

Objective 10: Hospitals and public health systems will establish routine surveillance of surgical capacity, volume and results.

Assessment of success, failure and progress in the provision and safety of surgical care relies on information on the status of care. Practitioners, hospitals and public health systems require information on surgical capacity, volume and results, to the extent practicable. Success in other fields of public health, such as the safety of childbirth, reduction of HIV transmission and the eradication of poliomyelitis, has been shown to depend on surveillance (1–4). Improvement of surgical safety and access is no different.

The absence of data on surgery in WHO metrics has probably contributed to the failure to recognize the enormous volume of surgery that is performed throughout the world and its contribution to avoidable disability and death (5). These guidelines therefore list an essential set of ‘vital statistics’ for surgical surveillance at a systems level and simple patient-level measures for use by hospitals and practitioners.

The current model for measuring health-care delivery is the Donabedian framework (6,7). First introduced in 1966, this framework is based on three types of metric: measures of structure, process and outcome.

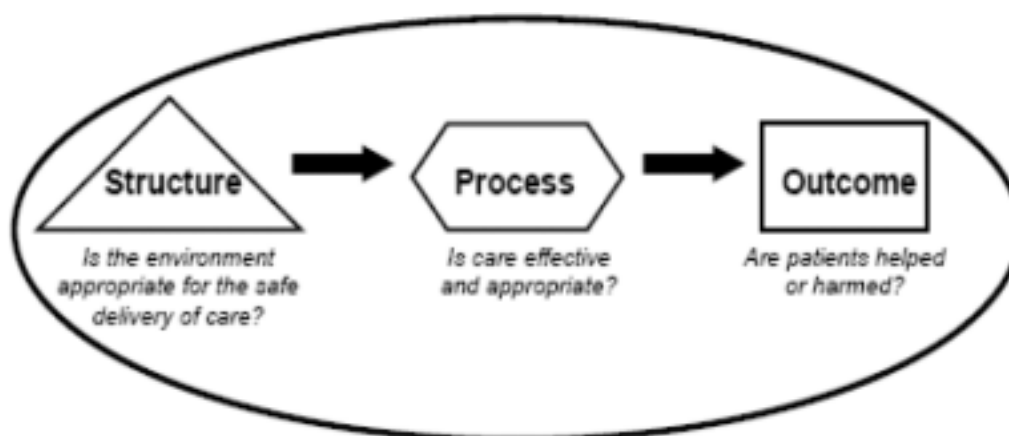
Structure metrics allow assessment of the physical infrastructure of a health system.

Process metrics allow assessment of how well a health-care protocol is carried out or delivered.

Outcome metrics allow assessment of the results or impact on a population’s health.

The strength of the Donabedian framework lies in the relations between these measures. As illustrated in Figure 10.1, structure influences process and process in turn influences outcome (8). A comprehensive assessment of health-care delivery requires understanding of all three elements individually and the relations among them.

Figure 10.1 – The interaction of structure, process and outcome on health care



A central objective of the Safe Surgery Saves Lives programme is to define a set of ‘vital statistics’ for surgery that incorporates measures of structure and

outcome and while tracking process efforts such as the use of a safety checklist and implementation of standardized protocols for care. The goal is to assess both access to and quality of care. Because of the significant difficulties associated with almost any form of measurement, the programme sought to maintain simplicity.

There are no simple measures to evaluate surgical care. In public health programmes to reduce maternal and infant mortality, data on structure, process and outcome are used to derive information about the quantity and quality of maternal care. The data include fertility rates, the volume of cesarean sections, the proportion of births assisted by a skilled birth attendant and the number of such attendants in a country, as well as outcome measures such as maternal mortality, infant mortality and Apgar scores. This guideline therefore outlines a similar set of indicators for which standardized data on the volume and safety of surgery can be collected and compared.

Feasibility and implications of measurement

In order to obtain surgical vital statistics, it is essential to have practical indicators and a realistic mechanism for data collection. WHO's Health Metrics Network defines the issues as follows (9):

Indicators. A minimum set of indicators and related targets, covering the main domains of health information (determinants, health system inputs and outputs, health service coverage and quality and health status) is the basis for a health information system plan and strategy.

Data sources. There are two main types of data source: those generating population-based estimates (census, vital statistics and household or population-based surveys and surveillance) and those that depend on health service or administrative records (disease surveillance, health-facility records, administrative records and health-facility surveys).

Infrastructure: A country must have an adequate infrastructure for collecting health information, be it based on population surveys or administrative records. Certain minimal structural requirements, such as personnel, training programmes, measurement collection tools and computer or data recording equipment, must be available.

As surgical vital statistics have broad global applicability, the structural limitations of the most resource-constrained countries must be considered. A complex indicator such as the rate of postoperative complications is more difficult to measure than an indicator such as postoperative mortality rate. Common indicators that are clearly defined and require only modest infrastructure are the easiest to measure.

Economic considerations: Closely related to structural feasibility is economic feasibility. In designing a surgical assessment tool, consideration must be given to the direct and indirect financial costs associated with its implementation. In resource-limited settings, certain data collection tools may be impractical for financial reasons. This is particularly true for designs that require computer-based data storage, state-of-the-art medical techniques (such as computed

tomography scanners) or other costly equipment. Feasible data collection tools can help a country to manage its information system in order to make surgical care both safe and cost-effective. The cost of efforts to collect data must translate into health savings for the population.

Positive incentives: The existence of a surgical assessment metric will probably improve surgery throughout the world for several reasons. Most importantly, it will provide a global baseline evaluation of the quantity and public health outcomes of the surgical care currently delivered. It will also establish a foundation on which to base evaluations of interventions to improve surgical access and safety. It will help establish health information systems specifically for surgery and surgical diseases that can be further developed and refined over time.

