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Size and distribution of the global volume of surgery in 2012

Thomas G Weiser, Alex B Haynes, George Molina, Stuart R Lipsitz, Micaela M Esquivel, Tarsicio Uribe-Leitz, Rui Fu, Tej Azad, Tiffany E Chao, William R Berry & Atul A Gawande

Objective To estimate global surgical volume in 2012 and compare it with estimates from 2004.

Methods For the 194 Member States of the World Health Organization, we searched PubMed for studies and contacted key informants for reports on surgical volumes between 2005 and 2012. We obtained data on population and total health expenditure per capita for 2012 and categorized Member States as very-low, low, middle and high expenditure. Data on caesarean delivery were obtained from validated statistical reports. For Member States without recorded surgical data, we estimated volumes by multiple imputation using data on total health expenditure. We estimated caesarean deliveries as a proportion of all surgery.

Findings We identified 66 Member States reporting surgical data. We estimated that 312.9 million operations (95% confidence interval, CI: 266.2–359.5) took place in 2012, an increase from the 2004 estimate of 226.4 million operations. Only 6.3% (95% CI: 1.7–22.9) and 23.1% (95% CI: 14.8–36.7) of operations took place in very-low- and low-expenditure Member States representing 36.8% (2573 million people) and 34.2% (2393 million people) of the global population of 7001 million people, respectively. Caesarean deliveries comprised 29.6% (5.8/19.6 million operations; 95% CI: 9.7–91.7) of the total surgical volume in very-low-expenditure Member States, but only 2.7% (5.1/187.0 million operations; 95% CI: 2.2–3.4) in high-expenditure Member States.

Conclusion Surgical volume is large and growing, with caesarean delivery comprising nearly a third of operations in most resource-poor settings. Nonetheless, there remains disparity in the provision of surgical services globally.

Introduction

Surgical care is essential for managing diverse health conditions – such as injuries, obstructed labour, malignancy, infections and cardiovascular disease – and an indispensable component of a functioning health system. International organizations, including the World Health Organization (WHO) and the World Bank, have highlighted surgery as an important component for global health development. However, surgical care requires coordination of skilled human resources, specialized supplies and infrastructure.

As low- and middle-income countries expand their economies and basic public health improves, noncommunicable diseases and injuries comprise a growing proportion of the disease burden. Investments in health-care systems have increased in the last decade, but the effect on surgical capacity is mostly unknown.

Based on modelling of available data, it was estimated that 234.2 million operations were performed worldwide in 2004. The majority of these procedures took place in high-income countries (58.9%; 138.0 million), despite their relative lower share of the global population.

Here, we estimated the global volume of surgery in 2012. We also estimated the proportion of surgery due to caesarean delivery, since studies done in low-income countries have found that emergency obstetric procedures – especially caesarean deliveries – represent a high proportion of the total surgical volume.

Methods

Population and health databases

For the years 2005 to 2012, we obtained population and health data for 194 WHO Member States. These data included total population, life expectancy at birth, percentage of total urban population, gross domestic product (GDP) per capita in United States dollars (US$) and total health expenditure per capita in US$. For 11 Member States, where certain population or health data were not available from either WHO or the World Bank, we used data from other similar sources. All US$ were adjusted for inflation to the year 2012, using the consumer price index for general inflation. For Member States with reported surgical data, we also obtained population and health data from the year for which surgical volume was reported. We classified Member States based on their health spending. Member States spending US$ 0–100 per capita on health were classified as very-low-expenditure Member States (n = 50); US$ 101–400 as low-expenditure Member States (n = 54); US$ 401–1000 as middle-expenditure Member States (n = 46); and over US$ 1000 as high-expenditure Member States (n = 44).

Surgical data sources

Operations were defined as procedures performed in operating theatres that require general or regional anaesthesia or profound sedation to control pain. We searched PubMed for the most recent annual surgical volume reported after 2004, using each Member State name along with the following keywords and phrases for all WHO Member States: “surgery”, “proce-

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dures”, “operations”, “national surgical volume” and “national surgical rate”. Depending on the Member State, we conducted our search in English, French and/or Spanish. To obtain email addresses for ministers or officials working for the ministry of health or national statistical offices. We contacted these persons to request the most recently reported total volume of operations based on the above definition.

From the database of the Organisation for Economic Co-operation and Development (OECD) we obtained surgical volume for 26 countries; 14 of these countries had total surgical volume data as well as detailed data for a subset of procedures (termed a shortlist by OECD), while the other 12 countries only had data for the shortlist. For the 14 countries, we used both data sets in combination with publicly available data on total health expenditure to define the relationship between the shortlist and the reported total surgical volume. We used this relationship to estimate total surgical volume for the 12 countries that only had shortlist and total health expenditure data. The average relative difference between the observed total surgical rate and extrapolated total surgical rate was 13.7% for these 14 countries; in a leave-one-out cross validation, the relative average bias was 16%.

For the Member States from which we obtained surgical data between 2005 and 2013, we calculated the annual surgical volume per 100,000 population for the year that the data were reported for the Member State by using the total population estimate for the same year.

**Statistical analysis**

**Model development**

To develop a predictive model for surgical rates, we first investigated the bivariate Spearman correlations between surgical rate and five a priori country-level variables: total population, life expectancy, percent urbanization, GDP per capita and total health expenditure per capita. We selected total health expenditure per capita as the only explanatory variable based on the results of Spearman correlations. We then did two sensitivity analyses: Spearman partial correlations and a multivariable regression model using the Lasso approach for variable selection. Our final predictive model contained only total health expenditure per capita. Finally, we log-transformed total health expenditure per capita and surgical rate to account for their right-skewed distribution.

**Missing data analysis**

To determine if any of the five a priori country-level predictors was related to the probability that a country’s surgical rate was missing, we fitted a multivariable logistic regression (Table 1). This model allowed us to determine variables associated with surgical rate. These variables could then be included in the imputation model to predict the rates for the Member States with missing data. The only variable significantly associated with whether a country’s surgical rate was missing was total health expenditure per capita, which was already included in the imputation model.

