Article:
COVIDSurg Collaborative (2020) Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. British Journal of Surgery, 107 (11). pp. 1440-1449. ISSN: 0007-1323

https://doi.org/10.1002/bjs.11746

Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans

COVIDSurg Collaborative

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Running title: Elective surgery during the SARS-CoV-2 pandemic

Keywords: SARS-CoV-2, COVID-19, elective surgery, cancellation

Conflicts of interest: The authors have no conflicts of interests to declare.

Funding: This report was funded by a National Institute for Health Research (NIHR) Global Health Research Unit Grant (NIHR 16.136.79), the Association of Coloproctology of Great Britain and Ireland, Association of Upper Gastrointestinal Surgeons, Bowel & Cancer Research, Bowel Disease Research Foundation, British Association of Surgical Oncology, European Society of Coloproctology, Sarcoma UK, Vascular Society for Great Britain and Ireland, and Yorkshire Cancer Research. The funders had no role in study design, data collection, analysis and interpretation, or writing of this report. The views expressed are those of the authors and not necessarily those of the National Health Service, the NIHR, or the UK Department of Health and Social Care.

Abstract

Background: The COVID-19 pandemic has disrupted routine hospital services globally. This study estimated the total number of adult elective operations that would be cancelled worldwide during the 12 weeks of peak disruption due to COVID-19.

Methods: A global expert-response study was conducted to elicit projections for the proportion of elective surgery that would be cancelled or postponed during the 12 weeks of peak disruption. A Bayesian beta-regression model was used to estimate 12-week cancellation rates for 190 countries. Elective surgical case-mix data, stratified by specialty and indication (cancer versus benign surgery), was determined. This case-mix was applied to country-level surgical volumes. The 12-week cancellation rates were then applied to these figures to calculate total cancelled operations.

Results: The best estimate was that 28,404,603 operations would be cancelled or postponed during the peak 12 weeks of disruption due to COVID-19 (2,367,050 operations per week). Most would be operations for benign disease (90.2%, 25,638,922/28,404,603). The overall 12-week cancellation rate would be 72.3%. Globally, 81.7% (25,638,921/31,378,062) of benign surgery, 37.7% (2,324,069/6,162,311) of cancer surgery, and 25.4% (441,611/1,735,483) of elective Caesarean sections would be cancelled or postponed. If countries increase their normal surgical volume by 20% post-pandemic, it would take a median 45 weeks to clear the backlog of operations resulting from COVID-19 disruption.

Conclusions A very large number of operations will be cancelled or postponed due to disruption caused by COVID-19. Governments should mitigate against this major burden on patients by developing recovery plans and implementing strategies to safely restore surgical activity.

Introduction

The COVID-19 pandemic has led to major disruption of routine hospital services globally[1]. During the pandemic hospitals have reduced elective surgery in the interests of patient safety and supporting the wider response[2-4]. Reducing elective activities protects patients from in-hospital viral transmission and associated postoperative pulmonary complications. This preserves personal protective equipment (PPE) supplies to be prioritised for the care of COVID-19 patients, and releases ward and critical care beds for surges in COVID-19 patients. It also enables recovery areas in theatre suites to be repurposed as overflow intensive care units. Surgeons and theatres teams may be redeployed to support other critical areas of the hospital.

Cancelling elective surgery at this scale will have substantial impact on patients and cumulative, potentially devastating consequences for health systems worldwide[5]. Delaying time-sensitive elective operations, such as cancer or transplant surgery, may lead to deteriorating health, worsening quality of life, and unnecessary deaths[6-8]. When hospitals resume elective activities, patients are likely to be prioritised by clinical urgency[9], resulting in lengthening delays for patients with benign but potentially disabling conditions where there may be less of a perceived time impact. This will lead to a deterioration in population health, productivity, and a substantial societal cost.

Worldwide cancellations in elective surgery are currently unquantified[10,11]. Few countries have access to real time data, and even those that do may experience delays in this information being released due to pressures on health systems. Estimating country-level estimates will provide the best possible baseline data to inform planning for post-pandemic surgical recovery. This study aimed to estimate the total elective operations that would be cancelled or postponed worldwide during the 12 weeks of peak disruption of hospital services due to COVID-19.

Methods

The methodology is summarised in Figure 1. Firstly, an expert response study was conducted to elicit surgeons' projections for the proportion of elective surgery that would be cancelled during the peak 12 weeks of disruption due to COVID-19. This data was fed in to a Bayesian beta-regression model to estimate 12-week cancellation rates for elective surgery for 190 countries. Secondly, elective surgical case-mix was determined for each Human Development Index (HDI) quintile using data from the Surgical Outcomes Studies and the expert response study. This case-mix was applied to existing figures for overall country-level surgical volume to calculate expected specialty-specific surgical volumes for 190 countries. Finally, these surgical volume figures and the 12-week cancellation rate estimates were used to calculate totals for cancelled operations by specialty and country.

All 193 United Nations member countries were included in this study except Liechtenstein, North Korea, and Somalia, as there was no surgical volume data available for these three countries[12]. At present the only region to have recovered from a large-scale SARS-CoV-2 outbreak is Hubei Province in China. Wuhan, the capital of Hubei, was in lockdown for 76 days (23 January 2020 to 8 April 2020). Therefore, the current best estimate for the duration of disruption to health systems caused by COVID-19 is around 12 weeks. This is consistent with advice that hospitals should plan to suspend non-urgent elective surgery for at least 12 weeks[4].

