineate study areas and do not necessarily depict accepted national boundaries.

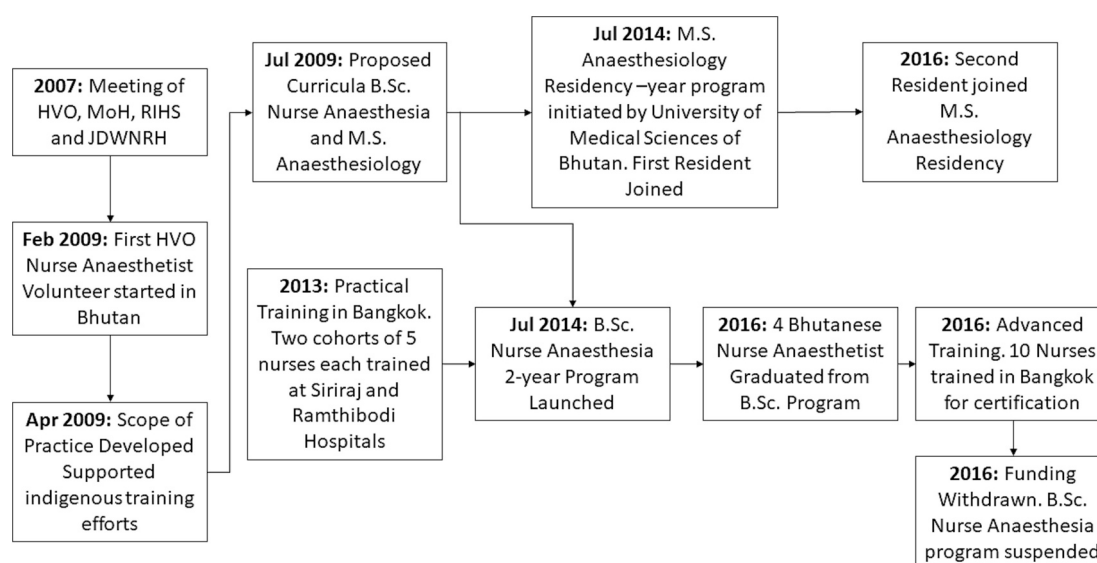


Fig. 5. Timeline for the development of anaesthesia programs in Bhutan.

provides a detailed timeline for the development of Bhutan's anaesthesia training programs. In 2007, HVO first met with representatives from the Ministry of Health (MoH), the Royal Institute of Health Sciences, and Jigme Dorjiangchuck National Referral Hospital (JDWNRH). After discussions over 2 years, nurse anaesthetist volunteers were welcomed to provide anaesthesia care in Bhutan. However, these volunteers were exclusively from HVO. To encourage native Bhutanese people to train, the HVO collaborated with the MoH to develop the 'Scope and Standards of Practice for Nurse Anaesthetists' in Bhutan. The Standards assisted in evaluating the quality of care while preserving and supporting a patient's fundamental rights. The Bhutanese nurse anaesthetists' scope of practice encompasses performing and documenting pre-anaesthetic evaluation, implementing an anaesthetic plan, patient monitoring, and managing emergencies. Additional responsibilities that come within their expertise are quality assessments, education, research, committee appointments, and interdepartmental liaison.

HVO developed three curricula, namely 1) a one-year certificate program for Bhutanese nurses to go to Ramathibodi and Siriraj Hospitals in Bangkok, Thailand, 2) a BSc Nurse anaesthesia Program in Bhutan,

and 3) a Master of Science in Medicine - anaesthesiology, which was a residency program in Bhutan. In July 2009, HVO submitted a proposal to the Ministry of Health, leading to the implementation of an accredited nursing curriculum with Khesar Gyalpo University of Medical Sciences of Bhutan (KGUMSB) in 2013. Initially, five Bhutanese nurses underwent practical training in Thailand. In 2014, the BSc Nurse Anaesthesia Program launched, enrolling four students with at least two years of critical care nursing experience. This two-year program included lectures and practicums, resulting in four graduates in July 2016 who began sharing anaesthesia tasks. Additionally, HVO and KGUMSB initiated a four-year Master of Science in Medicine-anaesthesiology program to further train non-specialist doctors and BSc Nurse anaesthetists, with the first resident admitted in 2014.

All these programs were supported by one or two volunteering anaesthesiologists or nurse anaesthetists each month who provided their expertise through HVO. In October 2013, Bhutan had five anaesthesiologists and 12 nurse anaesthetists [43]. By 2016, while the number of anaesthesiologists remained the same, there were two more anaesthesiology residents in training and 25 nurse anaesthetists [43]. These

cadres became essential for delivering safe surgical care across district hospitals where physician anaesthesiologists were unavailable.