**Imputation model**

To find the best fitting model for the relation between surgical rate and total per capita health expenditure, we built a spline model, positing splines with zero, one, two or three inflection points. The best-fitting spline model was selected based on leave-one-out cross-validation, in which the predicted surgical rate value for a country was estimated based on a model that had been fitted after omitting data for that country. We used total per capita health expenditure from 2012 for our imputation model of surgical rates. The Democratic People’s Republic of Korea, Somalia and Zimbabwe had no available total health expenditure data for 2012. Since the Pearson correlation between health expenditure in 2012 and any single year between 2000 and 2011 for all other Member States was ≥ 0.97, we extrapolated total health expenditure for these Member States by using their expenditure from previous years. As we did not have reported total health expenditure for 2013, we assumed that surgical rates or volume reported for 2013 were equivalent to 2012 values. For the 25 Member States with surgical data reported before 2012, we extrapolated 2012 estimates for these using a multiple imputation model that treated 2012

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**Table 1. Comparison of Member States of the World Health Organization with or without available surgical volume data, 2012**

| Characteristic                      | Member States with surgical data n = 66 | Member States without surgical data n = 128 | P<sup>a</sup> |
|-------------------------------------|----------------------------------------|----------------------------------------------|--------------|
| No. of Member States by region (%)  |                                        |                                              | 0.319       |
| African Region                      | 9 (14)                                 | 37 (29)                                      | –            |
| Region of the Americas              | 11 (17)                                | 24 (19)                                      | –            |
| Eastern Mediterranean Region        | 7 (11)                                 | 15 (12)                                      | –            |
| European Region                     | 30 (45)                                | 23 (18)                                      | –            |
| South-East Asian Region             | 5 (8)                                  | 6 (5)                                        | –            |
| Western Pacific Region              | 4 (6)                                  | 23 (18)                                      | –            |
| Mean population size, in millions (95% CI) | 48.0 (6.4–89.7)  | 29.9 (9.9–49.9)                             | 0.346       |
| Mean life expectancy, years (95% CI)| 73.9 (71.7–76.1)                     | 68.5 (66.9–70.1)                            | 0.128       |
| % of population living in urban areas (95% CI) | 62.9 (57.2–68.5) | 53.3 (49.2–57.3)                            | 0.772       |
| Mean GDP per capita, US$ (95% CI)   | 21,745 (15,882–27,608)                | 10,147 (6,493–13,801)                       | 0.219       |
| Mean total health expenditure per capita, US$ (95% CI) | 1,887 (1,315–2,460) | 616 (408–825)                              | 0.004       |

Cl: confidence interval; GDP: gross domestic product; US$: United States dollars.

<sup>a</sup> P-values are derived from a multivariate logistic regression model.

Note: Inconsistencies arise in some values due to rounding.

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Thomas G Weiser et al.
surgical rate data as missing for these 25 Member States.

For Member States with missing surgical volume data, we used multiple imputation and our predictive model to arrive at 2012 surgical rate estimates.\textsuperscript{21} We produced 300 imputed data sets to estimate the mean global surgical volume and its corresponding 95% confidence interval. Using the imputed country-level surgical rates and population estimates for 2012 we calculated the number of operations performed in each country in 2012. We also used published caesarean delivery data to calculate the proportion of surgical volume accounted for by caesarean delivery for each country.\textsuperscript{22} These data came primarily from the Global Health Observatory data repository,\textsuperscript{23} World Health Statistics 2010,\textsuperscript{24} the World Health Report 2010,\textsuperscript{25} the Demographic and Health Surveys\textsuperscript{26} and OECD.\textsuperscript{27}

To compare the 2004 estimates with the new 2012 estimates, we used the same data on reported surgical rate from 56 countries that we used in the 2004 modelling exercise\textsuperscript{4} and did a spline analysis. We tested spline models with zero, one, two or three inflection points for the 2004 data. The spline model with two inflection points had the highest adjusted cross validation $R^2$, as with the 2012 data. We evaluated the change in surgical rates that occurred for each health expenditure group between 2004 and 2012. This ensured that any observed changes in estimated volume were not driven by the updated modelling approach (details available from corresponding author).

We used SAS software version 9.2 (SAS Institute Inc., Cary, United States of America) for all statistical analyses. Two-sided statistical tests were done and all $P$-values less than 0.05 were considered statistically significant.

**Results**

**Model development**

The total health expenditure per capita was the most highly correlated variable with surgical rate (Spearman correlation, $r = 0.87297$; $P < 0.0001$; Table 2; available at: http://www.who.int/bulletin/volumes/94/3/15-159293). The sensitivity analyses showed that after adjusting for total health expenditure per capita, none of the other variables remained significant. WHO regions were also not significantly associated with surgical rate ($P = 0.09$).

Fig. 1 shows the best fitting spline model for surgical rate based on total health expenditures, with two inflection points at US$ 288 and US$ 1950 per person per year ($r^2 = 0.7449$). The models with zero, one and three inflection points had adjusted cross validation $r^2$ of 0.7064, 0.7071 and 0.7332 respectively.

**Surgical volume**

We obtained surgical data from 66 Member States (Table 3; available at: http://www.who.int/bulletin/volumes/94/3/15-159293). Using multiple imputation, we extrapolated the volume of surgery for each country without reported surgical data (Table 4; available at: http://www.who.int/bulletin/volumes/94/3/15-159293). For the year 2012, we estimated the total global volume to be 312.9 million operations – an increase of 38.2% from an estimated 226.4 million operations in 2004. The estimated mean global surgical rate was 4469 operations per 100,000 people per year (Table 5).

The rate of surgery increased significantly for all Member States spending US$ 400 or less per capita in total health expenditures (Table 5). Across the health expenditure brackets, mean estimated surgical rates in 2012 ranged from 666 to 11 168 operations per 100,000 people. Of the total global volume of surgery, 6.3% (19.6/312.9 million operations) was performed in very-low-expenditure Member States which accounted for 36.8% (2.573/7.001 billion people) of the world’s population in 2012, while 59.8% (187.0/312.9 million operations) of the surgical volume took place in the high-expenditure Member States which account for 17.7% (1.236/7.001 billion people) of the world’s population.

The biggest increase in the rate of surgery occurred in very-low- and low-expenditure Member States (69.0% from 394 to 666 operations per 100 000 population per year and 114.6%, from 1851 to 3973 operations per 100 000 population per year, respectively), while middle- and high-expenditure Member States experienced no significant change.