The secondary outcomes were total cancelled operations stratified by World Bank region (Europe and Central Asia, East Asia and Pacific, Latin America and the Caribbean, North America, Middle East and North Africa, South Asia, Sub-Saharan Africa), World Bank country income group (high, upper middle, lower middle, low income), and surgical specialty. Specialty-specific cancellation totals were calculated for those surgical specialties accounting for 5% or more of global surgical case-mix (Supplementary Table 1). This included colorectal, head and neck, gynaecological, orthopaedic, obstetric, plastics, upper gastrointestinal (including

hepatobiliary surgery), and urological surgery. Colorectal, head and neck, gynaecological, plastics, upper gastrointestinal, and urological surgery were further stratified in to operations performed for cancer versus benign pathology. Orthopaedic surgery was not stratified in this way as cancer accounts for a very small proportion of orthopaedic operations. Specialties that individually account for under 5% of surgical case-mix were pooled in to an 'other surgery' category, including breast surgery, cardiac surgery, neurosurgery, thoracic surgery, and vascular surgery. Therefore, a total of 15 specialty groups were included in this study (Table 1).

12-week elective surgery cancellation rates

Senior surgeons were invited to participate in an expert response study in order to elicit their projections for the proportion of elective surgery that would be cancelled during the peak 12 weeks of disruption due to COVID-19. Surgeons were contacted through the global CovidSurg network and asked to enter their estimates in to an online database. The questionnaire was open from 20 march 2020 to 30 March 2020.

Experts were asked to provide estimates for each of the 15 specialty groups included in this study. For each specialty group experts provided their best estimate (the most likely 12-week cancellation rate), as well as a lower bound estimate (the lowest possible cancellation rate) and an upper bound estimate (the highest possible cancellation rate). If the SARS-CoV-2 outbreak had resolved at the experts' hospital, they were asked to report actual rates of cancelled surgery due to the outbreak. If the outbreak was ongoing, experts were asked to project likely cancellation rates forward. If the experts' hospital had not yet experienced a SARS-CoV-2 outbreak, they were asked to estimate what would happen in the event of an outbreak.

After the expert response study questionnaire closed, responses were matched by hospital and in the cases of more than one expert participating per hospital, median values for each data point were calculated, so that there was one consolidated response per hospital. Overall median values for the best estimate and upper/ lower bounds were then calculated for each participating

country for cancer surgery, benign surgery, and obstetric (elective Caesarean section) operations.

A Bayesian beta-regression model was developed with 2018 Human Development Index (HDI) as a predictor, in order to establish 12-week cancellation rate estimates for all 190 countries included in the study (Supplementary Table 2). HDI is a composite index of life expectancy, education, and per capita income indicators and its relationship with surgical outcomes has previously been validated[13,14].

Non-informative priors were used with sensitivity analyses done on alternative priors and different chain initiation points or chain lengths. A restricted cubic spline transformation was applied to the continuous representation of the HDI rank (rank 1 being the most developed country and rank 190 being the least developed country) to account for potential non-linearity. This was substituted into the final beta regression model and posterior predictions were made for each HDI rank. The model was fitted for the best estimates and lower/ upper bounds for cancer surgery, benign surgery, and obstetric (Cesarean section) operations.

Surgical case-mix

The best available global data on surgical case-mix are from the African Surgical Outcomes Study (ASOS), European Surgical Outcomes Study (EuSOS), and International Surgical Outcomes Study (ISOS)[15-17]. These were prospective cohort studies that captured all adults undergoing surgery in participating facilities, providing case-mix data for a total of 102,539 patients across 64 countries. No comparable global case-mix data exists for paediatric surgery, therefore, this study was limited to adults.

Raw data from the three SOS studies were pooled to estimate case-mix by HDI quintile (Supplementary Table 2). First, the case-mix was determined according to urgency: elective versus emergency surgery. Next, within elective surgery the case-mix was stratified by

specialty. In order to determine cancer surgery versus benign surgery case-mix, the expert response study participants were asked to estimate the proportions of colorectal, head and neck, gynaecological, plastics, upper gastrointestinal, and urological operations performed in their hospitals for cancer. Hospital-level results were then pooled by HDI quintile to calculate median proportions for cancer surgery for each specialty.

Surgical volume

A previous report identified total country surgical volume for 72 countries (presented as point estimates) and modelled estimates for a further 120 countries (presented as confidence intervals)[12]. As only overall total (paediatric surgery) country volumes were available, population age-structure data from the World Bank was used to estimate total adult surgical volume for each country. Adults were defined age 15 years and above, consistent with age categories used for population data by the World Bank.

Country-level surgical volumes for each of the 15 specialty groups included in this study were calculated based on the country-specific adult surgical volume and case-mix for the appropriate HDI quintile. For the best estimate of total cancellations, the point estimate (if provided) or the midpoint of the confidence interval for country-level surgical volume were used in order to calculate specialty-specific country-level surgical.

Totals for cancelled surgery

Country-level surgical volume data and modelled 12-week cancellation rates were used to calculate specialty group-specific totals for adult elective operations cancelled during the peak 12 weeks of disruption. The best estimate for the number of cancelled operations was based on the modelled best estimates for 12-week cancellation rates.

Surgical recovery

The time it would take countries to clear the backlog of operations resulting from 12 weeks of disruption due to COVID-19 was estimated. It was assumed that cancelled obstetric (Cesarean section) operations would not need to be rescheduled post-pandemic. Therefore, the time taken to clear country-level backlogs of operations for benign disease and cancer was based country-level baseline volumes of surgery for benign disease and cancer. The number of whole or part weeks needed to clear these backlogs was caclulated based on 10%, 20%, and 30% increases in baseline surgical volume.