However, after 2016, the program's long-term sustainability was compromised by a critical shift in financing policy. While the Ministry of Health and the Ministry of Finance fully funded the inaugural cohort, support was withdrawn for subsequent intakes. The policy shifted to a tuition-based model, requiring students to self-finance their education. Given the economic context of the nursing workforce, the prohibitive cost resulted in zero applicants for the second cohort, forcing the program's suspension. In stark contrast, the physician anesthesiology residency program continued to receive full support from the Ministry of Finance. This divergence highlights a significant policy gap: while programmatic task-shifting pathways, such as the BSc in Nurse Anaesthesia, are clinically effective, they remain fragile without the same state financial protection afforded to specialist physician training.

3.3. Case study 3: the rural surgery fellowship program in Pakistan

Pakistan faces an inequitable distribution of the SOTA care workforce, resulting in a shortage of specialists in rural and remote areas [1]. This results in general physicians providing specialized surgical care, despite lacking obstetric or anaesthesia care training or authorization from the relevant health authorities. Provincial governments often focus on strengthening surgical care at tertiary hospitals, with minimal infrastructure development at district and sub-district hospitals. Consequently, this places a greater burden on the former. The Rural Surgery Fellowship Program, initiated in 2021, was designed and implemented by the Department of Surgery and Center for Global Surgical Care at Aga Khan University to overcome these challenges [44,45]. The program enrolls fully qualified general surgeons and trains them in 28 essential emergency procedures extracted from the Disease Control Priorities (DCP-3) list [46]. This one-year program enhances competence in essential and emergency surgical procedures while strengthening surgical delivery in resource-constrained environments (Fig. 6).

Trainees first spend four months at public and private hospitals in an urban setting. Then, they are placed under supervision at secondary care facilities in the remote, mountainous region of Gilgit-Baltistan for a rural surgical training rotation. The bulk of the procedures taught are related to emergency obstetric, orthopedic, and pediatric surgery. In addition, due to the relative paucity of anesthesiologists in Pakistan, trainees spent approximately 30% of their training developing proficiency in spinal anaesthesia, basic regional blocks, and uncomplicated general

anaesthesia. The last clinical component is related to basic general and obstetric ultrasound, and uncomplicated ultrasound-guided aspiration and drain placement [46].

Along with the clinical training rotations, the trainees are required to complete selected graduate-level online courses in healthcare leadership, including organizational management and strategic planning. After completing the rural surgical training rotation, trainees engage in a two-month elective in surgical care at a rural or sub-district hospital of their choice. Trainees also undertake elective rotations in managerial or administrative settings, providing exposure to diverse healthcare contexts and communities.

Since this program is training- and resource-intensive, it maintains a focused annual intake of 1–2 trainees. In the three years the program has run, three surgeons have graduated. Two currently work in district hospitals in mountainous northern Pakistan, where access is limited by terrain and climate. At the same time, the third serves in a high-critical-need center in rural Canada [46]. A fourth trainee is slated to join a district hospital in Pakistan's agricultural heartland upon completion. Trainee evaluations were conducted using Direct Observation of Practical Skills (DOPS) to assess procedural competence alongside overall assessments of medical knowledge, interpersonal and communication skills, professionalism, practice-based learning and improvement, and systems-based practice. Preliminary feedback from the district hospital administration estimated that the presence of rural fellowship-trained surgeons prevented 50–60% of referrals [46]. Graduates were also effective educators for nurses and technical staff and have successfully advocated for and initiated laparoscopic services for basic procedures like appendectomy and cholecystectomy [46].

The Rural Surgery Leadership Program is the first of its kind in an LMIC. At the end of one year, a surgeon advances not only their surgical skills but also their leadership, managerial, and administrative skills, leading to successful upskilling and task sharing. The ultimate goal is to address rural healthcare challenges and improve patient outcomes, all while empowering local healthcare workers.

3.4. Case study 4: rural surgery training through surgical camps in India

The absence of a specialized SOTA care workforce, coupled with the high cost of equipment and geographical obstacles, makes it particularly difficult to perform surgeries in rural and remote areas of India [1]. To address this gap, a dedicated team from the Association of Rural Surgeons of India (ARSI) regularly conducts surgical camps to upskill local

