Evaluating the status of the Lancet Commission on Global Surgery indicators for India

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Summary

For universal surgical, obstetric, trauma, and anesthesia care by 2030, the Lancet Commission on Global Surgery (LCoGS) suggested tracking six indicators. We reviewed academic and policy literature to investigate the current state of LCoGS indicators in India. There was limited primary data for access to timely essential surgery, risk of impoverishing and catastrophic health expenditures due to surgery, though some modeled estimates are present. Surgical specialist workforce estimates are heterogeneous across different levels of care, urban and rural areas, and diverse health sectors. Surgical volumes differ widely across demographic, socio-economic, and geographic cohorts. Peri-operative mortality rates vary across procedures, diagnoses, and follow-up time periods. Available data suggest India falls short of achieving global targets. This review highlights the evidence gap for India's surgical care planning. India needs a systematic subnational mapping of indicators and adaptation of targets as per the country's health needs for equitable and sustainable planning.

Keywords: **Global surgery; Low- and middle-income country; India; Surgery; Obstetrics; Trauma; Anesthesia care; Health system; Surgical indicators; Health policy**

Introduction

In 2015, the Disease Control Priorities Network found that lack of access to essential surgery results in 4.7 million avertable deaths occurring in low- and middle-income countries (LMICs) every year.[1] In the same year, the Lancet Commission on Global Surgery (LCoGS) estimated that over 98% of people in South Asia, the most densely populated region in the world, lacked timely access to safe and affordable surgical care.[2] To ensure attainment of universal surgical, obstetric, and anesthesia care by 2030–as envisioned in the World Health Assembly Resolution 68.15 on 'Strengthening emergency and essential surgical care and anesthesia as a component of universal health coverage',[3] LCoGS suggested the use of six global surgery indicators. These six indicators, situated in three larger domains are: preparedness for surgical, anesthesia, and obstetric care (timely access to care and SAO workforce availability), delivery of surgical, anesthesia, and obstetric care (surgical operative volumes and perioperative mortality rates), and effect of surgical, anesthesia, and obstetric care (financial risk protection or lack thereof against catastrophic and impoverishing health expenditures among surgery needing populations).

Subsequently, there has been increasing focus on research and policy surrounding surgical care indicators. These indicators have been incorporated in the World Development Indicators dataset,[4] assessed for their relevance and validity,[5] and updated for national-level data through the Global Indicators Initiative.[6,7] More recently, the indicator definitions and reporting processes have also been updated following an Utstein process for building consensus among a panel of 40 global surgery stakeholders with 21% from LMICs.[8] Table 1 documents the LCoGS indicator definitions and targets, updates to definitions in the Utstein

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Indicator	LCoGS definition[9]	LCoGS target for 2030[9]	Modifications to indicator definition as per the Utstein consensus report[8]	Value(s) for India from LCoGS related research	Global value from LCoGS related research
I. Access to timely essential surgery	Percentage of people living in a 2-h radius from a facility providing Bellwether procedures	At least 80% people to have timely access	Explicit mention of geographic access within 2 h to a facility capable of surgical and anesthesia care needed for Bellwether procedures (cesarean section, laparotomy, and surgical management of open long bone fracture).	–	–
II. Specialist surgical workforce density	SAO (Surgeon, Anesthetist, and Obstetrician) per 100,000 people	100% countries to have specialist SAO density of 20	Focus on actively practicing SAO providers including certified specialist SAO physicians, non-specialist physicians involved in SAO care, non-physician non-specialist practitioners of SAO care and other SAO relevant practitioners that do not fall under these categories, excluding trainees of any kind.	6.5[10]	28.2[10]
III. Surgical volumes	Number of operation theater procedures done per 100,000 population	100% countries to track surgical volumes and perform at least 5000 procedures per 100,000	Added specification to include only those procedures done under any form of anesthesia including general and spinal anesthesia.	904[11]	4475[11]
IV. POMR (Perioperative Mortality Rate)	Annual proportion of all-cause in-hospital mortality among those who underwent an operation theater procedure	100% countries to track POMR and set country-specific targets	Change in the time-point investigated for calculating POMR to include the deaths before the discharge up to 30 days post-operation.	–	–
V. Protection against Impoverishing Health Expenditure (IHE)	Percentage of people safe from impoverishment due to money spent out of pocket to bear direct costs of surgical and anesthesia care	0% people should face IHE or everyone to be protected against IHE	Not included in the Utstein indicators report.	63.5[12]	60.9[12]
VI. Protection against Catastrophic Health Expenditure (CHE)	Percentage of people safe from CHE due to money spent out of pocket to bear direct costs of surgical and anesthesia care	0% people should face CHE or everyone to be protected against CHE	Recording the population at risk of CHE if they require a surgical procedure. Hence, the indicator definition was flipped.	40.4[12]	68.3[12]

Table 1: **LCoGS indicator definitions, targets, and values for India and the world.**

consensus report, and summary data for India and the world.

While there has been concern for insufficient and low-quality data along with challenges in data homogenization for LMICs,[13] many nations have mapped these surgical care indicators subnationally such as Brazil,[14] Colombia,[15] Pakistan,[16] Uganda,[17] Somaliland,[18] and several countries in the Pacific region.[19] Baseline assessment and eventual routine monitoring of these indicators is considered the first essential step toward successful surgical, obstetric, and anesthesia care planning.

With a population of 1.4 billion people, India is the most populous LMIC whose residents bear 18.4% of the global disease burden.[20] This burden is managed by a large and complex health system involving multiple players (see Panel 1). While a precise estimate remains elusive, a large portion of India's disease burden requires surgical care. Despite the efforts from care providers, a major chunk of this burden goes unattended given that the LCoGS report estimated that >95% of people lack timely access to safe and affordable surgical care in the South Asian region. There have been efforts to form consensus over identifying needs and establishing centers of excellence for implementation of surgical research and training.[27] However, a comprehensive subnational assessment of indicators is missing with limited focus on and use of routine data collection for surgical care indicators.

In the absence of required primary data, a critical assessment of available literature is a viable alternative that has previously been used by other countries such as South Africa[28] and Kenya[29] facing similar data limitations, and Pakistan[30] prior to its subnational mapping. Our aim was to review existing literature to investigate the state of LCoGS-proposed surgical care indicators in India.

Indicator I: access to timely essential surgery

The indicator of timely access assesses the proportion (%) of the population who are within 2 hours of a surgical care facility that can provide basic Bellwether procedures (such as laparotomy, cesarean-section, and treatment of open fractures). The current target is that 80% of a nation's population should have timely access to essential surgical and anesthesia care by the year 2030. Studies of timely access in India are scant, aside from two abstracts.[31,32] The first analysis included six Indian states and several other countries and reported the value for only one state of India. In the state of Chhattisgarh which faces developmental challenges and has a large tribal population, only 4.7% of the population lived within 2-h of a surgical care facility.[33] While the abstract mentions the data sources for provider

Panel 1: Health system in India.