Sensitivity analyses

An estimate for the minimum operations likely to be cancelled was based on the lowest likely baseline surgical volume (i.e. the lower bounds for total surgical volume estimates where provided) and the modelled lower bounds for 12-week cancellation rates. An estimate for the maximum operations likely to be cancelled was based on the highest likely baseline surgical volume (i.e. the upper bounds for total surgical volume estimates where provided) and modelled upper bounds for 12-week cancellation rates.

Analyses were done using the R Foundation Statistical Program version 3.6.3 and rstan (the R interface to the statistical inference language Stan) and the packages brms and finalfit.

Results

12-week cancellation rates

From a total of 538 submissions to the expert response study (Supplementary Figure 1), data was available for 359 hospitals in 71 countries (Supplementary Table 3). Proportions of surgery projected to be cancelled were consistently estimated to be higher for benign surgery than for obstetrics (elective Caesarean sections). Proportions of cancer surgery projected to be cancelled were lower in the most developed countries compared to the least developed countries (Supplementary Figure 2).

Based on the Bayesian beta-regression model, best estimates for country-level 12-week cancellation rates (Supplementary Table 4) for cancer surgery ranged 23.4-77.1%, whilst they ranged 71.2-87.4% for benign surgery, and 17.4%-37.8% for obstetrics (Figure 2).

Surgical volume

The best estimate for cancellations was based on a global annual adult elective surgical volume of 170,195,382 operations (Supplementary Figure 3). Details of surgical case-mix are provided in Supplementary Table 5-8 and Supplementary Figures 4-7.

Total cancellations

The best estimate was that globally 28,404,603 operations would be cancelled or postponed during the peak 12 weeks of the COVID-19 pandemic. Worldwide 2,367,050 operations would be cancelled per week, with 11 countries cancelling more than 50,000 operations per week (Table 2).

Most of the cancelled or postponed operations were estimated to be benign surgeries (90.2%, 25,638,922/28,404,603), followed by cancer surgeries (8.2%, 2,324,070/28,404,603), and obstetrics (1.6%, 441,611/28,404,603, Table 1). The best estimate was that the global 12-week cancellation rates would be 72.3% (28,404,603/39,275,857) overall, 81.7%

(25,638,921/31,378,062) for benign surgery, 37.7% (2,324,069/6,162,311) for cancer surgery, and 25.4% (441,611/1,735,483) for obstetrics (Table 3).

Overall 12-week cancellation rates by World Bank region would range from 68.3% to 73.0%. The most cancellations were projected to take place in Europe and Central Asia (n=8,430,348, Figure 3) and the least in Sub-Saharan Africa (n=520,458, Table 4), reflecting the low baseline surgical volume there. Country-level totals stratified by specialty are presented in Supplementary Table 9.

Surgical recovery

It was estimated that based on a 20% increase in baseline surgical volume it would take countries a median of 45 weeks (range: 43-48 weeks) to clear the backlog of operations resulting from 12 weeks of disruption due to COVID-19 (Supplementary Table 10). If baseline surgical volume was increased by 10% it would take countries a median of 90 weeks (range: 86-95) weeks to clear the backlog, whereas with a 30% increase in baseline surgical volume this would take a median of 30 weeks (range: 29-32).

Sensitivity analyses

The minimum estimate was that 19,849,153 operations would be cancelled worldwide during the 12 weeks of peak disruption due to COVID-19 (1,654,096 per week), representing a 61.1% (19,849,153/32,488,250) 12-week cancellation rate. The maximum estimate was that 43,945,672 operations would be cancelled during the peak 12 weeks (3,662,139 per week), representing a 86.2% (43,945,672/50,960,625) 12-week cancellation rate.

Discussion

This study demonstrates the major burden of cancelled elective surgery due to the COVID-19 pandemic. Although a similar proportion of surgery will be cancelled across different country-income settings and geographic regions, the greatest number of cancellations will be in upper middle-income countries. Cancer surgery will be prioritised in most settings, with most cancellations relating to surgery for benign conditions, most frequently orthopaedics.

The risks of exposing patients to perioperative SARS-CoV-2 infection by performing surgery during outbreaks are high, but must be weighed against the risks of protracted treatment delays. Given that many health systems already lack sufficient capacity to meet the need for surgery[18], the impact of cancellations will be cumulative, adding to existing waiting lists. Governments will need to fund substantial increases in baseline surgical volume to clear backlogs, but this is likely to be costly. For example, based on an average cost of £4,000 per operation, it would cost over £2 billion to clear the United Kingdom's backlog.

There is a risk that delayed treatment of benign conditions as a result of pandemic-related cancellations will lead to deterioration in individual patients' conditions, increasing disability and reducing their ability to work. This will lead to lead to substantial societal costs, particularly in LMICs where catastrophic expenditure relating to surgical disease can lead to impoverishment[19,20].