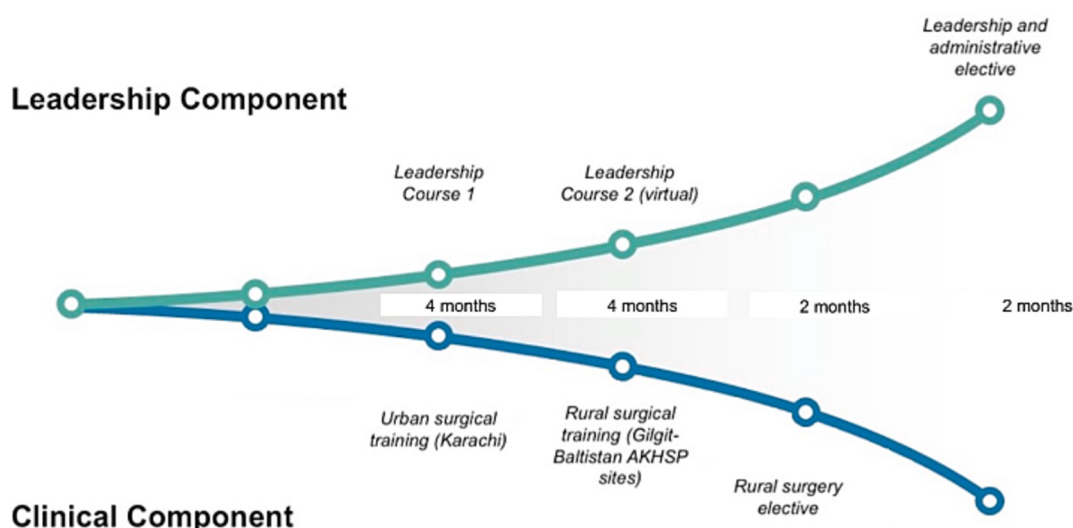


Fig. 6. Outline of rural surgery fellowship program in Pakistan.

surgeons, often originating from the villages or assigned to the region, who have MS General Surgery, DNB general or rural surgery, family medicine, or MBBS qualifications [47,48]. The ARSI team identified that conventional laparoscopy was inaccessible in rural areas due to the high cost of equipment and the requirement for general anaesthesia. To address this, they adopted the Gasless Laparoscopic Surgery (GILLS) technique. This system uses a mechanical lift to create the abdominal working space, eliminating the need for expensive carbon dioxide insufflators and cylinders. Critically, because there is no peritoneal pressurization, procedures can be safely performed under spinal anaesthesia, making it a viable, cost-effective option for rural hospitals with limited anaesthesia support [49]. The team has implemented non-programmatic training focused on bellwether procedures using Gas Insufflation-Less Laparoscopic Surgery (GILLS) at rural hospitals.

The GILLS training, initiated in 2015 at ARIS's Annual Conference, evolved through a collaboration with the University of Leeds to enhance surgical education and research [49]. Later, a three-day laparoscopic skills training program took place at Kolkata Medical College in March 2019, involving seven rural surgeons. It included online training, simulation, live operations under supervision, and an assessment phase (**Photo 1a**). Overall, participants showed improved knowledge and skills, with costs estimated at US\$354 for trainees and US\$461 for trainers [50]. However, we acknowledge that a 3-day duration is insufficient to ensure long-term mastery. The risk of skill attrition is high if trainees return to isolated settings without support. To address this, the program utilizes a longitudinal mentorship model in which expert faculty provide ongoing teleproctoring and site visits.



Photo 1 a): Gas insulation less laparoscopy (GILLS) training in ARSI workshop
b) Training of Surgical Accredited and Trained Healthcare Initiative (SATHI).

While scaling up these training camps to promote affordable onsite learning, the ARSI team loaned laparoscopic sets and essential equipment to rural hospitals where surgeons received mentorship. Training in resource-limited settings helped ensure that rural surgeons develop skills relevant to their environment, increasing their likelihood of returning to rural practice. This approach built their confidence and proficiency to perform surgeries independently. After a successful implementation, hospitals could purchase equipment from the ARSI team, which also funded new GILLS sets for other hospitals. A study from February 2022 to August 2023 showed that hospitals using GILLS saw surgical volumes rise significantly, with the median number of surgeries increasing from 108.7 to 374.29 annually [51]. Simultaneously, a non-blinded randomized non-inferiority trial evaluating GILLS was conducted at a tertiary care teaching hospital (Maulana Azad Medical College) and showed no significant differences in mean operating time, postoperative recovery, or hospital stay [52].

The ARSI team also collaborates with anaesthesiologists to train physicians and nurses to provide regional and spinal anaesthesia. The team conducted a non-inferiority trial demonstrating no significant difference in spinal anaesthesia delivery between trained non-specialist physicians and anaesthesiologists in rural settings [53]. During this study, the non-specialist physicians received a three-phase, 5–6-month clinical training program in spinal anaesthesia. Phase 1 involved a 10-module online course with examinations; Phase 2 included on-site

simulation training for anaesthesia emergencies; and Phase 3 provided directly supervised clinical training [53].

To enable scale-up of these non-programmatic training courses through a formal programmatic route, ARSI started a 6-month certification course in rural surgery in 2001, which was later converted into a DNB Rural Surgery residency program with support from the National Board of Examinations (NBE) [54,55]. The team also partnered with Martin Luther Christian University, Shillong, and SURGhub developed three comprehensive certificate courses for GILLS, Spinal anaesthesia, and Rural Urology for rural surgeons [56]. Though initially successful, these programs were discontinued due to low admissions, poor funding, and limited career incentives. Currently focused on the rural and remote areas of Northeast India, including Nagaland and Assam, and tribal regions of Jharkhand and Chhattisgarh, the team still conducts rural surgical camps that are instrumental in fostering local surgical competencies [48].

