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.

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.

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.
The participating as pilot sites for the Safe Surgery Saves Lives program were Washington Medical Center, Seattle, WA, USA; St Mary’s Hospital, London, UK; and the University of St Francis Designated District Hospital, Ifakara, Tanzania; Philippine General Hospital, Manila, Philippines; King Hussein Cancer Centre, Jordan; Auckland City Hospital, Auckland, New Zealand; and Prince Hamzah Hospital, Amman, Jordan.

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

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. *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. †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. ‡Mortality ratio calculated from the exact binomial distribution.

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

<table>
<thead>
<tr>
<th>Hospital</th>
<th>Annual cases per operating room</th>
<th>Annual cases per surgeon</th>
<th>Anaesthesia professionals per operating room</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toronto General Hospital, Toronto, Canada</td>
<td>543</td>
<td>188</td>
<td>17</td>
</tr>
<tr>
<td>St Stephen's Hospital, Delhi, India</td>
<td>1292</td>
<td>461</td>
<td>05</td>
</tr>
<tr>
<td>Prince Hamzah Hospital, Amman, Jordan</td>
<td>473</td>
<td>166</td>
<td>31</td>
</tr>
<tr>
<td>Auckland City Hospital, Auckland, New Zealand</td>
<td>828</td>
<td>150</td>
<td>30</td>
</tr>
<tr>
<td>Philippine General Hospital, Manila, Philippines</td>
<td>309</td>
<td>195</td>
<td>10</td>
</tr>
<tr>
<td>St Francis Designated District Hospital, Ifakara, Tanzania</td>
<td>605</td>
<td>363</td>
<td>13</td>
</tr>
<tr>
<td>St Mary's Hospital, London, UK</td>
<td>949</td>
<td>316</td>
<td>25</td>
</tr>
<tr>
<td>University of Washington Medical Center, Seattle, WA, USA</td>
<td>596</td>
<td>69</td>
<td>50</td>
</tr>
</tbody>
</table>

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

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

<table>
<thead>
<tr>
<th>Facility</th>
<th>Day-of-surgery mortality ratio (95% CI)*</th>
<th>Postoperative in-hospital mortality ratio (95% CI)†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Facility A</td>
<td>0% (0–0·20)</td>
<td>0·28% (0·09–0·64)</td>
</tr>
<tr>
<td>Facility B</td>
<td>0·13% (0·06–0·26)</td>
<td>0·36% (0·22–0·54)</td>
</tr>
<tr>
<td>Facility C</td>
<td>0·01% (0·00–0·04)</td>
<td>0·39% (0·30–0·48)</td>
</tr>
<tr>
<td>Facility D</td>
<td>0·08% (0·04–0·14)</td>
<td>0·62% (0·50–0·76)</td>
</tr>
<tr>
<td>Facility E</td>
<td>0·07% (0·04–0·11)</td>
<td>0·64% (0·55–0·74)</td>
</tr>
<tr>
<td>Facility F</td>
<td>0·06% (0·02–0·11)</td>
<td>0·92% (0·77–1·09)</td>
</tr>
<tr>
<td>Facility G</td>
<td>0·14% (0·07–0·23)</td>
<td>1·29% (1·08–1·53)</td>
</tr>
<tr>
<td>Facility H</td>
<td>0·27% (0·18–0·37)</td>
<td>1·45% (1·25–1·68)</td>
</tr>
</tbody>
</table>

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. †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. ‡Mortality ratio calculated from the exact binomial distribution.

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

**Policy implications**

Advances in maternal health have relied on a knowledge built around birth rates and crude maternal and neonatal mortality. 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. 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. 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.

Safe Surgery Saves Lives Measurement Group
Iraq Ali Sindi (Senior Advisor to the Prime Minister, Erbil, Iraqi Kurdistan). Philippines Teodoro Herbosa (Department of Surgery, College of Medicine-Philippine General Hospital, University of the Philippines, Manila). Switzerland Julie Storr (WHO, Patient Safety Programme, Geneva). USA Clifford Y Ko (Department of Surgery, University of California Los Angeles, Los Angeles, CA); Lola Jean Kozak (Centers for Disease Control and Prevention, National Center for Health Statistics, Hyattsville, MD); Martin A Makary (Department of Surgery, Johns Hopkins University, Baltimore, MD); Thomas G Weiser (Department of Health Policy and Management, Harvard School of Public Health, Boston, MA).

Safe Surgery Saves Lives Study Group
Australia Bruce Barracough (New South Wales Clinical Excellence Commission). Canada Richard K Reznick, Bryce Taylor (Department of Surgery, University of Toronto, Toronto). India Sudhir Joseph (Department of Surgery, St Stephen’s Hospital, Delhi). Jordan Abdel-Hadi S Breizat (Prince Hamzah Hospital, Ministry of Health, Amman). New Zealand Alan P Merry (Department of Anaesthesiology, University of Auckland, Auckland). Philippines Teodoro Herbosa (Department of Surgery, College of Medicine-Philippine General Hospital, University of the Philippines, Manila); Marie Carmela M Lapitan (National Institute of Health–University of the Philippines, Manila). Switzerland Liam Donaldson, Gerald Drezek, Pauline Philip (WHO, Patient Safety Programme, Geneva). Tanzania Pascience I Kibatala (Department of Surgery, St Francis Designated District Hospital, Ifakara). Turkey Iskender Sayek (Department of Surgery, Haceteteor University, Ankara). UK Lord Ara Darzi (Department of Surgery, Imperial College Healthcare; House of Lords, London); Liam Donaldson (National Health Service, London); Krishna Mohrty (Department of Surgery, Imperial College Healthcare, London). USA William R Berry, Atul A Gawande, Alex B Haynes, Thomas G Weiser (Department of Health Policy and Management, Harvard School of Public Health, Boston, MA); F Patchen Dellinger (Department of Surgery, University of Washington, Seattle, WA); Martin A Makary (Department of Surgery, Johns Hopkins University, Baltimore, MD).

Conflicts of interest
We declare that we have no conflicts of interest.

Acknowledgments
This work was supported by WHO, which also provided funding for AAG as lead of the Safe Surgery Saves Lives Initiative. WHO had no role in the decision to submit this work for publication. We would like to thank the following people for help in supplying data: Vanessa Beavis, Kylie Edwards, Ian Civil (Auckland, New Zealand); Amit Vats (London, UK); Chandra Meghrajani (Manila, Philippines); Vickie Kolios-Morris (Seattle, USA); Robert Bell, Joe Slack (Toronto, Canada).

References

© World Health Organization 2009