This study has several limitations. Whilst estimates were based on the best available global surgical data, several assumptions were required. As the COVID-19 pandemic is ongoing it was necessary for the expert response study participants to project forward their estimates for 12-week cancellation rates. Participants in countries where the pandemic was in its earliest stages, such as in Sub-Saharan Africa, may had to base their estimates on experience in previous emergencies, rather than the specific circumstances of COVID-19. The uncertainty around these estimates was captured by recording both lower and upper bounds, as well as best

estimates for 12-week cancellation rates. Surgical case-mix was principally based on snapshot cohort studies that collected data across 64 countries[15-17]. Given the barriers to participation in research, particularly in LMICs[21], it is unknown how representative this data is for global case-mix. Most countries do not publish surgical volume data so this study relied on previous estimates of country-level surgical volume.

The eventual geographic extent and intensity of the pandemic is currently unknown, but it is likely that most countries will be effected[22-24]. The country-level figures can be used to produce estimated of per-week cancellations, allowing policy makers to adjust estimates according to the predicted duration of local outbreaks. Prediction of the impact of COVID-19 on elective surgery in local communities can inform local planning and resource prioritisation.

Post-pandemic surgical recovery planning should anticipate the possibility of repeat waves of SARS-CoV-2 infection[25], leading to additional periods of cancellation of elective surgery. Therefore, strategies to safely maintain surgical volume during and immediately following SARS-CoV-2 outbreaks should be explored. For example, time-sensitive surgery, such as cancer resection, can be performed in designated non-COVID-19 units which do not treat COVID-19 patients. Although the optimal organisation of such surgical units is unknown, it is likely that they should carefully select low-risk patients who are unlikely to require intensive care and can be safely operated in satellite units. Both patients and staff will require rigorous screening to reduce the risks of cross-infection. Surgical recovery plans should also consider that an immediate return to high volume surgery may not be possible. For example, adaptations to operating theatres, such as installation of negative pressure flow systems, may need to be expedited in order to reduce the delay to resumption of normal activity.

Future research should be prioritised to identify strategies to mitigate the risk of operating in COVID-19 environments, so that cancellations are minimised. For example, whilst ongoing trials

are testing treatments for COVID-19[26-28], large randomised trials are also needed to test therapies to prevent postoperative COVID-19 pulmonary complications.

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Table 1: Best estimates of cancelled operations over a 12-week period of peak disruption, by specialty group

Specialty group	Normal volume	Estimated cancellations	12-week cancellation rate
Cancer surgery			
Colorectal	1,353,952	486,563	35.9%
Gynaecology	834,839	328,505	39.3%
Head & neck	959,190	373,603	38.9%
Plastics	505,294	178,362	35.3%
Upper gastrointestinal and hepatobiliary	1,258,862	498,885	39.6%
Urology	1,250,175	458,151	36.6%
Benign surgery			
Colorectal	1,201,825	976,992	81.3%
Gynaecology	2,665,361	2,175,774	81.6%
Head & neck	4,845,604	3,950,551	81.5%
Orthopaedics	7,677,515	6,295,041	82.0%
Plastics	933,822	764,033	81.8%
Upper gastrointestinal and hepatobiliary	2,728,786	2,223,194	81.5%
Urology	3,051,523	2,492,604	81.7%
Other	8,273,626	6,760,731	81.7%
Obstetrics			
Obstetrics	1,735,483	441,611	25.4%
Total	39,275,857	28,404,603	72.3%

Normal volume relates to surgical volume at full capacity (no cancellations)

Table 2: Weekly totals for best estimates of cancelled operations, by country

<1,000	Albania (567), Andorra (41), Antigua and Barbuda (54), Bahamas, The (280), Bahrain (514), Barbados (193), Belize (57), Benin (157), Bhutan (103), Botswana (792), Brunei Darussalam (249), Burkina Faso (237), Burundi (110), Cabo Verde (49), Cambodia (601), Cameroon (744), Central African Republic (32), Chad (29), Comoros (24), Congo, Dem. Rep. (642), Congo, Rep. (155), Cyprus (347), Djibouti (45), Dominica (27), Equatorial Guinea (211), Eritrea (78), Eswatini (195), Fiji (175), Gabon (242), Gambia, The (30), Grenada (43), Guinea (141), Guinea-Bissau (35), Guyana (93), Haiti (305), Honduras (974), Iceland (297), Jamaica (964), Kiribati (7), Kyrgyz Republic (877), Lao PDR (192), Lesotho (115), Liberia (168), Luxembourg (564), Madagascar (231), Malawi (283), Maldives (237), Mali (347), Malta (554), Marshall Islands (16), Mauritania (116), Mauritius (260), Micronesia, Fed. Sts. (22), Monaco (32), Montenegro (268), Mozambique (370), Namibia (497), Nauru (7), Nepal (277), Niger (206), North Macedonia (711), Palau (15), Papua New Guinea (338), Rwanda (349), Samoa (13), San Marino (16), Sao Tome and Principe (18), Senegal (267), Seychelles (232), Sierra Leone (110), Solomon Islands (55), South Sudan (135), St. Kitts and Nevis (33), St. Lucia (76), St. Vincent and the Grenadines (36), Suriname (243), Tajikistan (680), Tanzania (808), Timor-Leste (48), Togo (137), Tonga (26), Trinidad and Tobago (892), Tuvalu (4), Uganda (890), Vanuatu (15), Yemen, Rep. (188), Zambia (418), Zimbabwe (810)
1,000-9,999	Afghanistan (1048), Angola (1612), Armenia (1124), Azerbaijan (1556), Bangladesh (2671), Bolivia (1094), Bosnia and Herzegovina (1625), Bulgaria (5109), Costa Rica (1734), Cote d'Ivoire (1153), Croatia (2086), Cuba (5578), Czech Republic (6531), Denmark (5622), Dominican Republic (3934), Ecuador (2012), Egypt, Arab Rep. (9055), El Salvador (1200), Estonia (1255), Ethiopia (1124), Finland (6053), Georgia (1868), Ghana (1212), Greece (7492), Guatemala (1119), Iraq (3420), Ireland (1376), Israel (3766), Jordan (1839), Kazakhstan (7339), Kenya (1780), Kuwait (2593), Latvia (3565), Lebanon (2717), Libya (2060), Lithuania (2945), Moldova (1564), Mongolia (1283), Morocco (1302), Myanmar (1674), New Zealand (2721), Nicaragua (1351), Nigeria (9543), Norway (5370), Oman (1005), Pakistan (3746), Panama (2409), Paraguay (2211), Peru (7478), Portugal (8885), Qatar (1933), Romania (9135), Saudi Arabia (9410), Serbia (3476), Singapore (4418), Slovak Republic (4644), Slovenia (1524), Sri Lanka (3509), Sudan (3485), Switzerland (9162), Syrian Arab Republic (1697), Tunisia (3501), Turkmenistan (1208), United Arab Emirates (6402), Uruguay (2292), Uzbekistan (6988), Vietnam (7110)
10,000-49,999	Algeria (12870), Argentina (27088), Austria (11967), Belarus (17569), Belgium (22660), Canada (32881), Chile (11696), Hungary (13959), India (48728), Indonesia (31050), Iran, Islamic Rep. (32099), Korea, Rep. (17267), Malaysia (12891), Mexico (15315), Netherlands (15847), Philippines (13593), Poland (22656), South Africa (12795), Spain (45449), Sweden (14588), Thailand (18332), Ukraine (21943), United Kingdom (43307), Venezuela, RB (17234)
50,000-99,999	Australia (67149), France (58708), Germany (75730), Italy (50552), Russian Federation (93688), Turkey (82002)
>100,000	Brazil (247444), China (326177), Colombia (113082), Japan (113324), United States (343670)