Health sectors: Healthcare in India is provided by the public (or government) and private (for- and non-profit) sectors. The public sector has a well-defined referral hierarchy of care levels consisting of primary (in the form of Sub-Centers and Primary Health Centers), secondary (Community Healthcare Centers and Sub-District Hospitals), and tertiary (District Hospitals, Medical College/ Teaching Hospitals). Specialist SOTA care is typically available at secondary and tertiary levels. The private sector consists of nonprofit and for-profit clinics and hospitals. Several for-profit private multispecialty hospitals that are important for referral surgical patients are located in metropolitan and other urban areas. Private hospitals account for 54.3% and 64.7% of inpatient load in rural and urban areas, respectively.[21]

Health workforce: Health workforce includes several cadres with different roles and levels of training including doctors, dentists, nurses, midwives, pharmacists, accredited social health activist (ASHA) workers, and other community health workers. Doctors practice either allopathic or traditional/alternative medicine known as Ayurveda, Yoga, Unani, Siddha, and Homeopathy (AYUSH). Allopathic doctors specialize further in medical or surgical specialties through postgraduate and super-specialization degree or diploma programs. All health practitioners, particularly doctors, dentists, pharmacists, and nurses are accredited under respective councils. India faces a chronic shortage of health workers that is only worsened in public health facilities in rural areas.[22,23]

Health Financing: Health is financed through multiple channels in India. As per the estimates from the Institute for Health Metrics and Evaluation (IHME), Indian health spending in 2018 was distributed as follows: out-of-pocket: US$62 billion, pre-paid private spending: US$9.8 billion, development assistance for health: US$620 million, and government or public spending: US$27 billion.[24] Government-funded health insurance includes several national and state schemes. At the national level, workers employed in the formal sectors and their dependents are covered under the Central Government Health Scheme (CGHS) and Employees' State Insurance Scheme (ESIS).[25] While those in the informal sector are covered by the Rashtriya Swasthya Bima Yojana (RSBY) and Pradhan Mantri Jan Arogya Yojana (PMJAY). RSBY was the national health insurance covering secondary and tertiary level healthcare services for people living below the poverty line and was subsumed under PMJAY in 2018. PMJAY provides up to Rs. 500,000 (or US$7000 at an exchange rate of 1 US$ = 71.4 Indian rupees) per household for secondary and tertiary-level health services to the bottom 40 percent of the population. It is funded by central and state governments and implemented by the National Health Authority with the help of State Health Authorities.

Health Governance: While public health is under state governance, other elements such as education and management of health professionals belong under both central and state governments.[26] At the national level, the Ministry of Health and Family Welfare (MoHFW) is responsible for most of the health-related programs. It governs the Department of Health and Family Welfare and the Department of Health Research. Additionally, the Directorate General of Health Services (DGHS) provides advice on matters of medical and public health and helps in health services implementation. States have their health ministries and several supporting authorities that may be similar to the national governance structure.

locations, details regarding study methods and limitations are missing. The second study used geospatial modeling to predict that 99.2% and 99.8% of the rural and urban Indians live within a 2-h radius of a surgical care facility, respectively.[32] This study also found access disparities for rural and remote regions in the northern and northeastern parts of the country. It identified surgical care facilities to include community healthcare centers, subdistrict and district hospitals, civil hospitals, public and private medical college teaching hospitals, referral hospitals, maternity homes, post-partum units, dispensaries, and public and private hospitals empaneled under the Central Government Health Scheme (CGHS) and Pradhan Mantri Jan Arogya Yojana (PMJAY) for providing surgical care packages. Surgical care facilities were not restricted to facilities providing Bellwether procedures. However, these estimates assume the availability of motorized transport and optimal travel speeds, which may not be realistic. Further, the data source mentioned in the study — 'IndoHealMap' currently awaits validation. The study did not consider the actual availability of infrastructure and quality of care as per globally set standards, unlike studies conducted in other countries.[33–35]

Though not directly related to timely surgical access, previous Indian studies on healthcare access have relied mostly on distance-based measures. For instance, a national-level analysis triangulating data from mortality and health facility surveys found that as of 2010, 43% of the Indian population was estimated to be beyond 50 km of the nearest well-resourced district hospital or first-level surgical care facility.[36] Further, the odds of being in a high-mortality cluster for acute abdominal conditions were found to be over four times higher for those living ≥50 km from well-resourced district hospitals. Such a relationship between mortality and access was not found for non-acute conditions. However, the study did not comment on facilities actually providing surgical care and did not investigate the differences in times taken to travel the same distance for people residing in different regions. Another study analyzed data from the third round of the nationally representative District Household and Facility Survey (DLHS-3) (2007–08).[37] Regression analyses and policy simulations found that an increase of one kilometer from the nearest health facility (including primary and community healthcare centers, district hospitals, private clinics, hospitals, and nursing homes, etc.) can cause a 4.4% reduction in the probability of institutional delivery, with access to roads and motorized vehicle ownership influencing this relationship.[38]

A validated geodatabase of surgical facilities with routine updates details on functionality, availability of resources, and nature of care is urgently needed. Travel times must account for the availability of motor vehicles, access to ambulances and other modes of referral transport. Timely access estimates must be separated by public and private surgical facilities and those specific to rural, urban, and tribal regions.

Indicator II: specialist surgical workforce density

The second surgical care indicator is the number of surgeons, anesthetists, and obstetricians (SAO) available per 100,000 people, also called SAO density. The LCoGS suggests a target of 20 SAO density by 2030. The LCoGS data regarding the workforce in India counted only consulting physicians (excluding trainees) affiliated with specialist societies with voluntary paid membership. In 2009, India had 31,560 surgeons, 20,280 anesthetists, and 29,310 obstetricians resulting in a total SAO workforce of 81,150 and a density of 6.5.[13] Using these data, another study further calculated that India needs 291,824 more SAOs to meet the target density by 2030. These modeled estimates were based on supply-demand assumptions of a 30-year average SAO service time, 3.3% annual rate of retirement, and current population growth rate.[39] The recent WHO, World Bank, and Global Indicators Initiative reports have also used the LCoGS estimate.[4,6,7,40]

A WHO-sponsored report estimated the annual SAO production capacity of India, with a special mention of the southern state of Kerala, which leads the country in several areas of human resource development.[41] Available SAO residency positions were estimated using the number of surgical specialists registered with the Medical Council of India (MCI) and the state councils. SAO residencies included General Surgery, Orthopedics, Otorhinolaryngology, Ophthalmology, Anesthesia, Obstetrics & Gynecology. In 2015, India had 9037 SAO residency positions corresponding to 0.75 surgical trainees per 100,000 people. In Kerala, 411 surgical residency positions (excluding transfusion medicine) with a density of 1.23 were present with a 2:1 distribution across public and private medical college hospitals. The report used the Association of Surgeons of India (ASI) membership data from 2010 and LCoGS data to estimate that ranges (minimum and maximum) of SAO density for India and Kerala to be 1.5–6.8 and 2.3–10.2 per 100,000 people, respectively.[41]