3.5. Case study 5: SATHIs in urban slums in India

A group of surgeons collaborated to start the Surgical Accredited and Trained Healthcare Initiative (SATHI), in collaboration with a non-governmental organization, Saath Charitable Trust, and the Indian Institute of Public Health, Gandhinagar. They conducted a series of studies to identify the unmet surgical needs and reasons for not availing of treatment. This led to the creation of a curriculum for a new cadre of community health workers (CHWs) and to the implementation of that cadre in the community [57].

To establish a baseline, the team conducted a cross-sectional study in 2019 using the Surgeons Overseas Assessment of Surgical Needs (SOSAS) in urban slums in Ahmedabad, Gujarat, which found that the unmet surgical need in these settings was 42% [58]. Next, they conducted a mixed-method study to understand the reasons for unmet needs using the 'Socio-culturally Competent Trust in Physician Scale for a Developing Country Setting' and the 'Patient Perceptions of Quality' scale. While participants generally acknowledged that physicians were well-qualified and that hospitals provided good-quality care, there was a significant trust deficit, with 35.3% citing lack of trust as a primary barrier, alongside financial constraints (34.5%) [59–61].

These studies led to the creation of a new CHW cadre, called SATHI, to serve as a connecting link between residents in slum areas and SOTA care providers. However the program was initially launched as an implementation study, divided into two parts: training community members to become SATHIs, followed by an on-field period in which the SATHIs worked in the community. Volunteering community members with a drive to serve and at least 12 years of formal education were trained. Similar to most of the CHWs in India (discussed in detail in the next section), SATHIs were predominantly women chosen from the community. However, men were also actively recruited to make sure the men in the community were comfortable to share about symptoms related to inguinoscrotal, genital and ano-rectal diseases. The team created and delivered an eight-module curriculum interactively, supplementing theoretical topics with discussion, role play, and hands-on training. SATHIs were trained for seven days, after which they were put in charge of 500 people each from the community. SATHIs helped patients avail the benefits of government schemes and counseled them to build trust and eliminate the fear of surgical procedures. SATHIs also provided emergency first aid for minor injuries among labourers and measured blood pressure and blood sugar (**Photo 1b**) [62].

The team also developed an intake form, a monthly fieldwork form, a performance evaluation guide, and a test comprising short questions to assess the SATHIs' understanding. Six SATHIs were trained for a pilot study in the slums of Ahmedabad to evaluate their effectiveness in reducing unmet surgical needs. The pilot included 12,730 people from 3000 households over six months. SATHIs visited each home to identify unmet surgical needs using SOSAS. The team, along with SATHIs, reported data and maintained a database to monitor the steps required to

resolve unmet needs. They focused on identifying barriers to access to affordable surgical care for marginalized communities in an urban slum. They found that 293 households of the 3000 households had needed surgeries, of which 166 (57%) did not undergo surgery. SATHIs were able to convert 99 (60%) patients with unmet surgical needs by building trust and facilitating access to [63]. Following this success, the program expanded into Phase 1 (Jan–March 2024) and Phase 2 (April 2024–March 2025), covering over 16,000 households. A cumulative total of 401 patients were advised surgery, of whom 289 underwent successful surgeries (126 in Pilot, 58 in Phase 1, 105 in Phase 2), demonstrating a conversion rate of approximately 72% from diagnosis to surgical intervention [64]. Beyond clinical outcomes, the initiative showed significant economic impact, saving patients approximately INR 2.6 million in Phase 2 alone, with 90% of beneficiaries reporting an increase in post-surgical income [64]. Currently, the project is entering Phase 3 (2025–2026), which aims to scale impact to 50,000 individuals across 10,000 households. This phase focuses on long-term sustainability by enrolling 5000 households into the Saath Janvikas Multipurpose Cooperative (MPC). Through a nominal membership fee model, the MPC will fund the SATHI workforce while providing members with regular NCD check-ups and home-based care, thereby reducing reliance on external donor funding [64].

3.6. Case study 6: ASHA training by NIHR global surgery unit - India Hub

The National Institute for Health and Care Research Global Health Research Unit on Global Surgery (NIHR GSU) - India Hub has initiated non-programmatic training of Accredited Social Health Activists (ASHAs) and community health workers (CHWs) in surgical care and cancer screening to serve as frontline health advocates in their communities [65].

ASHAs are predominantly women community health workers, selected specifically from within the communities they serve as part of India's National Health Mission. [66]. They are often the first point of contact for healthcare needs, particularly in marginalized populations. The gendered composition of this cadre reflects both a deliberate policy design to empower women as health advocates and the sociocultural dynamics of community trust in marginalized settings. The GSU's initiative aimed to reskill ASHAs for early cancer detection, surgical site infection (SSI) identification and management, and wound care.