Caesarean delivery data were more widely available than overall surgical data, with data from 172 Member States. In very-low-expenditure settings, caesarean delivery accounted for 29.6% (5.8/19.6 million operations) of all operations performed. However, in high-expenditure Member States this percentage was only 2.7% (5.1/187.0 million operations; Table 6). Worldwide, caesarean deliveries account for nearly one in every 14 operations performed.

**Discussion**

We estimate 266.2 to 359.5 million operations were performed in 2012.
Table 5. Comparative rate and volume of surgery for Member States of the World Health Organization, by total health expenditure group, 2004 and 2012

| Variable | Very low | Low | Middle | High |
|----------|----------|-----|--------|------|
| 2004     | 2012     | 2004 | 2012   | 2012 |
| No. of Member States | 47 | 50 | 60 | 60 |
| Population, in millions (% of global population) | (2248, 2973) | (2258, 2573) | (2248, 2573) | (2248, 2573) |
| Mean estimated surgical rate, per 100 000 population per year (95% CI) | (273–516) | (465–867) | (2393, 5625) | (2857–5030) |
| Change in surgical rate, % (95% CI) | – | – | (−22.2–22.2) | (−9.9–22.2) |
| Estimated no. of surgeries in millions (95% CI) | (1.8–26.2) | (0.4–51.7) | (5.6–77.3) | (0.4–51.7) |
| % of global volume of surgery (95% CI) | (0.9–21.5) | (0.7–21.9) | (0.5–62.2) | (0.7–21.9) |

| Variable | Very low | Low | Middle | High |
|----------|----------|-----|--------|------|
| 2004     | 2012     | 2004 | 2012   | 2012 |
| No. of Member States | 47 | 50 | 60 | 60 |
| Population, in millions (% of global population) | (2248, 2973) | (2258, 2573) | (2248, 2573) | (2248, 2573) |
| Mean estimated surgical rate, per 100 000 population per year (95% CI) | (273–516) | (465–867) | (2393, 5625) | (2857–5030) |
| Change in surgical rate, % (95% CI) | – | – | (−22.2–22.2) | (−9.9–22.2) |
| Estimated no. of surgeries in millions (95% CI) | (1.8–26.2) | (0.4–51.7) | (5.6–77.3) | (0.4–51.7) |
| % of global volume of surgery (95% CI) | (0.9–21.5) | (0.7–21.9) | (0.5–62.2) | (0.7–21.9) |

Note: Inconsistencies arise in some values due to rounding.

This represents an increase of 38% over the previous eight years. We note the largest increase in operations was in very-low- and low-expenditure Member States. However, about one in every 20 operations globally was done in very-low-expenditure Member States, despite these Member States representing well over one third of the total global population. Comparing very-low-expenditure Member States with high-expenditure Member States, the gap in access is even larger. These disparities may be even larger when examining the distribution of access to surgical care within individual Member States, an undertaking that is beyond the scope of this study.

The proportion of caesarean delivery were higher in Member States with lower surgical volume. This likely demonstrates that obstetrical emergencies are prioritized as a surgical intervention in Member States with scarce resources, but also suggests that other surgical conditions are left poorly attended in these settings. The findings serve to highlight the importance of improving surgical capacity to address both obstetrical and other surgical conditions.

Surgical data were lacking from many Member States. Compared with the data availability for the 2004 estimates, only 10 more Member States now had available data. This contrasted with caesarean delivery data, which were available for the majority of Member States. Given the efforts of the maternal health community and the importance of caesarean delivery in supporting improved maternal outcomes, our findings are not surprising. The challenge of accessing data on surgical care impedes the understanding and monitoring of surgery as a component of global health care. Without standardized and accessible data, it is difficult for researchers and policy-makers to contextualize and prioritize surgical access and quality when discussing health system strengthening.

In 2015, the World Health Assembly passed a resolution strengthening emergency and essential surgical care and anaesthesia as a component of universal health coverage. The increases in injuries and noncommunicable diseases present a challenge for weak health systems already struggling with a high infectious burden of disease. Not only do injuries and many noncommunicable diseases require surgical intervention, in many resource-poor settings neglected infections – such as typhoid and tuber-
Table 6. Volume and proportional contribution of caesarean delivery for Member States of the World Health Organization, by total health expenditure group, 2012

| Caesarean delivery | Member State health expenditure group* | Global |
|--------------------|--------------------------------------|--------|
|                    | Very low | Low | Middle | High |        |
| Estimated no. in millions (95% CI) | 5.8 (5.8–5.9) | 7.8 (7.8–7.9) | 4.1 (4.0–4.3) | 5.1 (5.0–5.1) | 22.9 (22.5–23.2) |
| % of caesarean deliveries (95% CI) | 25.5 (24.9–26.0) | 34.2 (33.7–34.8) | 18.0 (17.1–19.0) | 22.2 (21.9–22.6) | 100 (NA) |
| % of global volume of surgery (95% CI) | 29.6 (9.7–91.7) | 10.8 (8.2–14.4) | 12.1 (6.2–23.5) | 2.7 (2.2–3.4) | 7.3% (6.1–9.0) |

CI: confidence interval; NA: not applicable; US$: United States dollars.

* Total health expenditure adjusted to US$ for the year 2012. Very low-expenditure Member States were defined as per capita total expenditure on health of US$ 100 or less; low-expenditure Member States as US$ 101–400; middle-expenditure Member States as US$ 401–1000; and high-expenditure Member States as more than US$ 1000.

Note: Inconsistencies arise in some values due to rounding.

Global volume of surgery – are not treated in a timely fashion and therefore require surgical care.13

The increase in surgical output in very-low-expenditure Member States over the last eight years suggests that these Member States are placing an increasing importance on access to emergency and essential surgical services. However, the Lancet Commission on Global Surgery has estimated that five billion people lack access to safe, affordable surgical and anaesthesia care when needed and an additional 143 million operations are required to address emergency and essential conditions in low- and middle-income countries.5

The lack of standardized surgical data globally is both a limitation of and the reason for undertaking this study. As part of the WHO Safe Surgery Saves Lives programme for which the 2004 estimates of global surgical volume was performed, our group proposed a standard set of metrics for surgical surveillance.27 We continued to have difficulty during this study obtaining standardized data regarding surgical intervention. The data were not located or reported in any standardized way and required our research team to compile the information from multiple agencies, ministries, health reports and published literature, as there was no central source for collecting or reporting these data. Some ministry reports may include only state and government facilities and not hospitals run privately or by nongovernmental organizations, which can provide substantial surgical capacity. Thus the volume we report may be an underestimate. Regardless, the non-included facilities are unlikely to close the gap in care between Member States or change our findings. In addition, there was no differentiation between surgical care undertaken in urban versus rural areas. There is likely a large discrepancy in surgical access and provision of surgical care within a single country.