The usefulness of surgical vital statistics may extend beyond these direct consequences. Assessing surgical care on a global basis may improve care simply through the power of measurement and reporting. Better awareness of the accessibility and outcomes of surgical care may cause subtle but tangible improvements in care delivery, thus creating a positive incentive to improve surgical results.

Negative incentives: Data collection can also have a perverse effect on health care, giving a negative incentive to caring for the sickest patients. A country's desire to appear to be performing high-quality surgery at an adequate volume may create an unintended incentive to increase the number of inappropriate elective operations, underreport mortality, discharge sick patients early and fail to operate on critically ill patients. It must be clear that surgical statistics are intended to help a country to improve its health system and the delivery and safety of surgical care, given its available resources. They are not intended or designed for comparing the quality of care in different health systems but represent a benchmark for progress in public health.

Case mix and risk adjustment: Any comparison must account for variations in patient conditions and the complexity of procedures. Methods to evaluate the differences between facilities and practitioners, even within a single institution, must take into account the characteristics of the patients, the case mix, urgency and hospital setting. Such complex data collection is beyond the capacity of most countries at present. Furthermore, the public health goal of this WHO initiative is to reduce complications and deaths from surgery, regardless of whether they are due to patient or institutional factors. Therefore, these guidelines outline the data required to provide basic information on surgical capacity, volume and overall outcomes.

Current measures in surgery

Volume: The global volume of surgery is estimated to be 234 million major operations per year (5). This estimate was based on reporting from a minority of countries, as less than 30% of countries have publicly available data on the volume of surgery performed nationally, and the data are infrequently updated. In the absence of standardized reporting, the data are based on various

definitions, making analysis difficult. Procedures such as percutaneous interventions, endoscopy, radiographically guided procedures and wound debridements are often excluded, even when performed under anaesthesia. In addition, administrative data systems may not record multiple operations on a single patient; billing data may miss surgical care provided outside the established payment system; facility surveys typically omit certain types of care facilities (such as private clinics and hospitals); and outpatient surgical procedures are often excluded.

Outcome: Several countries attempt to follow perioperative outcomes. The United Kingdom maintains a system for tracking and reporting all perioperative deaths, which has proved feasible to maintain (10,11). In Canada, Europe and the United States, sophisticated but costly reporting of risk-adjusted complications and mortality has become common in certain specialties, such as cardiac surgery, and in certain health-care sectors, such as the United States Veterans Health System (12–17). In Germany, a strategy for tracking specific index or proxy cases has been used in quality assurance programmes. By collecting data from ‘tracer’ operations—such as inguinal hernia, hip fracture and cholecystectomy—and designing policies on the basis of the findings from these data, the outcome and quality of care have been improved (18–22).

Trauma and cancer registries also provide information on the outcomes of clinical care. Frequently, such databases provide metrics that allow facility-level comparisons of treatment modalities and systems of care. Trauma systems have been compared both nationally and internationally (23–25), and the information gained from such surveillance has led to recommendations for improvements in infrastructure, planning, training and care (26–28). Data from cancer registries such as the United States’ National Cancer Institute’s Surveillance, Epidemiology, and End Results (SEER) database (29) has led to confirmation of the positive association between high volume and better outcomes (30–32). In addition, data from registries have helped refine the timing and extent of surgical resections for a variety of malignancies and guided systems changes (33–37).

Capacity: Current WHO health systems statistics include a range of indicators of health-care capacity. A comprehensive, up-to-date global database on the size of the health-care workforce in countries has been set up (38) on the basis of indicators from many sources covering many areas (profession, training level and industry of employment), but the coding does not distinguish specializations. The metrics give the number of physicians per 1000 population but no sub-strata. Such detailed data do exist in some countries, but the countries most in need of such data are often those in which data gathering systems are weakest. The 2006 World Health Report identified the design of health workforce classification tools that can be effectively integrated into existing reporting instruments as a priority (39).

Surgical surveillance: Surgical vital statistics for systems-level evaluation

Surveillance of surgical systems must include measures of capacity, volume and outcome to enable public health planning and progress. The data must be easy to collect in countries with limited resources, although countries with more

resources may be able to collect more extensive data on surgical care. Interest in expanding data collection is expected to increase once the basic measures of surgery are in place and apparent differences in the outcome of surgical care emerge. Therefore, in addition to defining the basic statistics for all countries, intermediate and advanced surgical vital statistics are described, which, when feasible, could further increase international understanding of the effect of surgical care on public health.

Basic surgical vital statistics: A review of current needs, capabilities and practice was the basis for a set of surgical 'vital statistics'. The goal is that all WHO Member States attempt to collect this information annually and to include it in their annual health reports. It was highly recommended that data from basic surgical surveillance include:

- the number of operating rooms in each country,
- the number of operations performed in operating rooms in each country,
- the numbers of trained surgeons and trained anaesthesia professionals in each country,
- the number of deaths on the day of surgery and
- the number of in-hospital deaths after surgery.

These basic measures are the structural and outcome components of surgical delivery systems. The structural metrics indicate the capacity of a country for delivering care. The number of operating rooms, the number of operations performed in operating rooms and the number of trained surgeons and anaesthesia professionals are measures of the resources available for delivery of surgical care. The day of surgery death rate and overall in-hospital death rate provide broad indicators of surgical outcomes, much as maternal and neonatal mortality rates do for obstetric outcomes.