The ASHA training in Ludhiana, Punjab, was delivered in two six-month phases. The first phase, from January 2024, focused on early cancer detection, including common cancer types, cancer screenings, self-exams, symptom awareness, and treatment options. The second phase, from May 2024, focused on identifying SSIs, understanding their consequences, and providing treatment and prevention strategies. It also covered stoma care and the establishment of referral pathways. The reskilling equipped ASHAs with the knowledge to manage surgical conditions in their communities and make timely referrals to higher levels of care when necessary, resulting in task creation for ASHAs. Hospitals from the GSU India Hub's Rural Network, such as Manali Mission Hospital in Himachal Pradesh, Chinchpada Christian Hospital in Maharashtra, and Padhar Hospital in Madhya Pradesh, played a crucial role in developing educational programs in local languages and providing video clips to disseminate information [65].

The NIHR India Hub had established a hotline number and shared it with all ASHA workers through WhatsApp groups tailored to their respective villages. Over two months, 25 consultation calls were received from ASHAs across 12 villages where the training program was implemented in the first phase. As a result, ten patients visited tertiary-level hospitals for outpatient services and were prescribed further treatment. NIHR GSU - India hub training covered over 2500 ASHAs in Ludhiana, Punjab, 500 village healthcare providers in Kolkata, West Bengal, and 200 caregivers in Vellore, Tamil Nadu [65].

4. Discussion

The case studies highlight the transformative potential of competency-based upskilling and reskilling healthcare workers to address workforce shortages and improve access to SOTA care in South Asian LMIC settings. Table 1 summarizes these case studies within the SOTA care workforce capacity-building framework. The synthesis identifies common and cross-comparable themes to help imagine scalable models that can provide actionable pathways to enhance SOTA care delivery in South Asia.

4.1. Cross-case study synthesis

4.1.1. Programmatic training & secure career trajectory

First, utilizing the existing healthcare workforce and training (upskilling and reskilling) them is essential. Analyzing these initiatives against the framework reveals a clear trade-off between Programmatic and Non-Programmatic pathways. The Programmatic pathway, illustrated by Pakistan's Rural Surgery Fellowship and Nepal's RSSP, offers structural stability. Both models succeed by coupling academic rigor with designated rural government postings, ensuring that the upskilled workforce actually serves in target areas. However, programmatic status alone does not guarantee sustainability. India's DNB Rural Surgery residency failed despite formal recognition because, unlike the Nepal and Pakistan models, it lacked a defined government career track or guaranteed employment. This structural gap led to low enrollment and eventual discontinuation.

In the absence of a sustainable formal route, India's rural training has relied on the non-programmatic pathway, exemplified by GILLS workshops. This model offers high agility, enabling rapid Upskilling of surgeons without the bureaucratic delays that stalled the DNB program. However, while GILLS avoids the rigidity of the programmatic route, it faces the inverse challenge, like heavy reliance on individual motivation, non-profit actors (ARSI), and funding instability due to the lack of institutional anchors. As noted in broader LMIC reviews, without accredited lateral pathways for career progression and state-absorbed financing, TSS cadres face job stagnation and attrition [5].

4.1.2. Multi-stakeholder collaborations & funding mechanisms

Second, multi-stakeholder collaborations play a pivotal role in sustainability. Partnerships between governments, academic institutions, and non-profit organizations, or with members of civil society, that align with national priorities ensure that capacity building is contextually relevant and systematically integrated. A critical cross-case comparison reveals that the origin of the stakeholder, local versus foreign, significantly impacts program longevity. Nepal's Rural Support Staff Program and Pakistan's Rural Surgery Fellowship succeeded because they were driven by local academic and philanthropic bodies (NSI and AKU) that were deeply embedded in the national health architecture. In contrast, Bhutan's Nurse Anaesthesia program faced significant hurdles. Because it was initiated and largely run by a foreign NGO, Health Volunteers Overseas (HVO), rather than by a local academic anchor, it struggled to transition to a self-sustaining model. Once the foreign support structure shifted, the program stalled because the government did not assume responsibility for tuition funding. While such reliance on foreign funding often threatens the longevity of community initiatives, the SATHI project is explicitly designed to overcome this dependency. In its current third phase, the program is transitioning to a self-sustaining "Multipurpose Cooperative" model. By enrolling households and generating revenue through nominal membership fees, SATHI is establishing a domestic funding stream, thereby ensuring long-term workforce viability independent of the external donor cycles that compromised the Bhutanese model. Furthermore, global evidence from other LMIC also highlights that operational longevity is frequently compromised by reliance on transient philanthropic and international missions [5,67]. Further, a systematic review assessing the economic value to strengthen surgical care in low- and

Table 1
Contextualizing case studies in SOTA care workforce capacity building framework.