Weekly total for cancelled operations indicated in parentheses.

Table 3: Best estimates for cancelled operations over a 12-week period of peak disruption, by country-income and region

	Benign surgery	Cancer surgery	Obstetrics	Total
High income	11,803,371 (83.6%)	937,740 (30.3%)	89,073 (20.1%)	12,830,185 (72.7%)
East Asia and Pacific	2,276,604 (84.6%)	167,830 (28.7%)	17,271 (21.7%)	2,461,704 (73.4%)
Europe and Central Asia	4,895,041 (83.7%)	384,630 (30%)	39,106 (20.9%)	5,318,777 (72.7%)
Latin America and the Caribbean	188,143 (81.7%)	22,331 (38.7%)	3,718 (23.4%)	214,192 (70.5%)
Middle East and North Africa	284,896 (83%)	26,142 (33.9%)	3,076 (23.3%)	314,114 (72.4%)
North America	4,156,253 (83.1%)	336,510 (31%)	25,855 (17.5%)	4,518,619 (72.4%)
Sub-Saharan Africa	2,434 (81%)	297 (39.5%)	47 (22.7%)	2,778 (70%)
Upper middle income	11,824,165 (80.4%)	1,171,864 (43.4%)	254,374 (26.4%)	13,250,403 (72.1%)
East Asia and Pacific	3,836,777 (79.6%)	370,906 (47.8%)	83,989 (27.9%)	4,291,672 (72.8%)
Europe and Central Asia	2,402,694 (81.5%)	277,144 (37.8%)	47,108 (23.2%)	2,726,946 (70.2%)
Latin America and the Caribbean	4,811,770 (80.6%)	436,109 (43.6%)	101,324 (26.9%)	5,349,203 (72.8%)
Middle East and North Africa	579,884 (80.4%)	67,302 (44.5%)	12,885 (24.9%)	660,070 (71.4%)
South Asia	38,931 (82.1%)	5,227 (45.1%)	798 (24.6%)	44,957 (72.2%)
Sub-Saharan Africa	154,110 (77.7%)	15,176 (55.6%)	8,270 (28.4%)	177,555 (69.7%)
Lower middle income	1,906,718 (78.8%)	200,315 (56.8%)	86,875 (29.5%)	2,193,909 (71.6%)
East Asia and Pacific	591,840 (79.5%)	63,188 (55.3%)	16,827 (28.6%)	671,855 (73.2%)
Europe and Central Asia	338,114 (80.8%)	31,754 (48.3%)	6,595 (24.4%)	376,463 (73.7%)
Latin America and the Caribbean	47,844 (76.7%)	4,839 (57.8%)	2,749 (28.8%)	55,433 (69.1%)
Middle East and North Africa	144,904 (77.7%)	14,644 (56%)	7,282 (29.9%)	166,830 (70.4%)
South Asia	571,190 (79%)	58,633 (60.1%)	33,156 (28.9%)	662,980 (70.9%)
Sub-Saharan Africa	212,826 (75.1%)	27,257 (67.8%)	20,266 (33.7%)	260,349 (67.8%)
Low income	104,668 (75.1%)	14,150 (70.2%)	11,289 (34.6%)	130,106 (67.7%)
Europe and Central Asia	7,055 (78.6%)	689 (57.2%)	418 (30.4%)	8,162 (70.7%)
Latin America and the Caribbean	2,900 (72.1%)	405 (69.1%)	355 (36.5%)	3,660 (65.6%)
Middle East and North Africa	18,259 (77.3%)	2,415 (70.2%)	1,941 (34%)	22,615 (69%)
South Asia	12,872 (75.2%)	1,710 (69.8%)	1,311 (34.4%)	15,892 (68%)
Sub-Saharan Africa	63,582 (74.2%)	8,931 (71.6%)	7,264 (35.1%)	79,777 (67.1%)