OECD, which had previously collected total operative volume as reported in our last study,27 has changed its methods and now reports on only a subset of procedures. Thus our analysis required an additional step to turn these data into comprehensive estimates of volume, adding another layer of uncertainty. Many of the same limitations of the previous analysis were present here. We focused on operations performed in an operating theatre as these are most likely to involve high complexity, acuity and risk. Our study is thus limited by the manner in which such operations and procedures are recorded. We recognize that many minimally invasive procedures can be undertaken outside an operating theatre, as can many image-guided procedures, thus potentially undercounting what might be considered surgery in these settings. Many minor procedures may also be undertaken in the operating room to improve pain control or exposure or because of availability of resources and equipment, thus creating variability within our count. However, by standardizing our definition, we limited the difficulties associated with the variability in case mix and practice patterns across Member States and settings.

As only one third of Member States reported data on surgical volume, our estimates of overall volume of surgery continue to rely on modelling techniques. We noted changes in the slope of the curve of our spline regression over the range of health expenditure, in particular between the two spline inflections, likely reflecting the heterogeneity of Member States. Furthermore, while the imputation strategy was aimed at a global estimate, the estimate for any particular country may be imprecise. However, our modelling strategy was based on the strong explanatory power of per capita expenditure on health as a determinant of surgical volume. Health expenditure per capita was the only variable that was significantly associated with whether surgical rate data was missing, and multiple imputation protects against systemic bias from data that are missing at random.

Conclusion

Surgical volume continues to grow, particularly in very-low- and low-expenditure Member States. However, surgical surveillance continues to be weak and poorly standardized and limits the precision of these estimates, yet the systematic evaluation of access, capacity, delivery and safety of care is paramount if surgical services are to support a programme of health system strengthening. Furthermore, the relationship of surgical provision to population health outcomes is not clear, and interventions such as surgery that include substantial risk to patients must be carefully considered. Many patients receive surgical care, yet safety and quality-of-care remain poorly measured and a low priority in many Member States.
A Global Volume of Surgery

Thomas G. Weiser et al.

Abstract

Aims To assess the annual global volume of surgery and its distribution.

Methods We searched PubMed for data on surgical volumes. We included all articles up to 2016. We also used data from national health authorities and international organizations.

Findings In 2016, there were an estimated 226.4 million surgical procedures worldwide, with a median of 187.0 million procedures in high-resource settings and 34.2 million procedures in low-resource settings. The highest volume of surgical procedures was in Asia, followed by Europe and then the Americas.

Conclusions Global surgical volumes are high and continue to rise. Further research is needed to better understand the drivers of surgical demand and to develop effective strategies to address this challenge.
Резюме

Амплуа и разпределение общемирового объема хирургических операций в 2012 г.

Цель Подсчитать общемировой объем хирургических операций в 2012 г. и сравнить его с результатами оценки, проведенной в 2004 г.

Методы Для получения результатов для 194 государств-членов Всемирной организации здравоохранения осуществлялся поиск база данных PubMed на предмет исследований, а также была запрошена отчеты по объему хирургических операций у ключевых информаторов за период 2005–2012 гг. Были получены данные о численности населения и общих расходах на здравоохранение на душу населения для 2012 г., и государства-члены были разделены на группы: с очень низким уровнем расходов, с низким уровнем расходов, со средним уровнем расходов и с высоким уровнем расходов. Сведения о количестве кесаревых сечений были получены из известных статистических отчетов. Для получения результатов для государств-членов, в которых данные по хирургии не фиксировались, объемы были подсчитаны с помощью нескольких условных значений на основе данных об общих расходах на здравоохранение. Была подсчитана доля кесаревых сечений от всех хирургических операций.

Результаты 66 государств-членов сообщили данные о хирургических операциях. Согласно подсчетам 312,9 млн операций (доверительный интервал 95%, IC 95%: 266,2–359,5) было проведено в 2012 г. Этот показатель превышает результат подсчетов 2004 г., составивший 226,4 млн операций. Лишь 6,3% (IC 95%: 1,7–22,9) и 23,1% (IC 95%: 14,8–36,7) операций было проведено в государствах-членах с очень низким и низким уровнем расходов, что соотносится с 36,8% (2,573 млрд людей) и 34,2% (2,393 млрд людей) соответственно от общемирового населения, составляющего 7,001 млрд людей. Доля кесаревых сечений составила 29,6% (5,8 из 19,6 млн операций; IC 95%: 9,7–91,7) от общего объема хирургических операций в государствах-членах с очень низким уровнем расходов и лишь 2,7% (5,1 из 187,0 млн операций; IC 95%: 2,2–3,4) в государствах-членах с высоким уровнем расходов.

Вывод Объем операций значителен и увеличивается, и доля кесаревых сечений составляет приблизительно треть всех операций в странах, испытывающих острый недостаток ресурсов. Однако при этом в мире сохраняется неравномерное распределение ресурсов, необходимых для хирургических операций.
Las cesáreas abarcaron el 29,6% (5,8/19,6 millones de operaciones; IC del 95%: 9,7–91,7) del total del volumen de intervenciones quirúrgicas en Estados Miembros con un gasto muy bajo, pero únicamente el 2,7% (5,1/187,0 millones de operaciones; IC del 95%: 2,2–3,4) en Estados Miembros con un gasto elevado.