A recent and rich source of SAO data has been the statistical and analytical reports led by government ministries, think tanks, and academic institutions. The Rural Health Statistics (RHS) reports published by the Ministry of Health and Family Welfare include data on the SAO workforce in community health centers, the secondary level care facilities in India's public health system. According to the RHS 2020–21 report, 5481 rural community health centers were functional with 1212 surgeons (including general surgeons and ophthalmologists), 1433 obstetricians and gynecologists (OBGYNs), and 805 anesthetists catering to an estimated 895,038,000 rural people, bringing the SAO density at community health centers to 0.385 per 100,000 for rural India.[42] Geographically inequitable SAO workforce distribution in rural community health centers was seen across states (Fig. 1a). The state of Uttar Pradesh, the most populous and geographically fourth largest state, had the most SAO workforce of 597 but an SAO density of only 0.338 per 100,000. SAO density in rural community health centers was highest for Lakshadweep (300) among union territories and Telangana (1.25) among states. Smaller states and union territories such as Sikkim, Mizoram, and Puducherry had two, nine and three functioning rural community health centers respectively, with no SAO workforce.

A total of 975 community health centers were functional in tribal regions with 244 surgeons and 208 OBGYNs.[42] While the national level combined surgeon and OBGYN density at tribal community health centers was 0.449, the values were heterogeneous across the country. Not all states have designated tribal regions, hence, Assam, Kerala, and Meghalaya had no surgeons in tribal community health centers. Himachal Pradesh, Mizoram, Andaman and Nicobar Islands, Dadra and Nagar Haveli and Daman and Diu, and Jammu and Kashmir lacked both surgeons and OBGYN specialists. Tamil Nadu has the highest density of surgeons & OBGYNs (2.34) among the Indian states lagging behind Lakshadweep with a density of 140 (Fig. 1b). No data were available for anesthetists.

The RHS report briefly mentions a total of 470 urban community health centers with 323 anesthetists resulting in a density of 0.068.[42] Jammu and Kashmir had the highest density with 0.59 anesthetist density while Kerala, Puducherry, Punjab, Chhattisgarh, and Jharkhand had no anesthetists in urban community health centers (Fig. 1c). However, it should be noted that community health centers form only a small fraction of all available surgical care facilities serving urban areas. No data on surgeons and OBGYNs at urban community health centers were presented.

NITI Aayog, a high-level government think tank, collected data for best practices and key performance indicators of district hospitals in 2018–19.[43] The data were primarily accessed through the hospitals' records in the Health Management Information System (HMIS) which includes over 200,000 healthcare facilities of which 95% are publicly-owned. These data were

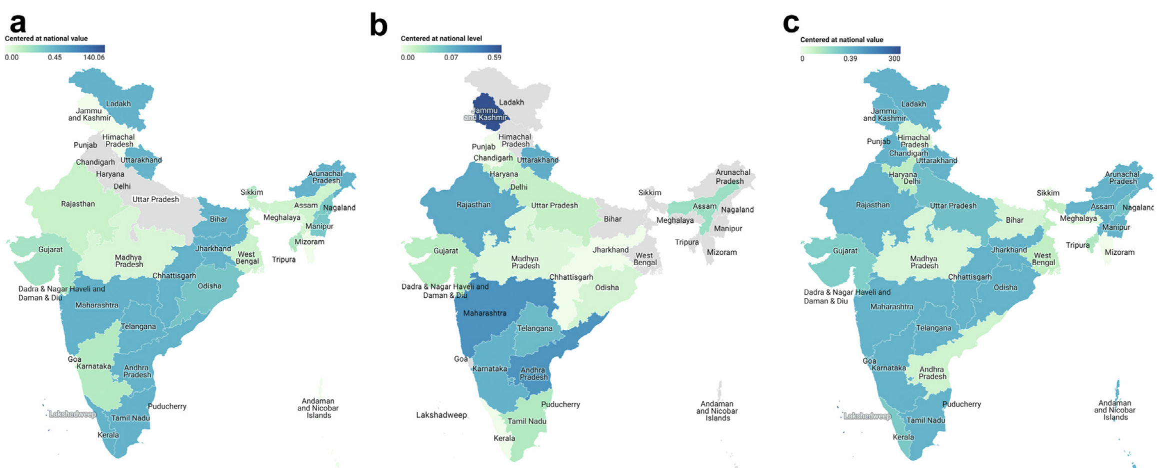

Fig. 1: **Community health center SAO workforce density per 100,000 people across 36 Indian states and union territories in 2021 for three regions: a. rural, b. tribal (includes only surgeons and OBGYNs), and c. urban (includes only anesthetists).** The scales across maps are different due to differences in specialists included in the SAO workforce. The color scale is centered at the national aggregate value for India in each case. Some states are grayed to depict missing data.

validated against on-field surveys by trained National Accreditation Board for Hospitals and Healthcare Providers (NABH) assessors who investigated percentage matches for the indicators. In 2019, India had 810 district hospitals; however, NITI Aayog excluded 79 hospitals for no specified reasons. Of the remaining 731 hospitals, data could not be collected from 24 due to security reasons and difficult terrain, finally leading to 707 district hospitals (87.3% of all district hospitals) with validated data. However, validation depicted a match rate of only 36% for this indicator, i.e., the numbers present in the HMIS and those entered by the NABH assessors did not match for 452 of the 707 hospitals.[43] The report quantified the total number of surgeons to be 3730, equating to a district hospital surgeon density of 0.273. Among the states and UTs, Ladakh had the highest surgeon density of 6.56 while Bihar had the lowest density of 0.0954. Among districts, Papum Pare in Arunachal Pradesh reported the highest surgeon density of 10.76 while 31 districts reported null values (Fig. 2). It should be noted that SAO density based on personnel working at district hospitals forms only a portion of the overall SAO density. Even so, investigating these data is important as district hospitals are supposed to be first point of care for surgery within the public health system that accessible at affordable costs to a large section of the Indian population.