Cancellation rate during the 12 weeks of peak disruption due to COVID-19 is indicated in parentheses

Table 4: Projected totals of cancelled operations over a 12-week period of peak distruption, by specialty and region

	Europe and Central Asia	East Asia and Pacific	Latin America and the Caribbean	North America	Middle East and North Africa	South Asia	Sub-Saharan Africa	Total
Colorectal	370,947 (271,699-525,058)	429,080 (293,754-648,207)	289,478 (225,678-387,241)	66,360 (40,354-107,578)	216,938 (82,055-557,016)	51,498 (29,220-84,688)	39,253 (23,429-63,129)	1,463,554 (966,189-2,372,917)
Gynaecology	615,432 (465,320-845,332)	726,822 (527,138-1,048,555)	438,252 (351,688-568,490)	109,110 (70,281-168,401)	413,412 (174,874-996,313)	108,772 (61,384-179,841)	92,479 (54,885-149,462)	2,504,279 (1,705,570-3,956,394)
Head & neck	1,273,813 (992,658-1,697,114)	1,145,636 (846,679-1,619,047)	1,040,920 (852,507-1,320,423)	161,277 (102,965-252,346)	599,701 (257,022-1,433,471)	56,571 (33,227-90,353)	46,237 (27,997-73,646)	4,324,155 (3,113,055-6,486,400)
Obstetrics	118,086 (73,147-170,326)	93,227 (61,570-152,867)	108,147 (68,085-153,903)	25,184 (13,781-47,053)	25,855 (10,451-97,857)	35,266 (21,493-64,886)	35,846 (19,567-63,694)	441,611 (268,094-750,586)
Orthopaedics	1,552,527 (1,198,532-2,099,308)	2,026,572 (1,505,280-2,862,626)	1,040,757 (854,680-1,319,648)	244,121 (162,132-369,337)	1,196,372 (525,886-2,813,418)	144,637 (84,657-230,216)	90,054 (55,692-141,092)	6,295,040 (4,386,859-9,835,645)
Plastic	177,608 (127,932-257,002)	344,224 (247,596-499,065)	113,308 (85,578-157,432)	48,738 (30,970-76,291)	173,955 (71,275-427,356)	48,222 (27,550-78,677)	36,341 (21,834-58,177)	942,396 (612,735-1,554,000)
Upper gastrointestinal and hepatobiliary	782,347 (598,486-1,054,538)	747,601 (548,811-1,057,813)	668,231 (531,744-873,887)	113,529 (70,173-182,131)	335,765 (140,659-814,011)	46,355 (27,099-74,315)	28,253 (17,250-44,753)	2,722,081 (1,934,222-4,101,448)
Urology	758,344 (571,645-1,044,176)	889,675 (642,223-1,288,273)	561,714 (448,141-733,207)	120,947 (77,150-189,014)	484,983 (201,581-1,181,362)	73,061 (42,221-117,986)	62,031 (37,381-99,027)	2,950,755 (2,020,342-4,653,045)
Other surgery	1,776,126 (1,390,121-2,366,924)	2,027,511 (1,528,468-2,816,774)	1,361,682 (1,122,998-1,717,845)	274,363 (179,792-420,180)	1,071,638 (471,057-2,520,091)	159,448 (93,597-253,148)	89,964 (56,058-140,272)	6,760,732 (4,842,091-10,235,234)
Total	7,425,231 (5,689,539-10,059,779)	8,430,348 (6,201,518-11,993,227)	5,622,488 (4,541,098-7,232,076)	1,163,629 (747,598-1,812,332)	4,518,618 (1,934,859-10,840,895)	723,829 (420,448-1,174,112)	520,459 (314,092-833,252)	28,404,603 (19,849,153-43,945,672)

Main figures represent the best estimates; minimum and maximum estimates are indicated in parentheses