Country	Program	Cadre Name	Type of Training	Course	Duration	Outcome	Task Per Cadre	Type of Healthcare worker trained	Task Description
Nepal	Rural Staff Support Program	Medical Doctors of General Practice (MDGP)	Programmatic	Doctor of Medicine in General Practice (MD) Residency program with NSI and Kathmandu University	3 Years	Task Shifting	> One	Graduate General Physicians	Shifting Essential and Emergency General Surgery and Obstetric Procedures from Specialists to Post-Graduate General Physicians
		Advanced Skilled Birth Attendant (ASBA)	Programmatic	Certificate Course with NSI	70 Days	Task Shifting	One	Graduate General Physicians	Shifting Essential and Emergency Obstetric Procedures from Specialists to Graduate General Physicians
		Anaesthesia Assistants (AA)	Programmatic	Certificate Course NSI	1 Year	Task Shifting	One	Nurses and Paramedics	Shifting anaesthesia procedures from Specialists to non-physicians like nurses and paramedics
		Biomedical Equipment Technicians (BMET)	Programmatic	Diploma in Biomedical Equipment Engineering (DBEE) with NSI	18 Months	Task Creation	One	Technicians	Creation of a new cadre for the role of device maintenance
Bhutan	Nurse Anaesthesia Training Program	Nurse anaesthetist	Programmatic	Certificate course with Ramathibodi and Siriraj Hospitals	1 Year	Task Sharing	One	Nurses	Sharing anaesthesia procedures between anaesthesiologists and non-physicians, like nurses
			Programmatic	Bachelor of Science in Nurse Anaesthesia (BSc) with KGUMSB, JDWNRH, HVO, and MoH	2 Years	Task Sharing	One	Nurses	Sharing anaesthesia procedures between anaesthesiologists and non-physicians, like nurses
		anaesthesiologist	Programmatic	Post-Graduate Residency Program, Master of Science in Medicine (MS anaesthesia) with KGUMSB, JDWNRH, HVO, and MoH	4 Years	Upskilling	One	Graduate Nurse anaesthetists and General Physicians	Enhancing the skills of physicians and nurse anaesthetists to provide anaesthesia and critical care procedures
Pakistan	Rural Surgery Fellowship Program	Rural Surgeons	Programmatic	Fellowship in Rural Surgery with Aga Khan University	1 Year	Upskilling and Task Sharing	> One	Post Graduate General Surgeons	Upskilling General surgical procedures and Sharing Essential and Emergency obstetrics and gynaecology, pediatric surgery, orthopedic, neurosurgery, and anaesthesia disciplines, and basic radiologic interventions with general surgeons
India	Rural Surgery Training Camps	Rural Surgeons	Non-Programmatic	Live and Simulation Workshops and virtual reality training	3 Days	Upskilling and Task Sharing	> One	Post Graduate General Surgeons and Graduate General Physicians	Upskilling in GILLS procedures and Sharing Spinal Anaesthesia and Urology Procedures
			Programmatic	Certificate Course in GILLS, Spinal anaesthesia, and Rural Urology with Martin Luther University	6–12 months				
	SATHI Program	Surgical Accredited & Trained Healthcare Initiative (SATHI)	Non-Programmatic	Training by SAATH NGO	7 days	Task Creation	One	Community Health workers	Assessment of unmet needs, health promotion, and wound care

(continued on next page)

Table 1 (continued)

Country	Program	Cadre Name	Type of Training	Course	Duration	Outcome	Task Per Cadre	Type of Healthcare worker trained	Task Description
	ASHA Training Program	Accredited Social Health Activist (ASHA)	Programmatic	Training by NIHR Global Health Research Unit on Global Surgery –India Hub	1 Year	Task Creation	> One	Community Health workers	Cancer screening, health promotion, and wound care

middle-income countries found that the unit costs per disability-adjusted life-year averted of domestic initiatives were significantly lower relative to the international missions, strengthening the argument for domestic-led systems strengthening [68].

4.1.3. Task creation for community engagement

Third, engaging community members is critical for building trust and promoting treatment-seeking behaviours. This aligns with the framework's Task Creation node, designing entirely new roles to bridge the gap between communities and hospitals. India's SATHI program trained a new cadre of community health workers to act as intermediaries, effectively bridging the trust deficit. A critical cross-comparison reveals a distinct advantage in this approach: by establishing a dedicated workforce, SATHI avoided adding to the burden of existing Accredited Social Health Activists (ASHAs), who are historically overworked and underpaid. In contrast, the NIHR GSU initiative, while successful in creating a task for wound surveillance, assigned this responsibility to the existing ASHA cadre, potentially exacerbating their workload saturation. However, a critical limitation identified in our analysis is that these remain non-programmatic pilots. Historically, community health worker cadres have been integrated programmatically in India for communicable diseases and maternal health [69,70]. These cadres also provide an opportunity to integrate SOTA care into primary care models, which has been historically neglected in global surgery [71]. It is also important to note that the gendered community health worker roles carries implications for equitable compensation, workload distribution, and career recognition. SATHI program has attempted to address this by creating a separate cadre to reduce the workload on ASHAs and also involving men as SATHIs to reduced gendered biases and stigma. As supported by the Surgical Health Policy 2025–35, for SOTA care, these “Created Tasks” for Community Engagement must transition into formalized, programmatic pathways with adequate compensation, and equitable gender representation to ensure they become a permanent feature of the health system [72].