The current literature highlights two major problems. First, there is a need to clearly define the 'surgical workforce' in the context of Indian healthcare practices. In India, resident-level trainees, nurses, ancillary staff, Bachelor of Medicine and Bachelor of Surgery (MBBS) students, and alternative medicine practitioners known as AYUSH (Ayurveda, Unani, Siddha, and Homeopathy) account for a measurable chunk of health service delivery. Some of these trainees and practitioners provide surgical care, especially in places where fully trained SAO workforce personnel may not be available. Hence, expanding the SAO workforce to include these groups is important (Panel 1). However, such inclusion should accurately differentiate among the different levels of training. Second, comprehensive nationwide data collection or aggregation is needed. Available data do not contain information on the workforce in the private health sector, except for voluntary memberships in professional societies, where updated publicly open data are unavailable. Ideally, the database should have information about the SAO demographics (gender, age, social groups, etc.), their geographic distribution, level of training, and sector of primary employment to understand the precise deficiencies in the workforce for targeted planning and investments. Current efforts toward Healthcare Professionals Registry under the Ayushman Bharat Digital Mission should focus on SAO care professionals.[44]

Indicator III: surgical volumes

The third indicator measures the number of procedures requiring general or local anesthesia done in operation theaters per 100,000 population per year with a target of 5000 surgical procedures per 100,000 people by 2030.[9] The World Development Indicators dataset and Global Indicators Initiative do not include primary data for surgical volumes in India and rely on imputed values from studies conducted under LCoGS.[4,6,7] This cross-national modeling study associated with LCoGS imputed an estimate of 904 operations per 100,000 for India based on a stepwise linear regression model using

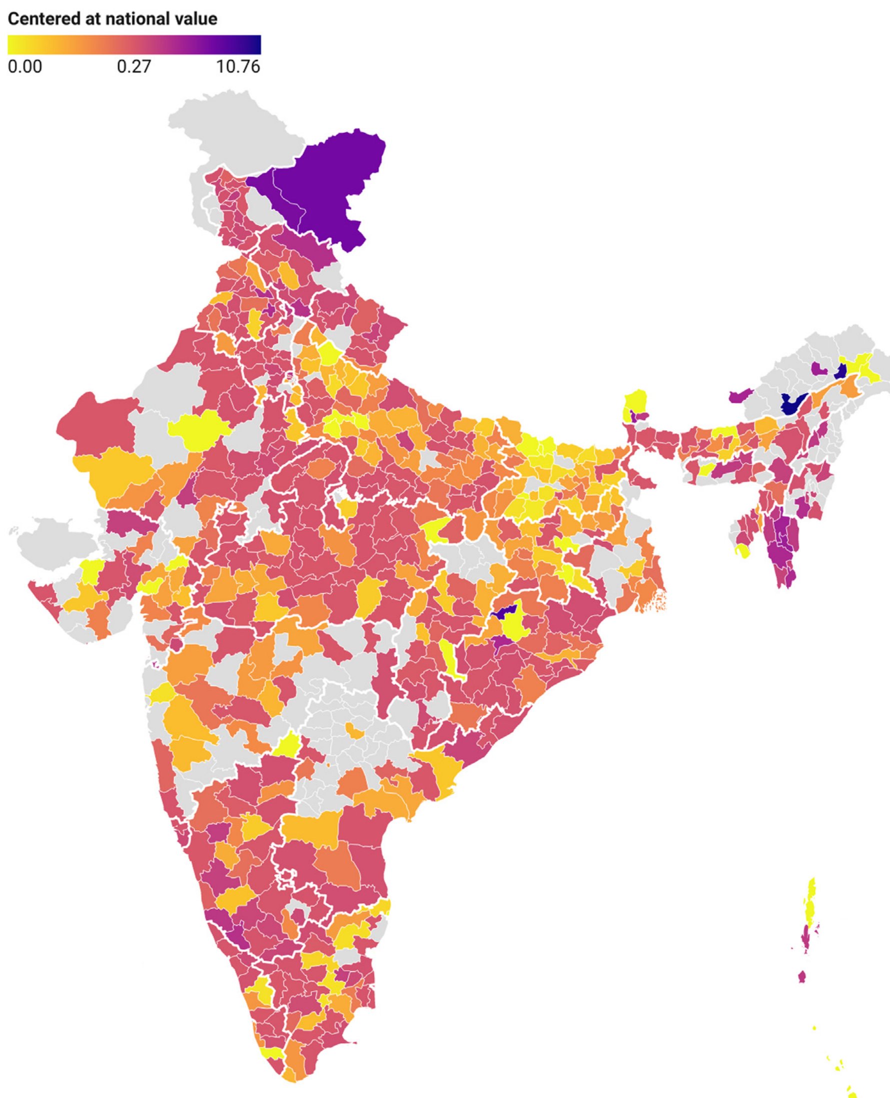

Fig. 2: **Surgeon density in 707 district hospitals across 580 districts in 2018–19.** The color scale is centered at the national aggregate value for India in each case. Some states are grayed to depict missing data.

total health systems spending per capita as the main predictor.[11] The analysis included outpatient procedures but excluded minor surgeries that may be conducted in operation theaters; minor surgeries were not clearly defined. Also, since this study estimated the volumes for 2012, it would not be representative of the current situation. The model is also known to underestimate surgical rates in South Asian countries including Myanmar and Sri Lanka.[6]

In a retrospective audit (2008–12) of insurance claims covering 81% of households with limited income in the southern states of Andhra Pradesh and Telangana estimated a mean annual surgical rate of 259 per 100,000 beneficiaries.[45] The study excluded cesarean sections (known to account for a third of surgeries in resource-limited settings) and cataract operations. The difference in estimates from the two studies[11,45] could be attributed to the inclusion of different operative procedures, different socioeconomic statuses of the populations, and different study periods.

The NITI Aayog report with data on 707 district hospitals (out of 810 total hospitals present) for 2018–19 found the rate of major surgeries (surgeries requiring general and spinal anesthesia) including cesarean sections to be 127.6 per 100,000 with the highest rate of 1560.9 surgeries per 100,000 in Dadra & Nagar Haveli and lowest rate of 33 surgeries per 100,000 people in Chhattisgarh where tribal people contribute to a third to the total population.[43] Shahdara (in Delhi) had the highest rate of major surgeries (including c-sections) with 2839 per 100,000 while 14 districts reported a null rate (Fig. 3). This number has multiple caveats. First, the indicator-wise validation between the field survey and pre-entered HMIS values showed only a 46% match depicting that the values for major surgeries in a year were similar between the two sources for only 325 out of 707 district hospitals. However, the report does not mention if the values were under- or over-reported for surgical volumes in HMIS. Second, while district hospitals are considered the first-level surgical care facilities in several parts of the world including India, they are few compared to the overall number of surgical facilities (20,802).[32] Third, district hospitals also form a small portion of the public system. For instance, in 2020–21 (two years after the study period mentioned in the report) district hospitals accounted for only 0.4% of healthcare facilities in India's public system that includes sub-centers, primary healthcare centers, community healthcare centers, sub-district hospitals, and medical college (teaching) hospitals, apart from district hospitals.[42] While the surgical capacity of district hospitals is critical for planning, the data on surgical volumes in district hospitals underestimate the overall surgical need of the country. In other words, surgical volumes at district hospitals should not be equated with population-level surgical volumes. Even so, investigating