Figure 1: Flowchart of methodology

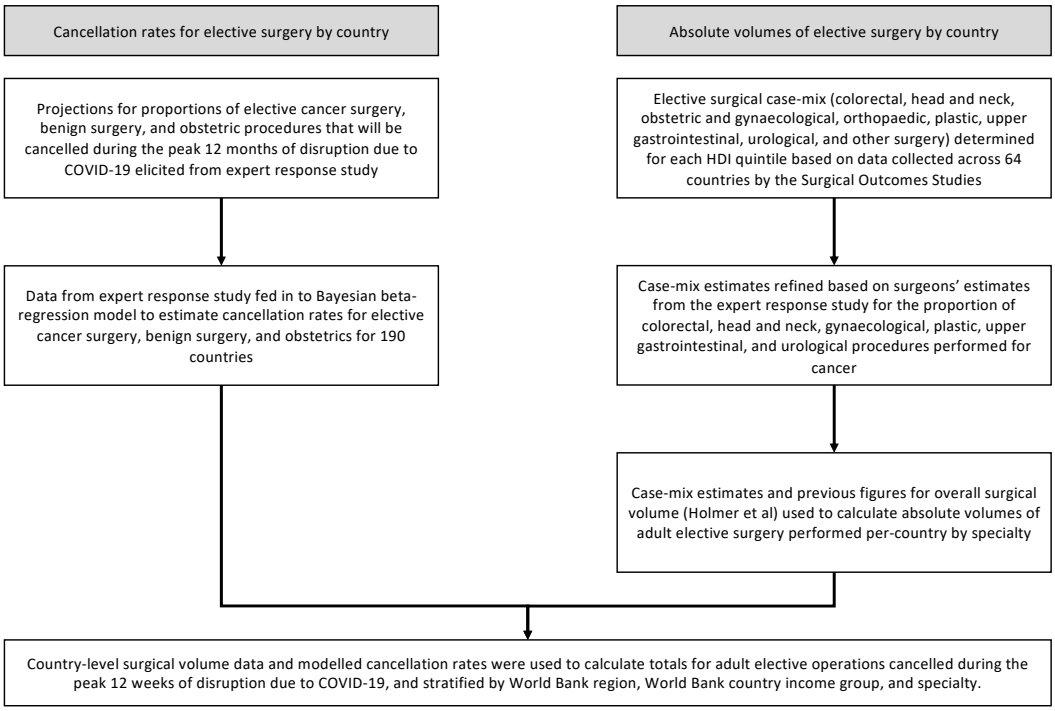


Figure 2: Country-level 12-week cancellation rates, by type of surgery

Figure 2(a): Benign surgery

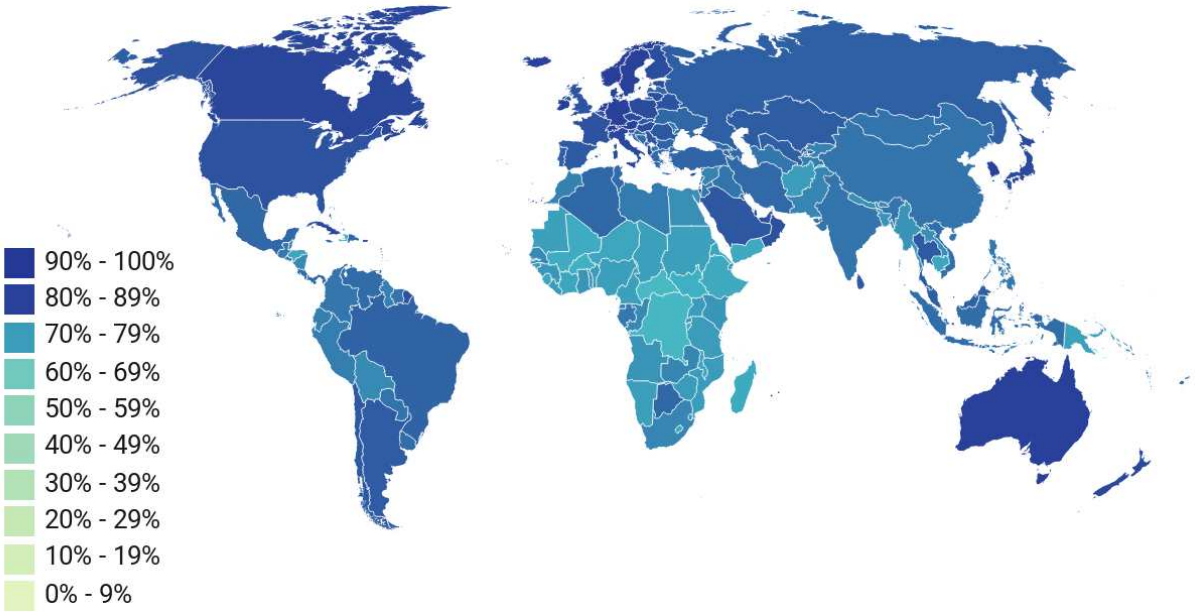


Figure 2(b): Cancer surgery

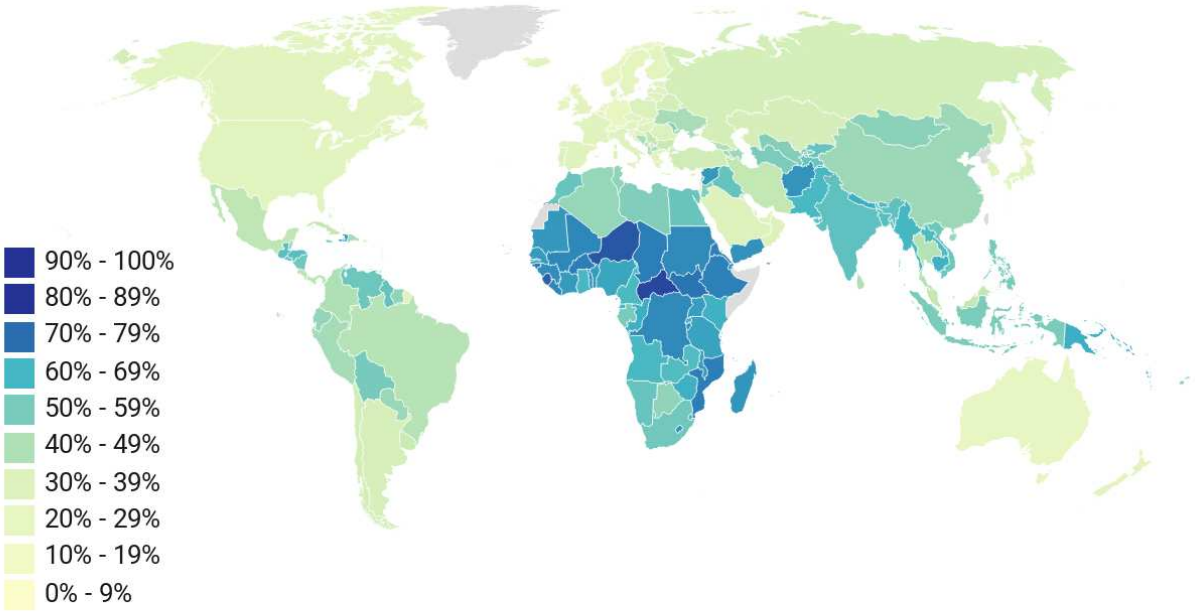


Figure 2(c): Obstetrics