The number of operating rooms in each country: Delivery of surgical services is an important component of health systems. Knowing the operating room density will help evaluate the availability, access and distribution of surgical services and coverage. An operating room is defined as an enclosed room specifically dedicated to surgical procedures and equipped to deliver monitored anaesthesia, whether or not it is located in a hospital facility. Potential sources of data for this measure include administrative records based on reported data by inpatient and outpatient facilities and censuses of health facilities with possible adjustment for underreporting (e.g. missing private facilities).

Certain procedures, such as incision and drainage of wounds, endoscopy and dilation and curettage, may be performed in procedure rooms that are not suitable for other types of invasive operations. Minor procedure rooms should not be included unless they meet the definition of an operating room.

The number of surgical procedures performed in operating rooms in each country: The number of surgical procedures performed in an operating room is an indication of access to and use of health care, particularly surgical services. A surgical procedure is defined as the incision, excision or manipulation of tissue

that requires regional or general anaesthesia or profound sedation to control pain. Potential sources of data for this measure include hospital records and routine health service statistics with possible adjustment for underreporting (e.g. surgery in the private sector). If data from only a subset of operating rooms (e.g. excluding private facilities) are reported, the number of operating rooms in the sample should be given.

This indicator does not provide information on the reason for performing a procedure and includes operations that might be performed without a clinical indication, in addition to those that are medically necessary. It is therefore not possible to determine whether a surgical procedure is performed according to clinical need. There is no consensus about the volume of surgery that ought to be performed in a given population, as the surgical rate changes according to the disease burden of the population and as indications for procedures change over time. Baseline rates of surgery can, however, help establish whether a health system is meeting the minimum surgical needs of a population.

Many invasive procedures not typically considered to be 'surgery' might be listed as a surgical procedure, such as endoscopy with or without biopsy and percutaneous vascular interventions. As these procedures may be performed in an operating room or an alternative procedure room, their inclusion may confound the data collection. Invasive procedures that meet the definition but are performed in a procedure room not suitable for larger invasive operations should not be considered in the total number of surgical procedures. If, however, they are performed in an operating room, they should be counted. In addition, the requirement that surgical procedures take place in an operating room does not exclude ambulatory operations, which make up a substantial and growing proportion of surgical care in some countries.

The numbers of trained surgeons and trained anaesthesia professionals in each country: The availability and composition of human resources for health are important indicators of the strength of a health system. Furthermore, as the disease burden shifts from infectious to chronic conditions, well-trained practitioners will be increasingly necessary for providing appropriate care. While there is no consensus about the optimal number of surgeons or anaesthetists for a population, specialist coverage and the quality of the provider are important for safe and appropriate provision of surgical care. In general, a 'surgeon' is a physician who treats disease, injury or deformity by operative or manual methods (40). The designation 'trained' refers to those practitioners registered by accepted national standards, each country defining what these standards are. Thus, surgeons are defined as physicians who have achieved certification in one of the surgical specialties as recognized by the accepted standards of the Member State or the national professional organization. Anaesthesia professionals are physicians, nurses and other practitioners who have achieved certification in the provision of anaesthesia as recognized by the accepted standards of the Member State or the national professional organization. Persons who perform surgery or administer anaesthesia but are not trained, including those in training, would not be included in this measure. Data sources for these measurements may include facility surveys, labour force surveys and records from professional and administrative sources.

Number of deaths on the day of surgery: Death on the day of surgery reflects comorbid conditions and physiological derangements in the patient, the quality and complexity of surgical care, the risks of anaesthesia or some combination of these three. These events are the basis for evaluating the performance of the health system and the state of health of the population. This measure is most useful when converted to day-of-surgery death rate, defined as the number of deaths on the day of surgery per 10 000 surgical procedures in a given year or period. Potential sources of data include administrative and hospital records based on health service statistics, with possible adjustment for underreporting (e.g. death on the day of surgery that occurs outside the surveillance system or which is not reported).

Although fairly rare, death on the day of surgery is an important indicator of patient, surgeon, operation and anaesthesia characteristics. There is no consensus about what an acceptable day-of-surgery mortality rate might be, particularly as it often reflects a combination of factors. This metric will provide valuable insight into the patterns of surgical deaths within a health system, from the burden of disease in a population that prompts them to seek surgical care to the skill, judgement and technical capacity of the surgery and anaesthetic providers. It cannot, however, be used to compare one site, facility or country with another without appropriate, valid, time-consuming risk adjustment.

Number of in-hospital deaths after surgery: Complications and death are not uncommon after surgical procedures. The in-hospital death rate after surgery provides insight into the risks associated with surgical intervention. Like the previous measure, this is most useful when converted to a postoperative in-hospital death rate, defined as the number of deaths in the hospital within 30 days of any surgical procedure per 10 000 surgical procedures performed in a given year or period. Potential sources of data include administrative and hospital records based on health service statistics, with possible adjustment for underreporting (e.g. in-hospital surgical death that occurs outside the surveillance system or which is not reported).

This measure reflects the number of patients who have undergone a surgical procedure and die in a hospital within 30 days of their operation. Patients who undergo surgery and are discharged but die outside a health facility would not be counted as in-hospital surgical deaths. The number does, however, include patients who undergo a procedure at one facility but are transferred and die in another within 30 days of the operation. The postoperative in-hospital death rate varies considerably with the type of procedure being performed, the type of health facility, the health of the population and the distribution of the burden of disease. Thus, comparisons of facilities and countries without risk adjustment are discouraged. The measure should instead be used to guide health service workers to improve performance and the outcomes of surgical patients.