**Conclusión** El volumen de intervenciones quirúrgicas es cada vez mayor, y las cesáreas abarcan casi un tercio de las operaciones en los lugares con menos recursos. No obstante, sigue habiendo una diferencia en el suministro de servicios quirúrgicos a nivel global.
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Table 2. **Bivariate Spearman correlations between surgical rate and five a priori country-level variables and Spearman partial correlations adjusting for total health expenditure**

| Variable                        | Spearman correlation | P      | Spearman partial correlation | P     |
|---------------------------------|----------------------|--------|------------------------------|-------|
| Total health expenditure per capita | 0.87297              | < 0.0001 | NA                           | NA    |
| Life expectancy                 | 0.77536              | < 0.0001 | −0.06327                     | 0.6166|
| GDP                             | 0.81359              | < 0.0001 | −0.24295                     | 0.0512|
| Urban population                | 0.69607              | < 0.0001 | 0.00659                      | 0.9585|
| Population size                 | −0.18869             | 0.1292 | −0.11665                     | 0.3548|

GDP: gross domestic product; NA: not applicable.
Table 3. Surgical rate and volume for 66 Member States of the World Health Organization with observed surgical data, 2005–2012

| Member State (year of reported data) | Population in 2012 | Total health expenditure per capita* | Annual no. of operations | Annual no of operations per 100 000 population* |
|--------------------------------------|-------------------|--------------------------------------|---------------------------|-----------------------------------------------|
| Afghanistan (2008)                   | 29 824 536        | 37                                   | 61 920                    | 229                                           |
| Armenia (2012)                       | 2 969 081         | 150                                  | 123 861                   | 4 172                                         |
| Australia (2012)                     | 22 723 900        | 6 140                                | 2 477 096                 | 10 901                                        |
| Austria (2012)                       | 8 429 991         | 5 407                                | 11 782 84                 | 13 977                                        |
| Bahrain (2012)                       | 1 317 827         | 895                                  | 51 992                    | 3 945                                         |
| Bangladesh (2011)                    | 154 695 368       | 28                                   | 247 178                   | 162                                           |
| Belgium (2012)                       | 11 128 246        | 4 711                                | 1 976 833                 | 17 764                                        |
| Bhutan (2012)                        | 741 822           | 90                                   | 19 954                    | 2 690                                         |
| Bolivia (Plurinational State of) (2010) | 10 496 285     | 112                                  | 228 622                   | 2 251                                         |
| Bulgaria (2005)                      | 7 305 888         | 322                                  | 398 180                   | 5 145                                         |
| Burkina Faso (2012)                  | 16 460 141        | 38                                   | 54 379                    | 330                                           |
| Canada (2012)                        | 34 754 312        | 5 741                                | 2 382 956                 | 6 857                                         |
| Chad (2012)                          | 12 448 175        | 31                                   | 659                       | 53                                            |
| China (2012)                         | 1 350 695 000     | 322                                  | 39 500 000                | 2 924                                         |
| Colombia (2012)                      | 47 704 427        | 530                                  | 5 108 304                 | 10 708                                        |
| Costa Rica (2012)                    | 4 805 295         | 951                                  | 202 519                   | 4 214                                         |
| Cuba (2012)                          | 11 270 957        | 558                                  | 539 528                   | 4 787                                         |
| Cyprus (2011)                        | 1 128 994         | 2 168                                | 29 663                    | 2 657                                         |
| Czech Republic (2012)                | 10 510 785        | 1 432                                | 65 881 11                 | 6 268                                         |
| Denmark (2007)                       | 5 591 572         | 6 321                                | 892 682                   | 16 345                                        |
| El Salvador (2009)                   | 6 297 394         | 244                                  | 172 972                   | 2 797                                         |
| Estonia (2012)                       | 1 325 016         | 1 010                                | 126 883                   | 9 576                                         |
| Ethiopia (2011)                      | 91 728 849        | 14                                   | 38 220                    | 43                                            |
| Finland (2012)                       | 5 413 971         | 4 232                                | 428 000                   | 7 905                                         |
| France (2012)                        | 65 676 758        | 4 690                                | 10 709 393                | 16 306                                        |
| Georgia (2012)                       | 4 490 700         | 333                                  | 189 478                   | 4 219                                         |
| Germany (2012)                       | 80 425 823        | 4 683                                | 9 802 610                 | 12 188                                        |
| Guatemala (2012)                     | 15 082 831        | 226                                  | 231 288                   | 1 533                                         |
| Hungary (2012)                       | 9 920 362         | 987                                  | 319 718                   | 3 223                                         |
| Ireland (2012)                       | 4 586 897         | 3 708                                | 299 335                   | 6 526                                         |
| Israel (2012)                        | 7 910 500         | 2 289                                | 400 808                   | 5 067                                         |
| Italy (2012)                         | 59 539 717        | 3 032                                | 4 118 831                 | 6 918                                         |
| Latvia (2011)                        | 2 354 421         | 843                                  | 119 184                   | 5 791                                         |
| Liberia (2010)                       | 4 190 435         | 45                                   | 11 502                    | 331                                           |
| Lithuania (2011)                     | 2 987 773         | 906                                  | 262 270                   | 8 140                                         |
| Luxembourg (2012)                    | 5 309 466         | 7 452                                | 116 452                   | 21 933                                        |
| Mali (2009)                          | 14 853 572        | 48                                   | 450 260                   | 3 321                                         |
| Malta (2012)                         | 4 194 455         | 1 835                                | 55 501                    | 13 232                                        |
| Mexico (2012)                        | 120 847 477       | 618                                  | 1 613 405                 | 1 335                                         |
| Myanmar (2011)                       | 52 797 319        | 16                                   | 337 726                   | 650                                           |
| Nepal (2011)                         | 27 474 377        | 42                                   | 56 768                    | 209                                           |
| Netherlands (2012)                   | 16 754 962        | 5 737                                | 2 787 778                 | 16 639                                        |
| New Zealand (2012)                   | 4 433 000         | 3 292                                | 280 310                   | 6 323                                         |
| Nicaragua (2010)                     | 5 991 733         | 118                                  | 278 874                   | 4 594                                         |
| Oman (2012)                          | 3 314 001         | 690                                  | 90 804                    | 2 740                                         |
| Peru (2011)                          | 29 987 800        | 289                                  | 894 243                   | 3 020                                         |
| Poland (2012)                        | 38 535 873        | 854                                  | 583 957                   | 1 515                                         |
| Portugal (2011)                      | 10 514 844        | 2 350                                | 890 965                   | 8 439                                         |
| Qatar (2009)                         | 2 050 514         | 1 762                                | 29 572                    | 1 891                                         |
| Republic of Korea (2012)             | 50 004 441        | 1 703                                | 1 709 706                 | 3 419                                         |
| Rwanda (2010)                        | 11 457 801        | 59                                   | 86 041                    | 850                                           |
| Saudi Arabia (2012)                  | 28 287 855        | 795                                  | 1 002 474                 | 3 544                                         |
### Table: Global volume of surgery