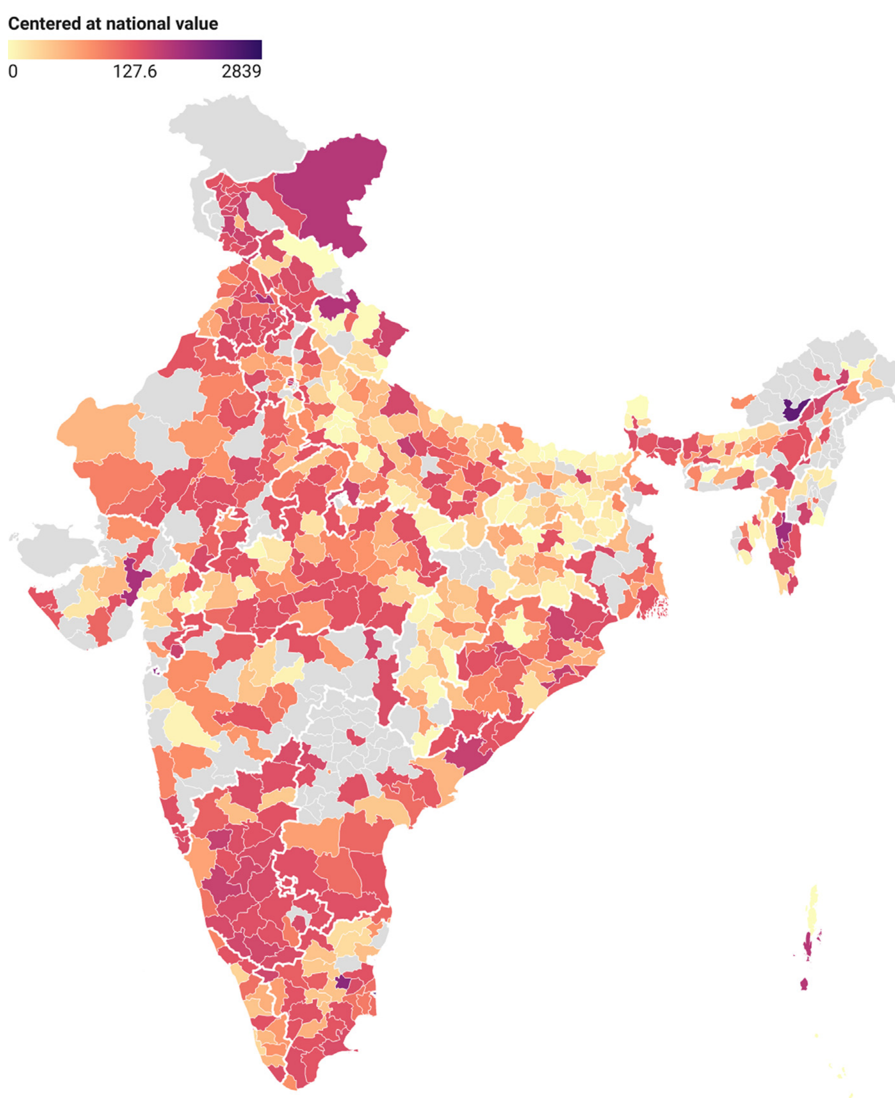

Fig. 3: **Combined rates of major surgeries and c-sections per 100,000 people conducted in 707 district hospitals across 580 districts in 2018–19.** The color scale is centered at the national aggregate value for India in each case. Some states are grayed to depict missing data.

these data is important as district hospitals are supposed to be first point of care for surgery within the public health system that accessible at affordable costs to a large section of the Indian population.

Analysis of high-value insurance claims filed from September 2018 to May 2019 under the Pradhan Mantri Jan Arogya Yojana (PMJAY)–the national health insurance scheme covering the 'bottom 40%' of the Indian population–found that 61% of the 2,000,000 claims were surgical (1,220,000).[46] With about 735,875,090 eligible beneficiaries,[47] the PMJAY surgical rate comes to 166 surgeries per 100,000 eligible beneficiaries. The low surgical rate under PMJAY, which provides financial risk protection against expenses at secondary and tertiary care levels, can be explained by a web of interacting supply and utilization factors including slow empanelment of major surgical care hospitals under the scheme, inequitable access to care for rural residents and those in low socioeconomic development zones, and lack of awareness among eligible beneficiaries along several other issues.[48]

Small-scale studies have also looked at surgical needs in certain urban regions, however, we could find only two studies with data fitting the definition of Indicator III. A community-based study of two slum pockets in the metropolitan city of Ahmedabad in Gujarat, reported a surgical rate of 1996.5 per 100,000 population in 2019 with an unmet surgical need of 42%.[49] The lower rate compared to the LCoGS' 5000 threshold can be explained by 80% of cohort participants belonging to low-income groups, where surgical uptake can be limited due to financial risks. However, there could be several determinants beyond finances for low surgical uptake. Also, it only included people above 14 years of age, excluding any pediatric patients. A retrospective audit study conducted on electronic medical records from 2017 to 2018 of surgical uptake in a well-characterized urban cohort receiving universal health coverage under the employees' health scheme in the city of Mumbai estimated a surgical volume of 4642 per 100,000 people per year in the cohort. Extrapolating to India's population after standardization based on the census demographics, the study estimated a surgical rate of 3646 per 100,000 people for India.[50] However, such an extrapolation is limited since the considered cohort does not capture all aspects of geographic, demographic, or socio-economic diversity in India that influence health services utilization. Further, the study assumed a 100% acceptability and utilization of services, which does not hold true in several parts of the country. The stark contrast between the surgical volume in the urban universal health coverage cohort in Mumbai[50] and the low-income urban cohort in Ahmedabad[49] points to the differential uptake across socioeconomic strata.

The current literature fails to capture data on surgical care provision and utilization from all the different demographic and socio-economic strata of Indian society. Further, different inclusion criteria for considering essential procedures across studies make comparisons and monitoring target achievement difficult. The lack of sub-national mapping of surgical volumes precludes reliable resource allocation for meeting the targets.

Indicator IV: perioperative mortality rate

The perioperative mortality rate (POMR) records the all-cause mortality rates before discharge among patients who have undergone a procedure in an operation theater. However, there are other POMR definitions looking at mortality 24 h or 48 h post-surgery or at 7–30 days follow-up. LCoGS recommended that by 2030, all countries should achieve tracking of perioperative mortality and set national targets.[9]

POMR has been measured in LMICs by many multinational studies. A systematic review summarizing studies by 2014 reported POMR for 191 procedures/diagnoses in 1,020, 869 patients from 83 LMICs. It included data for 54 on procedures/diagnoses for 30,458 patients from 82 Indian studies.[51] POMR was highly variable across procedures/diagnoses and studies (Table 2). Indian POMR values were higher than the meta-analytic aggregate of all studies for head injury, Fournier's gangrene, cardiac myxoma, resection of intracranial mass, and colonic volvulus, among others. Several procedures including congenital diaphragmatic hernia, intussusception, hepatic hydatidosis, laparoscopic orchiectomy, uterine rupture, etc. That are known for high mortality risk had zero POMR for India, questioning the reliability of these data. Studies included here were predominantly observational (n = 81, 98.8%), retrospective (n = 46, 56%), conducted in urban (n = 78, 95.1%) and teaching hospital (n = 75, 91.5%) settings. Most studies (n = 53, 63.9%) did not define the POMR timeframe explicitly. However, it is crucial to note that this review may not report from findings from methodologically diverse studies owing to its study aims, inclusion criteria, and analytical design. Almost all Indian studies included are from tertiary hospitals and academic centers, thereby biasing the true estimates for POMR in case of India. Hence, while important, these estimates should not be considered to be nationally representative.