The weaknesses of these death rate measures must be clearly understood. Both are subject to potential misinterpretation, because they do not specify the cause of death. The measures have a potential perverse effect insofar as they may encourage premature discharge of patients to avoid an impending death from occurring in the hospital. These measures are not intended to limit access to care or to subvert the procedure by which patients are evaluated, preoperatively or postoperatively. A surgical mortality rate, as noted above, reflects the patient's condition on arrival for surgery, the extent and complexity of the procedure and

the quality of care. Patients who die because of lack of timely surgical care are not counted either, because of the difficulty of doing so, although this measure would also indicate the quality of care. These are simple metrics that can provide a gauge of the overall outcome of surgical care and a target for progress in public health, but not strict measures of the quality of care.

Collection of the five 'surgical vital statistics' is expected to build a foundation of information about surgical care that will give it the visibility of other important areas of public health. As the strengths and weaknesses of surgical care are ascertained, the information should advance the knowledge of surgical services and provide valuable information for improving safety.

Intermediate-level surgical vital statistics: For countries that can build on the basic statistics, several intermediate-level measures will help further define the capacity, volume and outcome of surgical services. The recommended measures are:

- number of operating rooms by location: hospital or ambulatory, public or private;
- number of trained surgeons by specialty: general surgery, gynaecology and obstetrics, neurosurgery, ophthalmology, otorhinolaryngology, orthopaedics and urology;
- number of other surgical providers: residents, accredited nonsurgeon physicians, medical officers who are not medical doctors;
- number of trained anaesthesia professionals by level of training: physician anaesthesiologists, nurse anaesthetists, anaesthesia officers;
- number of perioperative nurses;
- number of surgical procedures performed in operating rooms for the 10 most prevalent procedures in the country, emergent or elective;
- proportion of deaths on the day of surgery by procedure for the 10 most prevalent procedures in the country; and
- proportion of in-hospital deaths after surgery by procedure for the 10 most prevalent procedures in the country.

The additional structural variables further describe the facilities and workforce associated with surgery. The number of operating rooms can be disaggregated by their location, as hospital-based or ambulatory. The number of surgeons can be disaggregated by surgical specialty, to include general surgery, gynaecology and obstetrics, neurosurgery, ophthalmology, otorhinolaryngology, orthopaedics and urology. In addition, other surgical providers who perform surgery, such as surgical residents and non-physician surgical practitioners, can be recorded. A breakdown of the numbers of physician anaesthesiologists, nurse anaesthetists and anaesthesia officers is particularly important for evaluating the strength of the anaesthesia workforce. Disaggregating the number of perioperative nurses involved in surgical care from the total number of nurses in a country adds substantially to knowledge about the health workforce.

In addition to the total number of operations, the numbers of operations by case and acuteness are important details for understanding surgical needs, the burden of disease and the safety and quality of surgery. The types of surgery

could include general categories, such as operations on the cardiovascular system, digestive system and nervous system. Data on the five or ten most frequent operations performed in a country could also be collected. The number of operations should be disaggregated into emergent or elective cases, if available and consistently defined.

The intermediate outcome measures are the same death statistics specified as basic statistics, that is, deaths on the day of surgery and in-hospital deaths after surgery. The added value would be to collect these measures for the subgroups discussed above: general categories of surgery, most frequent operations, specific surgical cases and emergent or elective surgery. Mortality per capita and per operation could be calculated for these subgroups, which would help identify specific problem areas.

Advanced-level surgical vital statistics: For countries with advanced capability for data collection, risk-adjusted surgical outcome data may be obtained and could include measures not only of mortality but also of morbidity. Comparisons of surgical statistics among countries are complicated by differences in population characteristics. The age structures of populations vary, as do the level and distribution of wealth and income and the incidence and prevalence of diseases. These and other population characteristics affect the outcome of surgery in a country. To assess the quality of surgical care accurately and not just measure overall outcomes, surgical data must be adjusted to take population differences and case-mix differences into account. Risk adjustment requires detailed information that would be difficult for the most resource-limited countries to collect, but, when it is available it can make comparisons of quality measures more meaningful.

Measures of surgical complications also add depth to knowledge of surgical outcomes beyond mortality measures alone. These measures require standard definitions and more extensive data collection. A successful model is the American College of Surgeons' National Surgical Quality Improvement Program (41), which has drawn up detailed definitions of complications, a statistically sound sampling method and a standard procedure of independent nurse surveillance for follow-up and detection of complications.

With these strata, postoperative complications can be linked to an operation, such as wound infection or haemorrhage, or they can be defined as any postoperative morbidity, such as cardiac dysrhythmia or pneumonia. Complications can be measured per capita or per surgical procedure. If data are not available on all surgical procedures, it still may be possible to obtain complication rates for a set of index cases (e.g. appendectomy, cholecystectomy) or for a category of operations (e.g. elective cases). Data on complications, like mortality data, should be risk adjusted whenever possible. At a minimum, adjusting or stratifying the data by age greatly improves comparisons and provides international benchmarks of safety.

Summary of the three-tiered approach to systems level evaluation: This three-tiered approach to measuring the quality of surgical care involves establishing basic surgical vital statistics, which should be feasible for countries around the globe. It also makes use of any additional data available or that can be obtained by countries with moderate resources. Even the basic measures illustrate the

impact of surgical care on death, disability and resources, which is a vital matter for public health planning now that the global volume of surgical procedures exceeds that of childbirth (5).

Surgical surveillance: Basic patient measures at hospital and practitioner levels

While national data such as vital statistics allow countries to track progress and identify problems from year to year, quality improvement in hospitals requires more regular local feedback for clinicians on outcomes of care (42). Thus, these guidelines define a set of basic surgical measures for use by hospitals and practitioners in any setting worldwide.