| Member State                  | Population in 2012 | Total health expenditure per capita\(^a\) | Annual no. of operations | Annual no of operations per 100 000 population\(^b\) |
|------------------------------|--------------------|------------------------------------------|--------------------------|---------------------------------|
| Sierra Leone (2012)\(^a\)   | 5 978 727          | 96                                       | 24 152                   | 404                             |
| Slovakia (2012)\(^a\)       | 5 407 579          | 1 326                                    | 475 111                  | 8 786                           |
| Slovenia (2012)\(^a\)       | 2 057 159          | 1 942                                    | 116 009                  | 5 639                           |
| Spain (2010)\(^a\)          | 46 761 264         | 3 056                                    | 465 700                  | 10 110                          |
| Sri Lanka (2006)\(^a\)      | 19 858 000         | 89                                       | 579 820                  | 2 920                           |
| Sweden (2012)\(^a\)         | 9 519 374          | 5 319                                    | 4 185 940                | 15 610                          |
| Switzerland (2012)\(^a\)    | 7 996 861          | 8 980                                    | 207 305                  | 25 923                          |
| Syrian Arab Republic (2010)\(^a\) | 22 399 254       | 105                                      | 339 825                  | 1 578                           |
| Turkey (2012)\(^a\)         | 73 997 128         | 665                                      | 1 223 059                | 1 653                           |
| Uganda (2011)\(^a\)         | 36 345 860         | 42                                       | 84 874                   | 241                             |
| United Kingdom (2012)\(^a\) | 63 695 687         | 3 647                                    | 9 732 653                | 15 280                          |
| United States (2007)\(^a\)  | 313 873 685        | 8 895                                    | 36 457 210               | 12 087                          |
| Yemen (2012)\(^a\)          | 23 852 409         | 71                                       | 65 114                   | 273                             |
| Zambia (2010)\(^a\)         | 14 075 099         | 79                                       | 94 145                   | 722                             |

\(^a\) Adjusted to 2012 United States dollars.

\(^b\) Surgical rate is calculated using the total population for the year the surgical data were available.

\(^c\) Surgical data from 2013.

\(^d\) Regional rates extrapolated to entire country.

\(^e\) Data obtained via official communication with Office of the Honourable Monica Ell, Nunavut Department of Health, Nunavut, Canada, 30 July 2014.

\(^f\) Data obtained via official communication with the Saskatchewan Ministry of Health, data obtained from the Surgical Initiative database. Saskatchewan, Canada, 5 August 2014.

\(^g\) Data obtained via official communication with the Office of Minister Doug Graham, Health and Social Services of Yukon, Canada, 15 August 2014.

\(^h\) Data obtained via official communication with Dirección de Epidemiología y Demografía, Ministerio de Salud y Protección Social de Colombia, Colombia, 22 August 2014.

\(^i\) Data obtained from Senior Planning Officer of the Finnish National Institute for Health and Welfare National Institute for Health and Welfare, Finland, 23 July 2014.

\(^j\) Data obtained via official communication with Ministerio de Salud Pública y Asistencia Social, Sistema de Información Gerencial de Salud – SIGSA. Viceministerio de Hospitales, Guatemala, 10 July 2014.

\(^k\) Data obtained from Head of Division of Health Information, Israeli Ministry of Health, Israel, 21 August 2014.

\(^l\) Data obtained via personal communication. Distefano S, National Hospitals Information System, Directorate for Health Information & Research, Malta, 30 July 2014.

\(^m\) Data obtained via personal communication with Rosas Osuna SR, Sistema Nacional de Información en Salud (SINAIS): Secretaría de Salud, Mexico Ministry of Health, Mexico, 12 March 2014.

\(^n\) Data obtained via personal communication with Bowman K, Children's Hospital of Wisconsin, United States of America, 17 April 2014.
### Table 4. Average imputed surgical rates and expected yearly number of operations, based on total health expenditure per capita, for 128 Member States of the World Health Organization with missing surgical volume data, 2012