A recent systematic review on perioperative mortality due to acute abdominal surgeries in LMICs included about a quarter of 70 studies published in 2017 for India.[52] However, it did not present any country-level data on POMR. Another recent systematic review on post-Cesarean section maternal mortality included 18 Indian studies published from 1990 to 2017 of which the majority (n = 13, 72%) were from tertiary facilities (mostly teaching hospitals) with 61% prospective cohort studies. The post-cesarean section maternal mortality was ≥1–5 per 1000 Cesarean sections in India.[53]

Only a few primary research studies published beyond the above-mentioned systematic reviews provide

Sr. No.	Procedure or Diagnosis Description	Indian POMR (%) Range (min to max, when applicable)[b] [No. of studies]	Inverse-variance weighted aggregated POMR (%)
1.	Bowel obstruction	4–8 [n = 2]	12.32
2.	All-comer head injury	54.6	27.2
3.	Hydatid disease, not otherwise specified	0	0.66
4.	Esophageal perforation	9.7	9.02
5.	Emergency peripartum hysterectomy	5.4–16 [n = 4]	7.81
6.	Perforated hollow viscus, excluding perforations secondary to Salmonella typhi infection	7–40 [n = 6]	11.85
7.	Trauma, not otherwise specified	4.7	2.93
8.	Bile duct procedures, excluding Whipple procedure	0	27.2
9.	Cardiac surgery, not otherwise specified	0–3.3 [n = 2]	4.96
10.	Oncologic diagnoses, not otherwise specified	2.6	1.97
11.	Minimally invasive surgery, not otherwise specified	0	0
12.	Appendicitis	0	0.01
13.	Laparotomy, not meeting other abdominal surgery code, includes laparotomy performed for trauma	4.9–12.5 [n = 3]	12.53
14.	Peripheral vascular injury	2.4–10.5 [n = 2]	3.52
15.	Complex congenital heart disease	0–18.2 [n = 3]	14.94
16.	Hepatic abscess	9.4–62.5 [n = 2]	15.86
17.	Congenital heart disease, adult population	1.3	2.77
18.	Congenital diaphragmatic hernia	0	21.72
19.	Intussusception	0	4.8
20.	Cesarean section	0.1–0.3 [n = 2]	0.05
21.	Coronary artery bypass graft	0–43.9 [n = 3]	4.38
22.	Pulmonary resection, excluding resection for Tuberculosis	1.9–5.6 [n = 2]	1.3
23.	Cardiac myxoma	5.3	2.24
24.	Traumatic diaphragmatic hernia	0–13.8 [n = 3]	9.59
25.	Necrotising fasciitis	9.1	7.91
26.	Esophageal carcinoma	3.2	5.4
27.	Nissen fundoplication	0	0
28.	Cardiac valve procedures	1.5	4.17
29.	Hepatic hydatidosis	0	0.46
30.	Laparoscopic orchiectomy	0	0
31.	Radical cystectomy	1	0.02
32.	Resection of intracranial mass	3.6	1.29
33.	Gunshot wound	14	14.45
34.	Upper gastrointestinal bleed	0	27.24
35.	Choledochal cyst	0.9	0
36.	Intracranial hemorrhage	3.8–35.7 [n = 3]	24.47
37.	Neurosurgical procedures, not otherwise specified	2.1	5.78
38.	Colonic volvulus	14.6	6.39
39.	Peripheral arterial bypass	3	4.24
40.	Colon resection, excluding resection for volvulus	1.2	2.83
41.	Ectopic pregnancy	0	0
42.	Whipple pancreaticoduodenectomy	3.6–5.4 [n = 2]	2.94
43.	Inguinal hernia	0	0.38
44.	Nephrectomy	0	0
45.	Mastoidectomy	0	0
46.	Typhoid intestinal perforation	20.7	20.09
47.	Cholecystectomy	0	0
48.	Vesicovaginal fistula	0	0
49.	Intracranial aneurysm	5.4	7.99
50.	Head and neck cancer	1.1	1.09

(Table 2 continues on next page)

Sr. No.	Procedure or Diagnosis Description	Indian POMR (%) Range (min to max, when applicable)[b] [No. of studies]	Inverse-variance weighted aggregated POMR (%)
(Continued from previous page)			
51.	Uterine rupture	0	7.36
52.	Fournier's gangrene	27.4	14.22
53.	Ascariasis	1.3	1.27
54.	General surgery	6	6

[a]This table contains data from 82 of the total 87 studies from India reported in the review by Ng-Kamstra and colleagues.[51] The other 5 studies, which were a part of international, multicentric studies, have been excluded due to a lack of India-specific values. For details, refer to Supplementary Materials 3 and 4 in the review article by Ng-Kamstra and colleagues.[51] [b]Single value is mentioned when the procedure was reported by only one study while range (minimum and maximum) is mentioned for multiple studies reporting values for the same procedure/diagnosis.

Table 2: **POMR by procedures in India[a] compared to the LMIC aggregate as extracted from Ng-Kamstra and colleagues.[51]**

data on POMR for India. A retrospective study of data collected during 2013–15 on 2986 patients from four urban tertiary public hospitals with dedicated trauma units noted POMR at 48 hours and 30 days post-surgery for trauma surgery to be 6% and 23.1%, respectively.[54] Another research abstract describing a retrospective audit from 2016 to 2020 from the departments of General Surgery, Orthopedics, and OBGYN from a low-resource non-governmental hospital reported a POMR of 0.16% for 1860 patients undergoing surgeries. However, the study did not define the timeframe for POMR data collection and acknowledged incomplete data.[55]

A multinational source of POMR data has been the Globalsurg Collaborative–an international research collaboration for prospective cohort studies among doctors, clinical officers, medical students, nurses, and researchers from over 100 countries. While GlobalSurg does not report country-specific data, they report data for world bank income groups and tertiles of countries based on their human development index (HDI) ranks. GlobalSurg 1 included data on 10,745 patients from 357 centers (6–10 Indian centers) in 58 countries collected from July to December 2014. For 2889 patients from middle HDI countries, including India, it reported unadjusted 24-h and 30-day mortality rates (or in-hospital mortality rate whenever 30-day mortality was not available) for emergency abdominal surgeries to be 1.9% and 6%, respectively.[56] Data from GlobalSurg 1 and 2 conducted in 2014 and 2016 with a pooled group of 12,296 patients from 326 to 356 centers in 76 countries, respectively, described the all-cause mortality within 30 days of emergency and elective surgeries.[57] For 3985 patients from middle-HDI countries, mortality was reported to be 15.7% after emergency laparotomy and 1.5% after elective gastrointestinal surgeries. GlobalSurg 3 conducted during April 2018–January 2019 documented the postoperative 30-day mortality data for primary breast, colorectal and gastric cancer from 16,838 patients in 428 centers (including 17 Asian centers) spread across 82 countries.[58] In the group including 4131 patients from low- and lower-middle income countries, the unadjusted mortality was reported to be 10.1% for gastric cancers, 7% for colorectal cancers, and 0.4% for breast cancers.

