Standardised metrics for global surgical surveillance

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Public health surveillance relies on standardised metrics to evaluate disease burden and health system performance. Such metrics have not been developed for surgical services despite increasing volume, substantial cost, and high rates of death and disability associated with surgery. The Safe Surgery Saves Lives initiative of WHO's Patient Safety Programme has developed standardised public health metrics for surgical care that are applicable worldwide. We assembled an international panel of experts to develop and define metrics for measuring the magnitude and effect of surgical care in a population, while taking into account economic feasibility and practicability. This panel recommended six measures for assessing surgical services at a national level: number of operating rooms, number of operations, number of accredited surgeons, number of accredited anaesthesia professionals, day-of-surgery death ratio, and postoperative in-hospital death ratio. We assessed the feasibility of gathering such statistics at eight diverse hospitals in eight countries and incorporated them into the WHO Guidelines for Safe Surgery, in which methods for data collection, analysis, and reporting are outlined.

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Introduction

Public health surveillance has long used standardised metrics to quantify disease burden in a population, track mortality rates, and guide health system programming and assessment.[1] Maternal mortality, infant mortality, and life expectancy have been important indicators for measuring the efficacy of health services and delivery for more than half a century. Many countries are also incorporating vaccination rates and treatment coverage for specific infectious diseases into surveillance programmes in an effort to identify gaps in resource allocation.[2] However, because of the overall worldwide increase in life expectancy and decrease in maternal and infant mortality, other measures are essential for monitoring health system performance.

Surgical care is one important example. An estimated 234 million major operations occur worldwide every year—a previously unrecognised amount that exceeds the global volume of childbirth.[3] Evidence suggests that surgical care results in at least 7 million complications every year, including 1 million deaths, which is twice the number of maternal deaths per year.[4–6] However, information on the frequency and safety of operative care is severely limited by gaps in national data and a paucity of standardised definitions for tracking surgical services globally. 70% of countries have no information on frequency of surgical procedures and virtually none attempt to assess distribution of surgical resources or outcomes. Basic metrics for surgical surveillance are needed if public health officials are to engage in effective planning of health system resources, safety, and access.

In 2007, WHO and its Patient Safety Programme launched an initiative called Safe Surgery Saves Lives.[7] One aspect of this programme was to develop standardised measures for surveillance of the volume of surgical care and its effect on public health outcomes over time. The aim of these measures is to improve assessment of the magnitude and safety of surgical care while being feasible to gather at a national level by public health agencies in nearly all resource settings. We report the results of this work and describe the rationale for each of the proposed measures. We also tested the practicability of their collection in eight hospitals in eight countries with a broad range of resources and record-keeping practices.

Identification of surgical measures

A technical working group comprised of experts in epidemiology, global health, and research on surgical outcomes from around the world was created to develop standardised metrics for assessing surgery on a global level. Individuals were selected to represent a variety of geographic regions and resource settings, and on the basis of their previous involvement with surgical research and outcomes work. The group reviewed the publications on measuring surgical services, studied the experiences of several countries, and reviewed lessons learned from other public health measures. Each potential metric was assessed by the working group and the Patient Safety Programme leadership, as well as other stakeholders, such as patients, ministerial-level advisers, and members of both national and WHO statistical agencies, to ensure that they were feasible for use and well defined. A list of metrics was agreed upon by consensus. These metrics aimed to capture the availability of surgical services with respect to personnel, infrastructure, quantity, and outcomes, while meeting the underlying principles shown in the panel.

The group proposed six surgical measures for use worldwide (table 1). These measures encompass structure (number of operating rooms, number of accredited surgeons, number of accredited anaesthesia professionals), process (volume of surgery), and outcome (post-operative death ratios) measures for evaluating health care.[8] These data can be obtained at an administrative level without the need for population-based surveys.

Feasibility testing

Once metrics were identified, we assessed the ability of individual facilities to gather the data by requesting such information from one hospital in eight different countries

Panel: **Guiding principles for establishing standardised metrics to evaluate surgery**

Simplicity
Metrics should be simple, clear, and inexpensive to obtain from hospitals, providers, professional societies, and governmental agencies. Health resources should not be diverted or unduly burdened by demands for data collection.

Wide applicability
Metrics should use definitions relevant to the span of surgical care worldwide. They should also be meaningful to health professionals, researchers, and policy makers, and provide information allowing reasonable conclusions on the state of surgical services within a country.

Relevance to public health
Surgical metrics should incorporate measures of access and outcome. They should provide indicators likely to respond to substantial changes in the delivery or quality of surgical care.

Unintended negative consequences of measurement reduced to a minimum
Potentially negative consequences should be considered, since scrutiny can result in perverse effects, driving practice patterns that bolster statistics at the expense of patient care.