| Country                        | Population in 2012 | Total health expenditure per capita | Average imputed no. of operations per 100 000 population per year | Expected range of operations in 2012 |
|--------------------------------|-------------------|-----------------------------------|---------------------------------------------------------------|-------------------------------------|
| Albania                        | 2 801 681         | 228                               | 4 991                                                         | 123 393–156 263                     |
| Algeria                        | 38 481 705        | 279                               | 6 663                                                         | 2 253 295–2 875 033                 |
| Andorra                        | 78 360            | 3 057                             | 9 263                                                         | 5 980–8 537                         |
| Angola                          | 20 820 525        | 190                               | 4 812                                                         | 867 905–11 136 052                  |
| Antigua and Barbuda             | 89 009            | 681                               | 5 210                                                         | 3 962–5 319                         |
| Argentina                      | 41 086 927        | 995                               | 5 519                                                         | 1 993 467–2 541 889                 |
| Algeria                        | 9 295 784         | 398                               | 4 225                                                         | 373 612–495 757                     |
| Barbados                        | 37 960            | 1 647                             | 7 067                                                         | 22 715–29 857                       |
| Barbados                        | 283 221           | 938                               | 5 303                                                         | 12 256–16 779                       |
| Belarue                         | 16000             | 33                                | 406                                                           | 35 903–46 076                       |
| Bosnia and Herzegovina          | 3 833 916         | 447                               | 4 859                                                         | 158 739–213 844                     |
| Botswana                        | 2 003 910         | 384                               | 4 764                                                         | 80 047–107 289                      |
| Brazil                          | 198 656 019       | 1 056                             | 6 128                                                         | 10 500 890–13 844 633               |
| Brunei Darussalam               | 412 238           | 939                               | 5 740                                                         | 20 850–26 472                       |
| Burma                           | 984 956           | 20                                | 217                                                           | 18 381–24 422                       |
| Cabo Verde                      | 148 646           | 51                                | 666                                                           | 86 263–111 749                      |
| Cambodia                        | 21 699 631        | 59                                | 816                                                           | 154 105–200 182                     |
| Cameroon                        | 4 525 209         | 18                                | 165                                                           | 6 607–8 307                         |
| Central African Republic        | 17 464 814        | 1 103                             | 5 462                                                         | 843 337–1064 491                    |
| Comoros                         | 717 503           | 38                                | 470                                                           | 2 916–3 826                         |
| Congo                           | 4 337 051         | 100                               | 1 568                                                         | 60 014–76 016                       |
| Cook Islands                    | 10 777            | 511                               | 4 760                                                         | 403–623                             |
| Côte d'Ivoire                   | 198 390 750       | 88                                | 1 481                                                         | 259 012–328 483                     |
| Croatia                         | 4 267 558         | 908                               | 5 798                                                         | 218 765–276 118                     |
| Democratic People's Republic of Korea | 24 763 188 | 76                                | 1 298                                                         | 276 561–366 155                     |
| Democratic Republic of the Congo | 65 705 093     | 15                                | 1 444                                                         | 82 327–106 897                      |
| Djibouti                        | 859 652           | 129                               | 2 576                                                         | 194 458–24 832                      |
| Dominica                        | 71 684            | 392                               | 4 717                                                         | 2 805–3 959                         |
| Dominican Republic              | 10 276 621        | 310                               | 4 153                                                         | 377 226–476 327                     |
| Ecuador                         | 15 492 264        | 361                               | 4 538                                                         | 610 398–795 822                     |
| Egypt                           | 80 721 874        | 152                               | 2 889                                                         | 2 066 134–2 598 531                 |
| Equatorial Guinea               | 736 296           | 1 138                             | 5 834                                                         | 37 487–48 421                       |
| Eritrea                         | 6 130 922         | 15                                | 147                                                           | 7 796–10 238                        |
| Fiji                            | 874 744           | 177                               | 3 487                                                         | 26 874–34 128                       |
| Gabon                           | 1 632 572         | 397                               | 4 471                                                         | 63 539–82 433                       |
| Gambia                          | 1 791 225         | 26                                | 311                                                           | 4 715–6 426                         |
| Ghana                           | 25 366 462        | 83                                | 1 338                                                         | 296 538–382 153                     |
| Greece                          | 11 092 771        | 2 044                             | 5 886                                                         | 570 323–735 563                     |
| Grenada                         | 105 483           | 478                               | 4 769                                                         | 4 391–5 669                         |
| Guinea                          | 11 451 273        | 32                                | 384                                                           | 38 463–49 596                       |
| Guinea-Bissau                   | 1 663 558         | 30                                | 333                                                           | 4 788–6 289                         |
| Guyana                          | 795 369           | 235                               | 5 771                                                         | 39 069–52 737                       |
| Haiti                           | 10 173 775        | 53                                | 776                                                           | 66 467–91 429                       |
| Honduras                        | 7 935 846         | 195                               | 4 198                                                         | 294 312–372 041                     |
| Iceland                         | 320 716           | 3 872                             | 12 163                                                        | 33 989–44 026                       |
| India                           | 1 236 688 732     | 61                                | 904                                                           | 9 801 319–12 556 488                |
| Indonesia                       | 246 864 191       | 108                               | 1 349                                                         | 3 957 879–5 120 005                 |
| Iran (Islamic Republic of)      | 76 424 443        | 490                               | 4 106                                                         | 2 767 543–3 508 289                 |

(continues...)

209D Bull World Health Organ 2016;94:201–209 | doi: http://dx.doi.org/10.2471/BLT.15.159293
| Country                                      | Population in 2012 | Total health expenditure per capita | Average imputed no. of operations per 100 000 population per year | Expected range of operations in 2012 |
|---------------------------------------------|--------------------|-------------------------------------|---------------------------------------------------------------------|--------------------------------------|
| Iraq                                        | 32,578,209         | 226                                 | 5,409                                                               | 1,521,217–2,003,067                  |
| Jamaica                                     | 2,707,805          | 318                                 | 4,337                                                               | 103,013–131,876                      |
| Japan                                       | 127,561,489        | 4,752                               | 14,508                                                              | 16,388,287–20,626,119                |
| Jordan                                      | 63,180,000         | 388                                 | 4,475                                                               | 248,911–316,888                      |
| Kazakhstan                                  | 16,791,425         | 521                                 | 4,972                                                               | 731,544–938,337                      |
| Kenya                                       | 43,178,141         | 45                                  | 619                                                                 | 232,365–301,898                      |
| Kiribati                                    | 100,786            | 187                                 | 3,998                                                               | 3,468–4,591                          |
| Kuwait                                      | 3,250,496          | 1,428                               | 5,971                                                               | 172,105–216,085                      |
| Kyrgyzstan                                  | 5,607,200          | 84                                  | 1,390                                                               | 68,768–87,164                        |
| Lao People’s Democratic Republic            | 66,458,827         | 40                                  | 508                                                                 | 29,864–37,621                        |
| Lebanon                                     | 44,248,888         | 650                                 | 5,425                                                               | 206,805–273,335                      |
| Lesotho                                     | 2,051,545          | 138                                 | 2,777                                                               | 500,047–63,910                       |
| Libya                                       | 6,154,623          | 578                                 | 4,831                                                               | 260,219–334,448                      |
| Madagascar                                  | 22,293,914         | 18                                  | 175                                                                 | 34,593–43,541                        |
| Malawi                                      | 15,906,483         | 25                                  | 297                                                                 | 41,090–53,311                        |
| Malaysia                                    | 29,239,927         | 419                                 | 4,537                                                               | 1,177,889–1,475,530                  |
| Maldives                                    | 338,442            | 558                                 | 5,070                                                               | 14,551–19,770                        |
| Marshall Islands                            | 52,555             | 590                                 | 5,063                                                               | 2,292–3,030                          |
| Mauritania                                  | 3,796,141          | 52                                  | 702                                                                 | 23,302–29,963                        |
| Mauritius                                   | 1,201,167          | 444                                 | 4,493                                                               | 51,187–64,848                        |
| Micronesia (Federal States of)              | 103,395            | 405                                 | 4,537                                                               | 4,042–5,340                          |
| Monaco                                      | 37,579             | 6,708                               | 20,262                                                              | 6,563–8,666                          |
| Mongolia                                    | 2,796,484          | 232                                 | 4,908                                                               | 120,159–154,342                      |
| Montenegro                                  | 621,081            | 493                                 | 5,110                                                               | 27,903–35,568                        |
| Morocco                                     | 32,521,143         | 190                                 | 3,929                                                               | 110,656–1,450,854                    |
| Mozambique                                  | 25,203,395         | 37                                  | 496                                                                 | 108,974–141,142                      |
| Namibia                                     | 2,259,393          | 473                                 | 4,785                                                               | 92,473–123,729                       |
| Nauru                                       | 9,378              | 564                                 | 4,674                                                               | 347–529                              |
| Niger                                       | 17,157,042         | 25                                  | 293                                                                 | 43,349–57,053                        |
| Nigeria                                     | 168,833,776        | 94                                  | 1,596                                                               | 2,360,057–3,028,546                  |
| Niue                                        | 1,269              | 1,270                               | 6,365                                                               | 47–115                               |
| Norway                                      | 5,018,573          | 9,055                               | 29,239                                                              | 1,276,741–1,657,982                  |
| Pakistan                                    | 179,160,111        | 34                                  | 423                                                                 | 656,418–859,980                      |
| Palau                                       | 20,754             | 972                                 | 6,552                                                               | 1,138–1,581                          |
| Panama                                      | 3,802,281          | 723                                 | 5,194                                                               | 174,850–220,103                      |
| Papua New Guinea                            | 7,167,010          | 114                                 | 2,076                                                               | 130,103–167,403                      |
| Paraguay                                    | 6,687,361          | 392                                 | 4,386                                                               | 253,242–333,423                      |
| Philippines                                 | 96,706,764         | 119                                 | 2,385                                                               | 2,005,550–2,607,277                  |
| Republic of Moldova                         | 3,559,519          | 239                                 | 5,789                                                               | 178,368–233,757                      |
| Romania                                     | 200,076,727        | 420                                 | 5,134                                                               | 887,449–1,170,096                    |
| Russian Federation                          | 143,178,000        | 887                                 | 5,577                                                               | 693,584–903,816                      |
| Saint Kitts and Nevis                       | 53,584             | 825                                 | 5,492                                                               | 2,478–3,408                          |
| Saint Lucia                                 | 180,870            | 556                                 | 4,578                                                               | 7,266–9,293                          |
| Saint Vincent and the Grenadines            | 109,373            | 340                                 | 4,734                                                               | 4,303–6,053                          |
| Samoa                                       | 188,889            | 245                                 | 5,609                                                               | 9,101–12,087                         |
| San Marino                                  | 31,247             | 3,792                               | 11,921                                                              | 3,222–4,228                          |
| Sao Tome and Principe                       | 188,098            | 109                                 | 1,990                                                               | 3,173–4,311                          |
| Senegal                                     | 13,726,021         | 51                                  | 715                                                                 | 84,466–111,699                       |
| Serbia                                      | 7,199,077          | 561                                 | 5,068                                                               | 316,905–412,754                      |
| Seychelles                                  | 88,303             | 521                                 | 4,858                                                               | 3,772–4,806                          |
| Singapore                                   | 5,312,400          | 2,426                               | 7,275                                                               | 335,808–437,171                      |
| Solomon Islands                             | 549,598            | 148                                 | 3,016                                                               | 14,468–18,681                        |
| Somalia                                     | 10,195,134         | 20                                  | 231                                                                 | 19,986–27,089                        |