Other studies have investigated surgical mortality that may not strictly fall under the definition of POMR. One such national-level resource for surgical mortality data is the PMJAY database. While the database is not publicly accessible, a report using PMJAY data from 2018 to 19 covering 3.68 million beneficiaries in total (beyond surgery) has shown that the in-hospital mortality rate was 0.58%. The rates were higher in public hospitals compared to those in private hospitals.[59] Surgical specialty-wise mortality rate differences between public and private hospitals are presented in Fig. 4. These mortality rates, however, do not strictly represent POMR as there may be cases registered under surgical specialty packages that may not have undergone an operation or may have died prior to their procedure. Next, a multi-center prospective cohort study, conducted during 2013–15, including five urban teaching hospitals from Mumbai, Kolkata, Chennai, and Delhi reported the mortality rate among people hospitalized for trauma within 30 days of admission to be 21.6%.[60]

POMR, though an important measure of surgical safety, remains under-utilized due to variable reporting and susceptibility to information bias & publication bias.[61,62] The time period considered for recording POMR varies across studies while the rate itself remains ill-defined in some.[52] This is especially true for LMICs like India where follow-up records of patients are unavailable. POMR data are still largely available through individual research studies than routine data collections such as HMIS or PMJAY. Beyond establishing standardized registries[52] and solving systemic challenges shared by LMICs,[61] India needs a consensus-driven definition and high fidelity measurement process adapted to the country's pragmatic needs and constraints for POMR data collection.

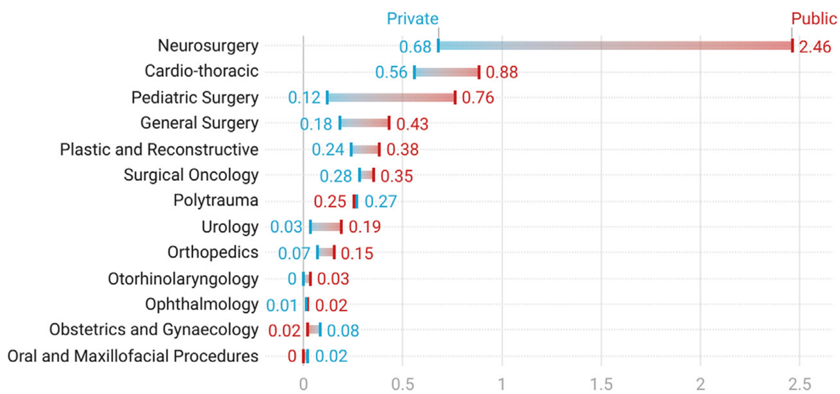

Fig. 4: **In-hospital mortality rates in public vs. private hospitals empanelled under Pradhan Mantri Jan Arogya Yojana (2018–19).**

Indicators V-VI: protection against impoverishing and catastrophic expenditures

The fifth and sixth indicators investigate the proportions of households protected against the risk of impoverishing (IHE) and catastrophic health expenditures (CHE) from direct out-of-pocket expenditure (OOPE) for surgical and anesthesia care.[9] CHE is defined as OOPE greater than 10% of the annual household consumption expenditure before care was sought while IHE is recorded when the OOPE pushes the care-seeker living above the poverty line into poverty or those already below the poverty line further into impoverishment.[63] The LCoGS targeted 100% protection against both CHE and IHE by 2030. While the definition and target are defined as protection against CHE and IHE risks, the data have been reported for proportions facing these risks.

LCoGS-associated research has modeled surgery-specific CHE and IHE risks for India as part of their global analyses.[12,63] The first analysis used stochastic modeling to estimate CHE risk based on surgery costs (proxied for Cesarean-section), within-country income inequality, and population proportions undergoing surgery across wealth quintiles.[63] This analysis found an approximately 80% chance of CHE for potential care-seekers receiving surgery in India. While a useful initial estimate, looking solely at Cesarean-sections for benchmarking CHE can be problematic for India. Cesarean-section rates and expenses differ across private and public sector health facilities,[64–66] residence, and socioeconomic conditions of care-seekers that influence care-seeking behaviors.[67] The second study used a similar modeling approach but used to estimate risks for both CHE and IHE across wealth quintiles. For India, the surgical care-seeking population facing CHE and IHE (relative to the national poverty line) were estimated to be 59.6% and 36.5%, respectively.[12] Population portions across wealth quintiles (poorest, poor, middle, rich, and richest), facing CHE risk were 100%, 63.4%, 14.2%, 3.8%, and 0.9%, while those for IHE were 89.8%, 73.9%, 60%, 45.6%, and 28.8% showing a steady increase in risk from richest to the poorest.

India does not have subnational surgery-specific estimates for indicators V and VI; though several studies have looked at CHE for overall healthcare services,[68,69] disease-specific CHE,[70] CHE due to OOP payments for medicines,[71] and that due to indirect costs associated with hospitalizations.[72] Analysis using data from nationally representative sample surveys has shown that CHE in India has grown 2.24 times from 1995 to 2014.[68] Additionally, there is a large inter-state variability in CHE with the highest affected state, Kerala (74.6%), having almost four times more proportion of households affected than that of the least one, Sikkim (18.7%).[69] A disease-specific analysis reported cancers to be responsible for 79% of the CHE while cataract was the smallest contribution to the CHE burden.[70]

Only one field study of three districts of the northern agricultural state of Haryana provided data exclusively on surgical care expenditure.[73] This interview-based study of ex-beneficiaries of a pre-paid surgical package program run at public hospitals from 2006 to 2013 found CHE prevalence to be 5.6% among surgery-seeking beneficiaries. Including the indirect costs, the mean OOPE incurred by the patients on secondary level surgical care under this program was Rs. 4564 (US$74.6). The low CHE prevalence can be explained by the program structure. Enrollees of the program made upfront one-time payments specific to the surgical procedures provided at fixed costs. The package covered the costs of pre-surgical medicines, diagnostics, surgery, and post-surgical medicines up to 14 days after discharge. Cesarean-sections, eye surgeries for adults and children, and cleft lip surgeries were provided free of cost, and people living in slums or those below the state poverty line were also provided exemptions from the one-time fees.