Day-of-surgery and postoperative in-hospital mortality rates: Information on the volume of operations, day-of-surgery mortality rates and postoperative in-hospital mortality rates will all help institutions to measure the success or failure of care. These data give facilities and practitioners an indication of their surgical activity and of how their patients fare overall, providing a target for improvements in care. These measures are not useful for comparing institutions, as case mixes can differ widely. For example, a hospital that accepts trauma patients or a high volume of urgent cases will have a rate of mortality on the day of surgery that is substantially different from that of a hospital in which primarily elective operations are performed. Measurement of the performance of a single institution over time, however, can allow identification of areas for improvement and tracing of progress as systematic changes are made to care.

Surgical site infections: A substantial proportion of major surgical complications consist of surgical site infections. Infections after surgical interventions have also been identified as a potential indicator of the quality of surgical care (43,44 and personal communication from D.A. Campbell, Department of Surgery, University of Michigan, 2008). Such infections are monitored in various settings as a means of assessing the consequences of care. While a number of methods are available, the most important principles for effective surveillance are use of standardized, consistent definitions of infection based on objective criteria and the maintenance of accurate data collection following established post-discharge follow-up strategies (45). These definitions are described under Objective 6.

Surveillance of surgical site infections is an important component of a hospital's infection control programme and has been used more broadly to improve the rate of infection after a surgical intervention. In the United Kingdom, mandatory surveillance of surgical site infections after orthopaedic surgery was instituted in 2004 with the support of the Surgical Site Infection Surveillance Service (46). This programme has led to system-wide evaluations of surgical site infection rates associated with various procedures and subsequent identification of facilities with high and low infection rates (47). Surveillance programmes at a number of facilities elsewhere in Europe prompted changes, which led to declining rates of surgical site infection (48,49). Studies are now being conducted to evaluate infection rates associated with specific procedures in different countries in order to further reduce infectious complications (50). Recent findings suggest that surgical site infection is a strong predictor of other postoperative complications (personal communication from DA Campbell, Department of Surgery, University of Michigan, 2008). The frequency of such

infections can readily be reduced by improving care (see Objective 6). Institutional surveillance of surgical site infection is essential for improving surgical quality and safety.

The Surgical Apgar Score: a simple outcome score for surgery

Because infection rates and the surgical mortality vital statistics are crude and apply to events that are relatively infrequent, it is difficult for individual practitioners to use them alone to set targets for improvements in outcome. In traditional morbidity and mortality conferences, at which patient complications are discussed among care providers, attempts are made to identify both outcome measures in order to audit surgical performance and results. These conferences, however, focus only on self-reported complications and overlook patterns of harm (51).

A simple measure of surgical patient outcome that can give practitioners immediate feedback about the condition of a patient after surgery is the ‘Surgical Apgar Score’. This is a 10-point system based on three intraoperation parameters: estimated intraoperative blood loss, the lowest heart rate and the lowest mean arterial pressure (52). Like the obstetric Apgar score to rate the condition of a newborn, the Surgical Apgar Score provides a readily available ‘snapshot’ of how an operation went by rating the condition of a patient after surgery from 0, indicating heavy blood loss, hypotension and an elevated heart rate or asystole, to 10, indicating minimal blood loss, normal blood pressure and a physiologically low-to-normal heart rate. Table II.10.1 demonstrates calculation of the score from information recorded routinely by anaesthetists. A prerequisite for obtaining an accurate score is monitoring and recording of reasonably accurate intraoperative physiological data—a basic accepted standard of anaesthesia care and record-keeping.

The Surgical Apgar Score was derived by analysing the outcomes of patients at a large academic medical centre in the United States who were included in the American College of Surgeons’ National Surgical Quality Improvement Program (52). The three intraoperative variables used to calculate the Surgical Apgar Score were chosen from an initial pool of more than 60 factors collected from the programme’s database, patients’ medical charts and intraoperative anaesthetic records, as they were found to be independently predictive of the likelihood of major complications and death within 30 days of surgery. Patients with low scores (< 5) were 16 times more likely to suffer a complication than those with the highest scores (9 or 10). This pattern was validated in a cohort of over 4000 patients in the National Surgical Quality Improvement Program at a different institution (55). Table II.10.2 shows the relative risks for complications of surgical patients at a large academic medical centre in the United States, on the basis of their scores. Patients with a score < 5 had a three times greater risk for a postoperative complication, while patients with scores of 9 or 10 had only one third the risk of patients who had a score of 7. Even after careful adjustment for fixed preoperative risk factors due to patients’ comorbid conditions and procedure-related complexity, the Surgical Apgar Score conveys additional prognostic information about the likelihood of complications, allowing surgeons to discern objectively whether and by how much their operation increased or decreased a patient’s predicted risk for major complications (56).

Table II.10.1 – Calculation of the ‘Surgical Apgar Score’ from intraoperative measurements of estimated blood loss, lowest heart rate, and lowest mean arterial pressure. The score is the sum of the points from each category.

	0 points	1 point	2 points	3 points	4 points
Estimated blood loss (mL) ^a	>1000	601-1000	101-600	≤100	
Lowest mean arterial pressure (mm Hg) ^{b,c}	<40	40-54	55-69	≥70	
Lowest heart rate (beats per min) ^{b,d}	>85*	76-85	66-75	56-65	≤55*

*Occurrence of pathologic bradyarrhythmia, including sinus arrest, atrioventricular block or dissociation, junctional or ventricular escape rhythms, and asystole also receive 0 pts for lowest heart rate

^a The estimated blood loss used in the calculation should be the number entered in the official operation record. This is usually computed by the anaesthetist and confirmed by the surgeon. While this method may seem imprecise, estimates of blood loss have been shown to be accurate within orders of magnitude (53,54).