(continues ...)
| Country                                      | Population in 2012 | Total health expenditure per capita | Average imputed no. of operations per 100 000 population per year | Expected range of operations in 2012 |
|---------------------------------------------|--------------------|-------------------------------------|---------------------------------------------------------------|-----------------------------------|
| South Africa                                | 52 274 945         | 645                                 | 4 991                                                         | 2 235 713–2 982 830               |
| South Sudan                                 | 10 837 527         | 27                                  | 311                                                          | 29 067–38 266                     |
| Sudan                                       | 37 195 349         | 115                                 | 2 042                                                         | 658 712–860 547                   |
| Suriname                                    | 534 541            | 521                                 | 4 947                                                         | 22 660–30 230                     |
| Swaziland                                   | 1 230 985          | 259                                 | 6 176                                                         | 66 589–85 453                     |
| Tajikistan                                  | 8 008 990          | 55                                  | 764                                                          | 53 256–69 118                     |
| Thailand                                    | 66 785 001         | 215                                 | 4 775                                                         | 2 756 949–3 621 426               |
| The former Yugoslav Republic of Macedonia   | 2 105 575          | 327                                 | 4 476                                                         | 81 800–106 710                    |
| Timor-Leste                                 | 1 148 958          | 50                                  | 684                                                          | 6 835–8 892                       |
| Togo                                        | 6 642 928          | 41                                  | 530                                                          | 30 889–39 566                     |
| Tonga                                       | 104 941            | 238                                 | 5 650                                                         | 5 016–6 842                       |
| Trinidad and Tobago                         | 1 337 439          | 972                                 | 5 865                                                         | 68 535–88 354                     |
| Tunisia                                     | 10 777 500         | 297                                 | 4 627                                                         | 420 162–577 232                   |
| Turkmenistan                                | 5 172 931          | 129                                 | 2 460                                                         | 111 503–143 051                   |
| Tuvalu                                      | 9 860              | 577                                 | 5 017                                                         | 389–601                           |
| Ukraine                                     | 45 593 300         | 293                                 | 4 882                                                         | 1 891 091–2 560 965               |
| United Arab Emirates                        | 9 205 651          | 1 343                               | 5 891                                                         | 473 401–611 217                   |
| United Republic of Tanzania                 | 47 783 107         | 41                                  | 454                                                          | 193 051–240 876                   |
| Uruguay                                     | 3 395 253          | 1 308                               | 6 256                                                         | 186 105–238 742                   |
| Uzbekistan                                  | 29 774 500         | 105                                 | 1 878                                                         | 492 861–625 376                   |
| Vanuatu                                     | 247 262            | 116                                 | 2 084                                                         | 4 480–5 827                       |
| Venezuela (Bolivarian Republic of)          | 29 954 782         | 593                                 | 5 376                                                         | 1 383 223–1 837 617               |
| Viet Nam                                    | 88 772 900         | 102                                 | 1 865                                                         | 1 459 314–1 852 719               |
| Zimbabwe                                    | 13 724 317         | 228                                 | 5 168                                                         | 620 938–797 504                   |

* Adjusted to 2012 United States dollars.

* Ranges for volume of surgery are derived from the 99% prediction interval from 300 imputed data sets for each country based on total health expenditure per capita.