(Toronto General Hospital, Toronto, Canada; St Stephen's Hospital, Delhi, India; Prince Hamzah Hospital, Amman, Jordan; Auckland City Hospital, Auckland, New Zealand; Philippine General Hospital, Manila, Philippines; St Francis Designated District Hospital, Ifakara, Tanzania; St Mary's Hospital, London, UK; and the University of Washington Medical Center, Seattle, WA, USA) that were participating as pilot sites for the Safe Surgery Saves Lives quality improvement initiative described elsewhere.[9] The local principal investigator at each site provided information for each of the proposed measures. They were asked to report data from administrative records, including surgical records, death records, and staff rosters.

All eight pilot site hospitals were able to report on the structure, process, and outcome measures (table 2). Table 3 shows the self-reported crude mortality ratios for each pilot site in an anonymous fashion along with 95% CIs to account for normal annual variation. Data for operating room use and staffing were also available from all eight facilities (table 4).

The structure and process measures proved simple to gather on the basis of knowledge of the facility, staff rosters, and operative records. However, the outcome measures proved more difficult—many hospitals had to cross-reference death registries and surgical records to establish which patients had undergone an operation before death. Despite their wide range of resources and record-keeping capacities, however, all eight pilot sites were able to provide information for each measure without the need to hire additional staff or to gather prospective data. Since these pilot data showed 30-day postoperative in-hospital death ratios ranging from 1 in 69 operations to 1 in 357 operations at these sites, measuring outcomes of surgical care is important for public health safety and planning.

Global surgical surveillance

Measurement of the provision and outcomes of surgical care through the use of standardised metrics seems feasible across diverse settings and would provide an important indication of health system performance for these high-risk and complex services. In view of the value of such data, WHO adopted these measures as recommended guidelines for national public health surveillance.[10]

Facility information, aggregated at a national level, can provide ministries of health and departments of health with valuable information on surgical services, resources, and outcomes. Four of the six measures—number of operating rooms, number of operations, death on the day of surgery, and postoperative in-hospital death—rely on data collection mechanisms at the facility level only. Since clinicians often work at more than one facility, total numbers of accredited surgeons and anaesthesia professionals should be assessed by use of professional society registries, training programmes, and medical facilities to determine and verify results. Although these data were available at each of the pilot sites, it remains to be seen whether they can be gathered at a national level in all countries and settings. However, despite the difficulty of obtaining information on other health indicators such as maternal and neonatal mortality, these efforts have had a profound effect on health policy and planning. We expect that as the value of surgical metrics are recognised, countries will prioritise data collection.

Facility-level data also help to identify issues of resource allocation and access. The annual number of operations per operating room and of cases per surgeon, and the association between accredited anaesthesia professionals and operating rooms are all important indicators for resource management. The annual operating room and surgeon caseloads provide a measure of resources available to the community for surgical services. In St Francis Designated District Hospital, for instance, the use of operating rooms was in the middle of the range for the eight sites, but the output per surgeon was high, suggesting a large workload and the potential need for more clinical support at the facility. Since this is also the only facility in the region providing such care, its resources are essential. Conversely, the data for the University of Washington Medical Center might suggest that a large number of surgical staff operate outside the medical centre, that cases are long and complex, or that an emphasis on research and education diverts time away from clinical care. The ratio of anaesthesia staff per operating room might also provide an indication of