4.1.4. Barriers to institutionalization and policy gaps

Fourth, for scalability, supportive policy and regulatory environments are needed. A critical divergence emerges between the region's smaller and larger nations. Smaller countries like Nepal and Bhutan, facing absolute workforce scarcity similar to Sub-Saharan Africa, have more readily embraced clinical task shifting to non-physicians, exemplified by the successful integration of non-physician anaesthesia providers into the public sector.

In contrast, larger nations like India and Pakistan experience severe workforce maldistribution, characterized by a concentration of specialists in metropolitan areas alongside a critical scarcity in rural regions. Consequently, task shifting of clinical duties faces significant professional opposition from specialist lobbies, who fear quality dilution. Several studies assessing specialists' perceptions of TSS report resistance rooted in concerns about ethics, perceived erosion of safety and quality, and changing power dynamics [5]. This explains why the successful case studies in these countries primarily rely on upskilling existing doctors (e.g., Pakistan's Rural Surgery Fellowship, India's GILLS) or restrict task shifting to community-level work (e.g., ASHAs, SATHIs), rather than authorizing non-physicians to participate in clinical SOTA care.

However, these nations must leverage global evidence confirming the safety and efficacy of TSS in SOTA care, which originates not only from Sub-Saharan Africa but also from High-Income Countries (HICs) like the USA and Canada [7]. These HICs successfully utilize TSS cadres specifically to serve rural populations where specialists are unavailable. Following the example of Nepal's Rural Staff Support Program, larger South Asian nations could implement dedicated rural programs that facilitate TSS restricted specifically to designated rural and tribal areas where specialists are unavailable, thereby mitigating professional opposition while addressing the service gap. However, it is important to note that such dedicated programmes have shown limited success in Indian settings, making a case for the rethinking of programmatic solutions. Global systemic reviews indicate that numerous TSS training programs are not accredited, which negatively impacts career growth. This situation contributes to job stagnation, forcing these professionals to remain at mid-level competencies. While the aim of establishing this workforce is to temporarily mitigate personnel shortages, there are insufficient pathways for them to obtain specialized training as the capacity for workforce production increases. Additionally, it is essential to enhance legal protections for all professionals authorized to perform certain procedures, allowing them to work without the fear of litigation, and thus foster a secure and resilient workforce in rural areas [7].

However, there is a critical gap in policy implementation. Previously, policy analyses have noted limited focus on financing for SOTA care in national health plans, strategies, and policies in South Asian countries, validating the experience of institutions implementing the programs on the ground [10,73]. While Pakistan has successfully launched a National Surgical, Obstetric, and Anaesthesia Plan (NSAOP), it faces challenges in achieving full-scale implementation due to financing gaps [74]. Similarly, Nepal is currently drafting its NSAOP with technical support from the Nick Simons Institute, whereas India relies on fragmented state-level initiatives [10,73,75]. To address these systemic barriers, the recent DIPICA (Data Innovation, Program Implementation, and Community Action) Observatory for Surgical, Anaesthesia, and Obstetric (SAO) Care consensus meeting in India, attended by a multi-sectoral group of government officials, academia, and NGOs, explicitly prioritized workforce strengthening and dedicated financing mechanisms to support TSS integration to facilitate rural surgery [76]. NSOAPs or any national-level policy integrating SOTA care serve as the strategic vehicle to institutionalize the capacity-building framework's pathways, transitioning fragmented initiatives into programmatic, state-led workforce solutions. By embedding these training modalities into national plans, countries can systematically address the maldistribution of SOTA providers through formalized legal and ethical TSS pathways [5].

4.1.5. Regional cooperation

Finally, South Asia lacks the cohesive regional governance seen in the Pan-African Surgical Healthcare Forum (PASHeF) or the Western Pacific Region's (WPRO) Action Framework (2021–2030) [77–79]. The expiration of previously recognized SAARC surgical bodies highlights the need for institutional permanence rather than ad-hoc meetings [1]. We recommend establishing a dedicated SAARC Center for SOTA Care, modeled after the regional TB and HIV/AIDS Centres, supported technically by WHO Country Offices and the South-East Asia Regional Office (SEARO) [1]. Active engagement from SEARO is crucial to bridge national policy gaps and convene stakeholders. Institutionalizing SOTA

care within these platforms would facilitate cross-border programmatic training and degree recognition, enabling the strategic migration of skilled workers across the region to address inequities.

4.2. Limitations and future direction

This study has several limitations inherent to its design. The active representation within the G4 Alliance Asia Working Group defined the scope of this study. Consequently, while we acknowledge the robust history of health workforce innovation in other South Asian nations, these countries are not represented in our case studies because they lack direct partner involvement, which would provide granular, ground-level data. As an advocacy-driven compilation rather than a systematic review, the selection of case studies was non-systematic and relied on the G4 Alliance Asia Working Group's network. This introduces potential selection bias, as successful initiatives were more likely to be reported than failed attempts. Furthermore, reliance on grey literature, internal reports, and anecdotal evidence, while necessary given the scarcity of peer-reviewed data on rural workforce initiatives, limits the independent verifiability of some findings.