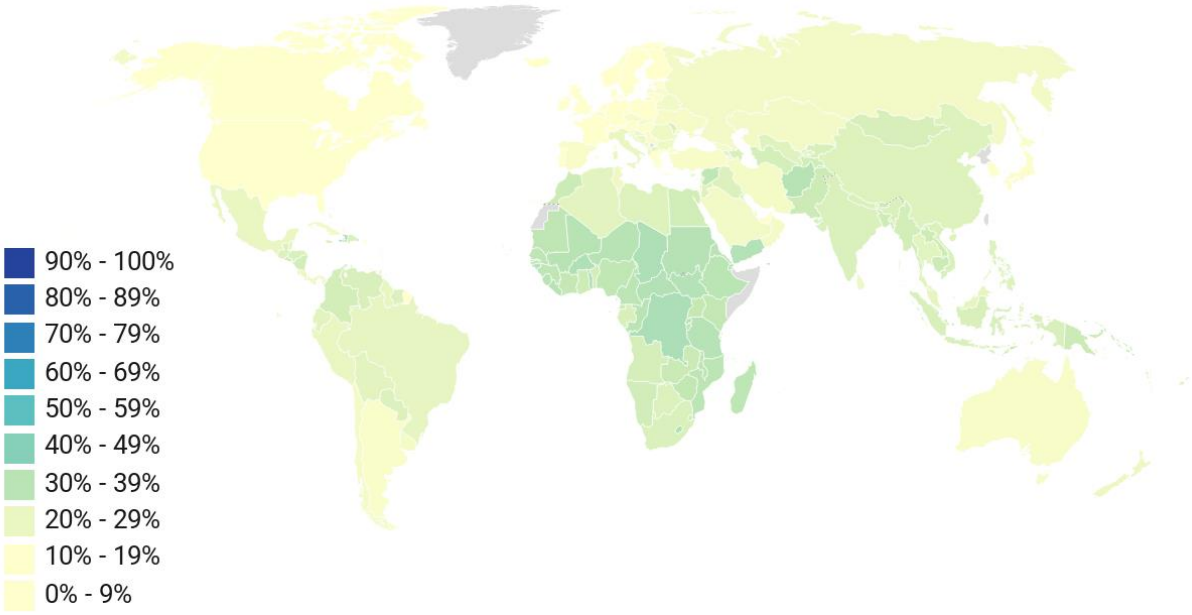
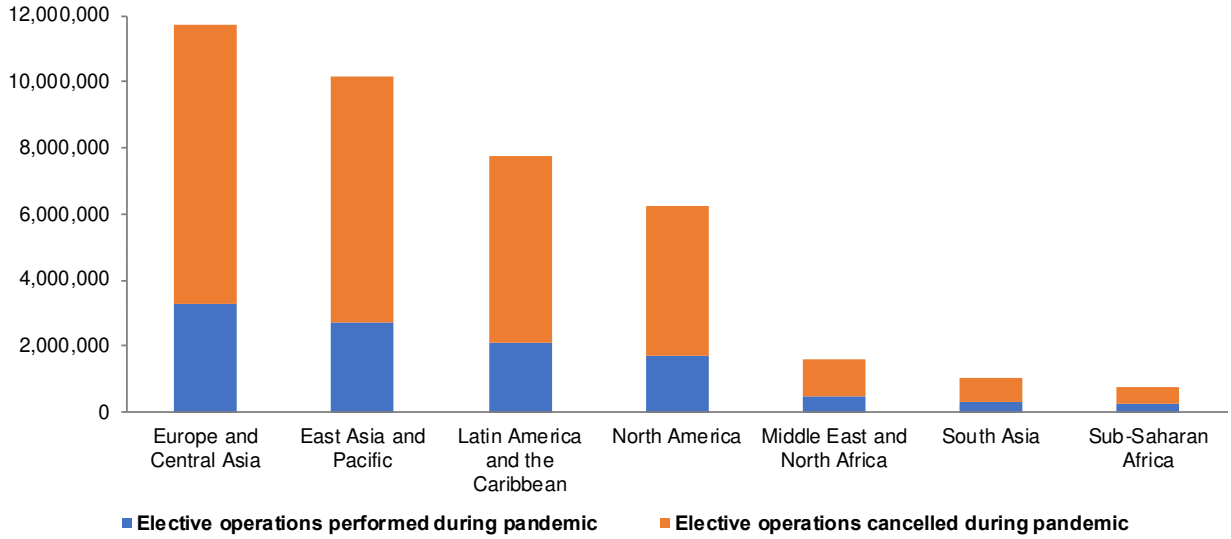


Figure 3: Best estimates for elective operations cancelled during the peak 12 weeks of disruption due to COVID-19, by geographical region



Elective operations performed are those that are projected not to be cancelled during the 12 weeks of peak disruption due to COVID-19