	Definition	Rationale for use	Data sources	Comments
Number of operating rooms	Operating rooms are rooms used specifically for surgical procedures and equipped to deliver anaesthesia	The number of operating rooms available to a population is a structural indicator of the ability to provide surgical interventions	Administrative records based on reported data by inpatient and outpatient facilities; censuses of health facilities	Minor procedure rooms that are not suitable for invasive operations and are not equipped to deliver anaesthesia should not be included in the total number of operating rooms
Number of accredited surgeons and number of accredited anaesthesia professionals	Accredited surgeons are physicians who have achieved certification in a surgical specialty as recognised by the accepted national standards of the member state or national professional organisations. Accredited anaesthesia professionals are physicians, nurses, and other practitioners who have achieved certification in the provision of anaesthesia as recognised by the accepted national standards of the member state or national professional organisations	The availability and composition of human resources for health is an important indicator of the strength of the health system	Facility surveys, labour force surveys, and records from professional and administrative sources	Each country can define what the acceptable national standards for accreditation of surgeons and anaesthesia professionals are. The word professional in anaesthesia professional recognises the important contribution non-physician anaesthesia practitioners provide in both the developed and developing worlds. Individuals who perform surgery or administer anaesthesia but are not accredited, including those still in training, would not be included in this measure
Number of surgical procedures done in an operating room per year	The absolute number of all surgical procedures, defined as the incision, excision, or manipulation of tissue that requires regional or general anaesthesia, or profound sedation to control pain, undertaken in an operating room	Surgical volume is an indication of the access to and use of health care, particularly surgical services	Hospital records and routine health service statistics	Invasive procedures that meet the definition but are done in a procedure room not suitable for more extensive operations should not be considered in the total number of surgical procedures. If, however, they are done in the operating room they should be counted
Day-of-surgery death ratio	Number of deaths on the day of surgery, irrespective of cause, divided by the number of surgical procedures in a given year or period, reported as a percentage	Day-of-surgery death ratios allow the health system to assess its performance and the state of health of the population	Administrative and hospital records based on health service statistics	Death on the day of surgery often reflects the comorbidities and physiological disorders of the patient, the quality and complexity of surgical care, or the risks of anaesthesia. It cannot be used to compare one site, facility, or country with another without appropriate, validated, and time-consuming risk adjustment
Postoperative in-hospital death ratio	Number of deaths in the hospital following surgery, irrespective of cause and limited to 30 days, divided by the number of surgical procedures done in a given year or period, reported as a percentage	Understanding the in-hospital death ratio after surgery provides insight into the risks associated with surgical intervention	Administrative and hospital records based on health service statistics	Patients who undergo surgery and die outside a health facility or after readmission to the same or a different facility are important to record in postoperative mortality assessments. Facilities should be encouraged to gather such information. Neither circumstance is included in this statistic, however

Table 1: **Standardised statistics for surgery: definitions, rationale, and data sources**

	Annual number of operations	Number of operating rooms	Number of accredited surgeons	Number of accredited anaesthesia professionals
Toronto General Hospital, Toronto, Canada	10 323	19	55	33
St Stephen's Hospital, Delhi, India	19 377	15	42	7
Prince Hamzah Hospital, Amman, Jordan	6147	13	37	40
Auckland City Hospital, Auckland, New Zealand	25 667	31	171	92
Philippine General Hospital, Manila, Philippines	12 062	39	62	40
St Francis Designated District Hospital, Ifakara, Tanzania	1814	3	5	4
St Mary's Hospital, London, UK*	15 187	16	48	40
University of Washington Medical Center, Seattle, WA, USA	14 305	24	208	119

For definitions of measures see table 1. *St Mary's Hospital has since been renamed St Mary's Hospital–Imperial College National Health Service Trust.

Table 2: **Structure and process measures for eight hospitals, 2007**

potential vulnerabilities for adequate provision of anaesthetic care. For example, St Stephen's Hospital had an anaesthesia staff to operating room ratio of less than 1:1; combined with its high operative volume, this ratio could suggest a serious staffing shortage.

There was some variation in the way measures were reported at different facilities. Some facilities had difficulty providing exact numbers of staff for particular disciplines, such as whether affiliate surgeons operating at sister institutions were counted as staff. There was variability in the types of procedures reported—for example, some reports excluded procedures done in operating rooms that were physically separate from the main set of operating suites (such as the labour and delivery ward where caesarean sections take place, or satellite outpatient operating suites). Some invasive interventions, such as endoscopy or percutaneous vascular procedures, were included inconsistently since they were done in an operating room in some settings and in outside procedure rooms in others. Furthermore, the volume metric does not provide information on the reason for undertaking a procedure, the staff metrics do not indicate the level of

clinical activity, and the operating room metric does not describe intensity of use. Nonetheless, at a national level these measures can provide a broad picture of health system resources for surgical care and ability to meet essential surgical needs of a population.

All-cause surgical mortality ratios were reported from different sources in different facilities. In many sites, hospital deaths were not linked directly to surgical procedure records and thus had to be manually cross-referenced with surgical records. Some facilities kept death records within the departments rather than at the hospital administrative level, and this required each department to provide operation and death data. Other facilities cross-referenced surgical deaths on the basis of numbers of patients treated rather than number of operations, rendering a nominally higher mortality rate than the ratios reported with operative volume as the denominator. With consistent methods in any one facility or country, however, mortality ratio information can provide a crucial indicator of the burden of harm.