A significant limitation across the included case studies is the heterogeneity of outcome metrics. The majority of the data presented reflects immediate, short-term operative outputs, such as the number of personnel trained, immediate post-training knowledge scores, or increases in surgical volume, rather than long-term skill retention or workforce migration patterns. Crucially, these short-term outputs have not yet been causally linked to population-level outcomes, such as reductions in perioperative mortality or maternal morbidity rates in the regions served. While these case studies provide proof of concept for various training models, their transferability to other settings is constrained by the unique regulatory, cultural, and health system contexts of each country.

Future research can build upon these foundational case studies by employing implementation science frameworks. Studies need to move from Kirkpatrick Levels 1 and 2 (reaction and learning) to Levels 3 and 4 (behavior and results) [80]. This requires prospective study designs that track trainees over years to evaluate skill retention, career progression, and rural retention. Linking workforce training directly to patient-centered outcomes will also be critical to reinforcing the global evidence base and justifying policy integration.

5. Conclusion

A skilled workforce is essential for SOTA care, but requires systematic institutionalization. Our analysis using the SOTA Care Workforce Capacity Building Framework highlights two structural imperatives. First, Programmatic Training pathways require secure government career trajectories to ensure retention. Second, TSS initiatives must transition from philanthropy-driven pilots to state-absorbed cadres. To operationalize this, South Asian policymakers must integrate SOTA care capacity building into national health policies and plans. Furthermore, establishing an SAARC Center for SOTA Care can facilitate regional accreditation and mobility. At the same time, national registries for safety tracking are essential to mitigate professional resistance and ground policy in evidence.

Availability of data and materials

Data sharing is not applicable to this article, as no datasets were generated or analyzed during the current study. The case studies are based on previously published sources, grey literature, and aggregated program records. Internally sourced program data used in the case studies consist of aggregated, non-identifiable figures (e.g., numbers of personnel trained, deployed, and surgical volumes). No individual-level patient or participant data were collected or used. Aggregated data were shared by program leads who are co-authors of this manuscript and were

handled securely within the research team, with access restricted to the authorship group. Primary ownership of program records resides with the respective implementing organizations, and data cannot be independently deposited without institutional authorization. Readers seeking further information may contact the corresponding author.

CRediT authorship contribution statement

Shirish Rao: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Uma Gupta:** Writing – review & editing, Writing – original draft, Validation, Investigation. **Aishwarya Ramanujam:** Writing – review & editing, Writing – original draft, Investigation. **Abigail Knoble:** Writing – review & editing, Writing – original draft, Visualization, Investigation. **Isha Gondi:** Writing – review & editing, Writing – original draft, Investigation. **Poorvikha Gowda:** Writing – review & editing, Writing – original draft, Investigation. **Chaitanya Reddy:** Writing – review & editing, Writing – original draft, Investigation. **Kashim Shah:** Writing – review & editing, Investigation. **Archana Amatya:** Writing – review & editing, Investigation. **Arpana Kalaunee:** Writing – review & editing, Investigation. **Ruma Rajbhandari:** Writing – review & editing, Investigation. **Richard Henkar:** Writing – review & editing, Investigation. **Mashal Shah:** Writing – review & editing, Investigation. **Sadaf Khan:** Writing – review & editing, Investigation. **Gnanaraj Jesudian:** Writing – review & editing, Investigation. **Kranti Vora:** Writing – review & editing, Investigation. **Rahul M. Jindal:** Writing – review & editing, Investigation. **Atul Suroy:** Writing – review & editing, Investigation. **Dhruva Ghosh:** Writing – review & editing, Investigation. **Irum Fatima:** Writing – review & editing, Investigation. **Lovenish Bains:** Writing – review & editing, Investigation. **Dhananjaya Sharma:** Writing – review & editing, Investigation. **Siddhesh Zadey:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Conceptualization.

Ethics approval and consent to participate

The manuscript does not involve the collection of primary human subjects data, such as interviews or biological samples. The case studies are based on previously published, ethics-approved sources, supplemented by program records and first-hand accounts from program leaders who are co-authors of this manuscript. Hence, ethics approval and consent obligations are not applicable. Institutional consent has been obtained from the representatives of organizations that own the picture. The owners of the pictures are co-authors of the study, Dr. Gnanraj Jesudian and Dr. Rahul Jindal, respectively. Verbal consent to use the images for the manuscript was obtained from the participants who appear in the photograph. We confirm that no identifiable participant information is included anywhere in the manuscript.

Declaration of generative AI and AI-assisted technologies in the writing process

During the preparation of this work, the authors used Grammarly, Google Gemini, and ChatGPT to improve the readability and language clarity of the manuscript. These tools were not used for data analysis, interpretation, or drawing conclusions. The authors reviewed and edited all AI-assisted content and take full responsibility for the integrity of the work. No figures, images, maps, or graphical abstracts were created or altered using generative AI tools.

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