^b The heart rate and blood pressure should be obtained from the anaesthesia record, as values recorded from the time of incision to the time of wound closure.

^c Mean arterial pressure should be used to calculate the blood pressure score. When the systolic and diastolic blood pressures are recorded without mean arterial pressure, the lowest mean arterial pressure must be calculated by selecting the lowest diastolic pressure and using the formula: mean arterial pressure = diastolic pressure + (systolic pressure–diastolic pressure)/3.

^d In cases in which asystole or complete heart block occurs, the score for heart rate should be 0.

Examples of calculations of a Surgical Apgar Score:

- 1) A patient has an estimated blood loss of 50 ml, a minimum heart rate of 56 and a lowest mean arterial pressure of 67 mm Hg. He or she would therefore receive 3, 3 and 2 points, respectively, for a score of 8.
- 2) A patient has an estimated blood loss of 1500ml (0 points), a minimum heart rate of 75 (2 points) and a lowest mean arterial pressure of 43 mm Hg (1 point) and would thus receive a score of 3.

Table II.10.2 – Relative risks for major complications or death based on the Surgical Apgar Score, with a score of 7 as the reference value (at a United States academic medical center)

Surgical Apgar Score	Total no. of patients	No. with complications	Complication rate	Relative risk for complications (95% CI)	p value
0–4	128	72	0.563	3.4 (2.7–4.2)	< 0.0001
5	233	93	0.399	2.4 (1.9–3.0)	< 0.0001
6	487	108	0.222	1.3 (1.1–1.7)	0.017
7	730	122	0.167	Reference	Reference
8	1100	114	0.104	0.6 (0.5–0.8)	< 0.0001
9	1091	55	0.010	0.3 (0.2–0.4)	< 0.0001
10	350	17	0.049	0.3 (0.2–0.5)	< 0.0001
Total	4119	581	0.141		

Adapted from reference (55)

Findings from international pilot sites: The Surgical Apgar Score was designed for international use as a measure of outcome for surgical patients. It has been validated in published findings for more than 5000 patients undergoing general and vascular surgical procedures at two large academic medical centres in the United States. Preliminary data showed that it also had predictive value in urological and orthopaedic patients in these institutions (57 and personal communication from T. Wuerz, Department of Orthopedic Surgery, Massachusetts General Hospital, Boston, 2008). Its value was further confirmed in eight hospitals in Canada, India, Jordan, New Zealand, the Philippines, the United Kingdom, the United Republic of Tanzania and the United States, participating as international pilot sites in the WHO Safe Surgery Saves Lives programme. These hospitals are a heterogeneous group of institutions, ranging from high- to low-income settings. Data collected at baseline included the Surgical Apgar Score, inpatient complications and inpatient deaths up to 30 days after surgery in 3435 consecutive adults undergoing non-cardiac surgical procedures, including general and trauma surgery, orthopaedic surgery, urological surgery and obstetric and gynaecological surgery. One or more in-hospital complications occurred in 366 (10.7%) patients during postoperative follow-up. Table II.10.3 shows the distribution of these patients by Surgical Apgar Score: patients with a score of 10 had a complication rate of 3.9%, while 36.2% of those with a score less than 5 had at least one complication.

Table II.10.3 – Relative risks for major complication or death based on the Surgical Apgar Score, with a score of 7 as the reference value (at eight international pilot sites, World Health Organization Safe Surgery Saves Lives project data)

Surgical Apgar Score	Total no. of patients	No. with complications	Adjusted complication rate*	Relative risk for complications (95% CI)	p value
0–4	141	51	0.362	2.8 (1.8–4.2)	< 0.0001
5	348	56	0.171	1.3 (0.8–2.1)	0.088
6	672	87	0.137	1.1 (0.7–1.6)	0.754
7	720	89	0.131	Reference	Reference
8	809	50	0.067	0.5 (0.3–0.7)	< 0.0001
9	593	27	0.051	0.4 (0.2–0.6)	< 0.0001
10	152	6	0.039	0.3 (0.1–0.9)	0.004
Total	3435	366	0.107		

* Adjusted to account for clustering at individual sites ($p < 0.0001$)

These findings, from diverse institutions around the world, provide confirmation that the Surgical Apgar Score is both feasible to determine and useful as a measure of surgical outcome, regardless of setting or circumstance. While the score is not a substitute for other measures of outcome, it is a meaningful, objective, immediate measure that can give a valid indication of how a patient has fared in surgery.

Each component of the score captures elements of the patient's overall condition, the extent of the surgical insult and the ability of the team to respond

to and control haemodynamic changes during the procedure. Alterations in the heart rate and blood pressure often represent both the physiological status of the patient and the adequacy of anaesthetic management. Blood loss is an indicator of the complexity of an operation and the performance of the surgeon. These components result in a Surgical Apgar Score that gives feedback to clinicians on the relative success of their operation and the relative risks for complications or death.

This measure has several important potential uses. Like the Apgar score in obstetrics, the Surgical Apgar Score can give practitioners a target for care, inciting them to ensure that patients have as high a score as possible. It also identifies groups at high risk for complications, indicating the need for more monitoring, vigilance and readiness to intervene. It can also identify 'near-miss' cases, whether or not complications actually occur. For administrators, it offers a target for quality improvement, either to decrease the proportion of patients with low scores or to increase the proportion with high scores. While the score does not allow comparisons of quality between institutions because of the influence of case-mix and variations in the condition of the patient on presentation, it can be used in any setting, as it is derived only from routinely available intraoperative data.