	Day-of-surgery mortality ratio (95% CI)*	Postoperative in-hospital mortality ratio (95% CI)†
Facility A	0% (0–0·20)	0·28% (0·09–0·64)
Facility B	0·13% (0·06–0·26)	0·36% (0·22–0·54)
Facility C	0·01% (0–0·04)	0·39% (0·30–0·48)
Facility D	0·08% (0·04–0·14)	0·62% (0·50–0·76)
Facility E	0·07% (0·04–0·11)	0·64% (0·55–0·74)
Facility F	0·06% (0·02–0·11)	0·92% (0·77–1·09)
Facility G	0·14% (0·07–0·23)	1·29% (1·08–1·53)
Facility H	0·27% (0·18–0·37)	1·45% (1·25–1·68)

Mortality statistics are presented in an anonymous fashion because of the sensitivity of death ratios at a facility level and to discourage comparison of one site with another without adjustment for case mix, patient demographics, or patient condition. *Number of deaths on the day of surgery, irrespective of cause, divided by the number of surgical procedures in a given year or period, reported as a percentage. 95% CI calculated from the exact binomial distribution. †Number of deaths in the hospital after surgery, irrespective of cause and limited to 30 days, divided by the number of surgical procedures done in a given year or period, reported as a percentage. 95% CI calculated from the exact binomial distribution.

Table 3: **Crude mortality ratios for eight hospitals, 2007**

	Annual cases per operating room	Annual cases per surgeon	Anaesthesia professionals per operating room
Toronto General Hospital, Toronto, Canada	543	188	1·7
St Stephen's Hospital, Delhi, India	1292	461	0·5
Prince Hamzah Hospital, Amman, Jordan	473	166	3·1
Auckland City Hospital, Auckland, New Zealand	828	150	3·0
Philippine General Hospital, Manila, Philippines	309	195	1·0
St Francis Designated District Hospital, Ifakara, Tanzania	605	363	1·3
St Mary's Hospital, London, UK*	949	316	2·5
University of Washington Medical Center, Seattle, WA, USA	596	69	5·0

*St Mary's Hospital has since been renamed St Mary's Hospital–Imperial College National Health Service Trust.

Table 4: **Operating room use and staffing for eight hospitals, 2007**

There is legitimate concern that mortality information could be misinterpreted or misused, which could adversely affect care if it led to avoidance or premature discharge of critically ill patients, or overtreatment of some patients. These measures do not allow an accurate comparison between institutions or countries. Hospital case-mix varies substantially, as does the disease burden of a population. Additionally, variations in the number of deaths per operation are likely to occur from year to year. The measures are thus not metrics of quality but rather of the effect of surgery on public health and mortality, and for tracking surgical trends over time.

We present the reported mortality statistics in an anonymous fashion because of the sensitivity of death ratios at the facility level and to discourage comparison of one site to another without adjustment for case-mix, patient demographics, or patient condition. Countries with sophisticated measurement techniques will be able to gather detailed information about specialists, specific operations, and complication rates such as surgical site infections, but global measures must necessarily be more widely feasible to obtain.

Policy implications

Advances in maternal health have relied on a knowledge built around birth rates and crude maternal and neonatal mortality.[11] Such data not only provided a benchmark to measure improvement but also recognition of the enormous effect of unsafe childbirth on global health. Similar to the improvements in maternal health achieved in many parts of the world, a better understanding of the magnitude and outcomes of operative care will allow better research on health services in surgery and provide assistance to governments and other organisations seeking to allocate resources effectively. The direct and indirect financial costs associated with data collection can be reduced to a minimum if they are incorporated into the routine data collection processes established between government agencies and hospitals. However, if no such data collection processes are in place, the cost of establishing such a system could be substantial. Nonetheless, although surgery is expensive and can consume a large portion of health-care resources, it can also be highly cost effective when applied in the right settings.[12–14] Rational planning is needed to make surgical services an effective component of the public health delivery system. Furthermore, the data can be linked to other health metrics, such as burden of disease data for needs assessment.

Conclusion

Enthusiasm is growing for measuring and improving health systems in a comprehensive way rather than focusing on narrow areas of care.[15] Additional metrics are needed for a more complete assessment of health system function. These surgical metrics, including surgical mortality, are one component. Countries can use such

information on a national level to identify barriers to access, to assess surgical safety, and to track changes over time. On a broader level, improvements in the capacity of a health system to assess delivery and outcomes of care for a variety of conditions and therapies—from pneumonia, malaria, HIV, and tuberculosis to heart disease, cancers, and trauma—can guide programming and resource allocation. Such knowledge provides a baseline by which improvements in health delivery can be measured.

Contributors

TGW, MAM, ABH, GD, WRB, and AAG were responsible for the initial conception of this work. Members of the Safe Surgery Saves Lives Measurement Group identified and developed the surgical metrics led by MAM. Members of the Safe Surgery Saves Lives Study Group evaluated the surgical metrics and contributed to the study design and data collection processes. ABH led the data collection process. TGW, ABH, WRB, and AAG analysed and interpreted the data. TGW drafted the report, which was critically revised by TGW, MAM, ABH, GD, WRB, and AAG. All authors read and approved the final report.

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Conflicts of interest

We declare that we have no conflicts of interest.

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