There is a dearth of primary data on surgical care expenditures from different healthcare settings and demographic cohorts in India. Further, future research on expenditures needs to include indirect costs and lost productivity as a recent analysis of a nationally representative health consumption survey has demonstrated that the indirect costs account for about a quarter of OOPE among inpatient hospitalizations in India.[72] Analysis of impoverishment needs to account for the dynamic movement of households across the poverty line due to accessing surgical care.[74]

Discussion

In this review, we found that India currently falls below the targets for all indicators across different health sectors and regions. There is limited data for access to timely essential surgery, and catastrophic and impoverishing expenditures due to surgery. Evidence on SAO workforce, surgical volumes, and POMR depicts wide variability across health sectors, levels of referral hierarchy, procedures, diagnoses, regions, etc. For several indicators, rural and tribal regions lag urban SAO care. The public health sector has more limited capacity for surgical care provision than the private sector.

Future research focus

While we collated data from wide-ranging sources, this review points to multiple gaps needing further research. First, subnational district and state-level data on all indicators are needed. These data need to be further disaggregated for rural, tribal, urban regions, public and private (non- and for-profit) private health sectors, and different levels of care. Surgical volumes, POMR, and financial risk protection indicators should be investigated across different population groups typified by social determinants of healthcare seeking including gender, age, income, caste, and religion among others. Synthesizing disaggregated indicators is crucial for a country as large and diverse as India, where tracking only aggregate numbers often deceives true target achievement, especially among vulnerable populations.[75]

Second, the initially proposed LCoGS indicators and the subsequent consensus-based modifications need further adaptation for India's context. Such adaptation has been observed in the national vision document drafted for Pakistan's National Surgical, Obstetrics, and Anesthesia Plan (NSOAP).[76] In India's case, indicators will need to be adapted in several ways such as: a) assessing the access to timely surgery by selecting only functional surgical facilities evaluated for their quality of care, b) expanding the definition scope of the surgical workforce to include MBBS and other practitioners, c) considering defining procedure-specific surgical volume targets given the skew created by excess Cesarean-sections and other procedures in some regions, d) ensuring in-hospital POMR data collection in places where pragmatic constraints may make 30-day POMR recording challenging, and e) using appropriate thresholds for measuring CHE and IHE that account for multiple dimensions of social and economic deprivation and regional variation in the poverty line.[77,78] More importantly, the adaptation needs to be driven through a systematic process involving Indian stakeholders. The Utstein consensus report, for instance, involved only 8 LMIC panelists out of 38 but no one from India.[8] A similar process or a Delphi panel study would be suitable for adapting the indicators and targets for India.

In the current review, we did not investigate the impact of the COVID-19 pandemic on surgical care indicators. However, studies have demonstrated that the pandemic and the policy responses to it have reduced surgical volumes, particularly for elective procedures.[79–81] Post-operative mortality rates were also higher in COVID-19 patients, thereby increasing overall POMR.[82] More broadly, there have been increases in the delay to care,[83] unemployment,[84] and poverty.[85] These socioeconomic adversities have direct implications for indicators I, V, and VI. Future research needs to establish the baseline (pre-pandemic) for surgical indicators in India and estimate the impact of COVID-19 on the indicators. Estimates for baseline and changes to it due to the pandemic are necessary for targeted planning, prioritizing care domains and regions that may have been most impacted by the pandemic.

Policy implications

Data on workforce and volumes depict the need to scale up. Given the country's large geographic scope, relying solely on district hospitals that are thought to be the first point of contact in case of SOTA care in other LMICs may not be optimal for India. Diversifying surgical services provided at different levels of care is feasible. A large section of essential surgery can be provided at the secondary care level, i.e., community health centers.[86] Investing in SAO care scale-up at community health centers can be particularly useful for patients in rural and tribal regions.[87] Such policies and investments would also be supported by the guidelines from the Indian Public Health Standards that enlist several essential surgical procedures, workforce targets, and quality indicators as necessary components at CHCs. In fact, the Indian Public Health Standards guidelines go beyond community health centers to ambitiously suggest surgery as a desirable integration at the primary health centers.[88] Assessing the current SAO care capacity at community health centers, possibly through the LCoGS indicators, to decide policy needs and opportunities for public health investment would be critical for improving surgical care access in India.

For monitoring and evaluation purposes, India could benefit from instituting a surgical care indicators database or integrate these indicators into existing databases. It should be noted that integrating these indicators into existing databases would be more feasible and economic than instituting a new database. Indicators I, II, III, and IV can be integrated into the

Search strategy and selection criteria

A narrative review was conducted that included–a) research papers, reviews, and conference abstracts published in peer-reviewed academic journals, and b) international and national policy reports published by intergovernmental, governmental, and relevant nongovernmental stakeholders. Peer-reviewed articles published from 2000 to 2020 were retrieved from PubMed and Google Scholar searches including the names of the individual indicators and India. We also accessed LCoGS website (https://www.lancetglobalsurgery.org/) to retrieve Commission related research articles and abstracts. For policy reports, we relied on websites of LCoGS (https://www.lancetglobalsurgery.org/), Disease Control Priorities Network (https://dcp-3.org/surgery), Program in Global Surgery and Social Change (https://www.pgssc.org/), Ministry of Health and Family Welfare (https://www.mohfw.gov.in/), NITI Aayog (https://www.niti.gov.in/), and Pradhan Mantri Jan Arogya Yojana (https://nha.gov.in/PM-JAY). We also screened the references of the included materials. Reports were only considered for inclusion if they provided data for India or Indian states on any of the six surgical care indicators. Reports available through the internet and published in English were included. Research articles posted on pre-print servers/repositories (e.g., BioRxiv, MedRxiv, etc.) that had not undergone peer-review were excluded. All data included were collected before the COVID-19 pandemic. The pandemic has adversely impacted surgical care around the world, however, investigating the impact of the pandemic on surgical care indicators was beyond the scope of this study.

Health Management Information System and Pradhan Mantri Jan Arogya Yojana databases recording data from hospitals. While indicators I, III, IV, V, and VI could be included in the National Family Health Survey recording data from household surveys with representative samples.[89] Data collection across two different kinds of sources for indicators I, III, and IV will provide ways to validate data, point to gaps, and better understand surgical care needs and utilization patterns. In line with its National Digital Health Mission, India could formulate data governance policies ensuring that surgical care indicators data are interoperable and publicly accessible. In the long run, there needs India will benefit by shifting from relaying on individual research studies to utilizing health data systems that routinely collect data on surgical care indicators.

Conclusion

India has limited primary data for timely access to surgery and financial risk protection for seeking surgical care. The data are heterogeneous across regions and health sectors for surgical specialist workforce and surgical volumes. Data on perioperative mortality rate are low quality. However, available data show that the country falls short of achieving global targets for all indicators. Future research and policy efforts should focus on systematic subnational mapping of indicators and adaptation of targets as per the country's health needs for sustainable and equitable surgical care planning.

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Declaration of interests

The authors declare no competing interests.

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