Future directions of surgical surveillance

The surgical statistics proposed here have not been collected in a standardized or systematic fashion. They are the first step towards collecting surgical information in a manner consistent with public health. It is not envisioned that these indicators remain static: they should be used to guide policy and direct the future of surgical data collection. Although these indicators may be limited, the information they provide will add considerable knowledge about the indicators themselves and about the public health benefits of surgery.

Recommendations

Highly recommended:

- For surgical surveillance at national level, the following data should be collected systematically by Member States:
 - number of operating rooms,
 - number of surgical procedures performed in an operating room,
 - number of trained surgeons and number of trained anaesthesia professionals,
 - day-of-surgery mortality rate and
 - postoperative in-hospital mortality rate.
- For surgical surveillance at hospital and practitioner level, the following data should be collected systematically by facilities and clinicians:
 - day-of-surgery mortality rate,
 - postoperative in-hospital mortality rate,

surgical site infection rate and
Surgical Apgar Score.

Recommended:

- As a more detailed measure of surgical surveillance in Member States with more advanced data capability, the following data should be collected systematically:

number of operating rooms by location: hospital or ambulatory, public or private;

number of trained surgeons by specialty: general surgery, gynaecology and obstetrics, neurosurgery, ophthalmology, otorhinolaryngology, orthopaedics and urology;

number of other surgical providers: residents, unaccredited physicians, medical officers;

number of trained anaesthetists by level of training: physician anaesthesiologists, nurse anaesthetists, anaesthesia officers;

number of perioperative nurses;

number of surgical procedures performed in operating rooms for the most frequent 10 procedures in the country, emergent or elective;

proportion of deaths on the day of surgery by procedure for the most frequent 10 procedures in the country; and

proportion of in-hospital deaths after surgery by procedure for the most frequent 10 procedures in the country.

Suggested:

- In Member States with the resources and capability to conduct risk-adjusted evaluations, countries should adjust outcome data for case mix and extend outcome measures to include morbidity by defining complications and conducting independent clinical surveillance for follow-up and detection of complications.

References

1. World Health Organization. *Millennium development goals*. Geneva, 2000.
2. World Health Organization. *Make every mother and child count: The World Health Report 2005*. Geneva, 2005.
3. Ronsmans C, et al. Maternal mortality: who, where, and why. *Lancet*, 2006, 368:1189–200.
4. World Health Organization. *World health statistics 2007*. Geneva, 2007. www.who.org/statistics (accessed 20 October 2006).
5. Weiser T, et al. An estimation of the global volume of surgery. *Lancet* (accepted for publication).

6. Donabedian A. Evaluating the quality of medical care. *Milbank Memorial Fund Quarterly*, 1966, 44:166–203.
7. Donabedian A. *Explorations in quality assessment and monitoring*. Vol I. *The definition of quality and approaches to its assessment*, 1980; Vol II. *The criteria and standards of quality*, 1982; Vol III. *The methods and findings of quality assessment and monitoring: an illustrated analysis*. Ann Arbor, Michigan, Health Administration Press, 1985.
8. Makary MA, et al. Patient safety in surgery. *Annals of Surgery*, 2006, 243:628–32.
9. Health Metrics Network. *Framework and standards for the development of country health information systems*. Geneva, World Health Organization, 2006.
10. Lunn JN. The history and achievements of the National Confidential Enquiry into Perioperative Deaths. *Journal of Quality in Clinical Practice*, 1998, 18:29–35.
11. Gray A. United Kingdom national confidential enquiry into perioperative deaths. *Minerva Anestesiologica*, 2000;66:288–92.
12. Hannan EL, et al. Improving the outcomes of coronary artery bypass surgery in New York State. *Journal of the American Medical Association*, 1994;271:761–6.
13. Wyse RK, Taylor KM. Using the STS and multinational cardiac surgical databases to establish risk-adjusted benchmarks for clinical outcomes. *Heart Surgery Forum*, 2002;5:258–64.
14. Tu JV, Wu K. The improving outcomes of coronary artery bypass graft surgery in Ontario, 1981 to 1995. *Canadian Medical Association Journal*, 1998;159:221–7.
15. Khuri SF. Safety, quality, and the National Surgical Quality Improvement Program. *American Surgeon*, 2006;72:994–8.
16. Khuri SF, et al. The National Veterans Administration Surgical Risk Study: risk adjustment for the comparative assessment of the quality of surgical care. *Journal of the American College of Surgeons*, 1995;180:519–31.
17. Khuri SF, et al. Risk adjustment of the postoperative mortality rate for the comparative assessment of the quality of surgical care: results of the National Veterans Affairs Surgical Risk Study. *Journal of the American College of Surgeons*, 1997;185:315–27.
18. Horntrich J. [Surgical quality assurance in the former Cottbus district]. *Zentralblatt für Chirurgie*, 2000;125(Suppl 2):112–3.
19. Hupe K, Wenning M. [Value of current quality assurance for surgery]. *Zentralblatt für Chirurgie*, 2000;125(Suppl 2):146–8.
20. Laas HD, Scheibe O. [Baden-Württemberg quality assurance in surgery]. *Swiss Surgery*, 1995;1:35–9.
21. Schmidt C, et al. [Quality management in surgery—an overview of methods and possibilities]. *Chirurg; Zeitschrift für alle Gebiete der operativen Medizin*, 2003;74:501–9.
22. Troidl H. [Quality control in surgery of inguinal hernias]. *Chirurg; Zeitschrift für alle Gebiete der operativen Medizin*, 1997, 68:1225–34.
23. Celso B, et al. A systematic review and meta-analysis comparing outcome of severely injured patients treated in trauma centers following the establishment of trauma systems. *Journal of Trauma*, 2006;60:371–8.
24. Jurkovich GJ, Mock C. Systematic review of trauma system effectiveness based on registry comparisons. *Journal of Trauma*, 1999 Sep;47(3 Suppl):S46–55.
25. Mock C, et al. Overview of the Essential Trauma Care Project. *World Journal of Surgery*, 2006;30:919–29.

26. Mock C. Improving prehospital trauma care in rural areas of low-income countries. *Journal of Trauma*, 2003;54:1197–8.
27. Mock CN, et al. The development of continuing education for trauma care in an African nation. *Injury*, 2005;36:725–32.
28. Mock C, et al. Strengthening the prevention and care of injuries worldwide. *Lancet*, 2004;363:2172–9.
29. National Cancer Institute. *Surveillance, Epidemiology, and End Results (SEER) database*. <http://seer.cancer.gov> (accessed 5 May 2008).
30. Begg CB, et al. Impact of hospital volume on operative mortality for major cancer surgery. *Journal of the American Medical Association*, 1998;280:1747–51.
31. Schrag D, et al. Influence of hospital procedure volume on outcomes following surgery for colon cancer. *Journal of the American Medical Association*, 2000;284:3028–35.
32. Bach PB, et al. The influence of hospital volume on survival after resection for lung cancer. *New England Journal of Medicine*, 2001;345:181–8.
33. Hershman D, et al. Timing of adjuvant chemotherapy initiation after surgery for stage III colon cancer. *Cancer*, 2006;107:2581–8.
34. Govindarajan A, et al. Population-based assessment of the surgical management of locally advanced colorectal cancer. *Journal of the National Cancer Institute*, 2006;98:1474–81.
35. Baxter NN, et al. Lymph node evaluation in colorectal cancer patients: a population-based study. *Journal of the National Cancer Institute*, 2005;97:219–25.
36. Cummings LC, Payes JD, Cooper GS. Survival after hepatic resection in metastatic colorectal cancer: a population-based study. *Cancer*, 2007;109:718–26.
37. Malthaner R, Fenlon D. Preoperative chemotherapy for resectable thoracic esophageal cancer. *Cochrane Database of Systematic Reviews (Online)*, 2003:CD001556.
38. Dal Poz MR, et al. *Counting health workers: definitions, data, methods and global results*. Geneva, World Health Organization, 2006.
39. World Health Organization. *Working together for health: The World Health Report 2006*. Geneva, 2006.
40. *Webster's New World Medical Dictionary*, 3rd Ed. New York, Wiley, 2008.
41. American College of Surgeons. *National Surgical Quality Improvement Program (NSQIP)*, 2008 www.acsnsqip.org/ (accessed 15 May 2008).
42. Berwick DM. The science of improvement. *Journal of the American Medical Association*, 2008;299:1182–4.
43. McLaws ML, Murphy C, Keogh G. The validity of surgical wound infection as a clinical indicator in Australia. *Australian and New Zealand Journal of Surgery*, 1997;67:675–8.
44. Burke JP. Infection control—a problem for patient safety. *New England Journal of Medicine*, 2003;348:651–6.
45. Smyth ET, Emmerson AM. Surgical site infection surveillance. *Journal of Hospital Infection*, 2000;45:173–84.
46. Health Protection Agency. *Surgical Site Infection Surveillance Service (SSISS)*. <http://www.hpa.org.uk/webw/HPAweb&Page&HPAwebAutoListName/Page/1191942150156?p=1191942150156> (accessed 13 May 2008).

47. Wilson J, et al. Rates of surgical site infection after hip replacement as a hospital performance indicator: analysis of data from the English mandatory surveillance system. *Infection Control and Hospital Epidemiology*, 2008;29:219–26.
48. Geubbels EL, et al. Promoting quality through surveillance of surgical site infections: five prevention success stories. *American Journal of Infection Control*, 2004;32:424–30.
49. Rioux C, Grandbastien B, Astagneau P. Impact of a six-year control programme on surgical site infections in France: results of the INCISO surveillance. *Journal of Hospital Infection*, 2007;66:217–23.
50. Wilson J, Ramboer I, Suetens C. Hospitals in Europe Link for Infection Control through Surveillance (HELICS). Inter-country comparison of rates of surgical site infection--opportunities and limitations. *Journal of Hospital Infection*, 2007;65(Suppl 2):165–70.
51. Hutter MM, et al. Identification of surgical complications and deaths: an assessment of the traditional surgical morbidity and mortality conference compared with the American College of Surgeons National Surgical Quality Improvement Program. *Journal of the American College of Surgeons*, 2006;203:618–24.
52. Gawande AA, et al. An Apgar score for surgery. *Journal of the American College of Surgeons*, 2007;204:201–8.
53. Delilkan AE. Comparison of subjective estimates by surgeons and anaesthetists of operative blood loss. *British Medical Journal*, 1972;ii:619–21.
54. Gardiner AJ, Dudley HA. The measurement of blood loss at operation. *British Journal of Anaesthesia*, 1962;34:653–6.
55. Regenbogen SE, et al. Utility of the surgical Apgar score: validation in 4,119 patients. *Archives of Surgery*, 2008 (accepted for publication).
56. Regenbogen SE, et al. Does the surgical Apgar score measure intraoperative performance? *Annals of Surgery*, 2008 (accepted for publication).
57. Prasad SM, et al. Surgical Apgar: perioperative risk assessment for radical cystectomy. Abstract presented at *American Urologic Association Annual Meeting, Orlando, Florida, 2008*. <http://www.abstracts2view.com/aua/authorindex.php> (accessed 15 May 2008).