



Appendicitis Global Outcomes (AlliGatOr) Study Protocol: Identifying areas for whole systems strengthening in emergency care pathways

AlliGatOr Study Group on behalf of the NIHR Global Surgery Unit*

Correspondence: Theophilus TK Anyomih, NIHR Global Health Research Unit on Global Surgery, Institute of Applied Health Research, University of Birmingham, Birmingham B15 2TH, UK

t.t.k.anyomih@bham.ac.uk

Dmitri Nepogodiev, NIHR Global Health Research Unit on Global Surgery, Institute of Applied Health Research, University of Birmingham, Birmingham B15 2TH, UK

d.nepogodiev@bham.ac.uk

Abstract

Background: Acute appendicitis is one of the most common surgical emergencies worldwide. The presentation of appendicitis and its management can serve as a benchmark for evaluating the efficiency and effectiveness of emergency health systems. This prospective cohort study aims to identify areas for whole systems strengthening in emergency care using pre-defined key performance measures.

Methods: This international prospective, multicentre cohort study will include all consecutive patients undergoing appendicectomy for suspected appendicitis. A measurement set comprising key outcome measures has been pre-defined to comprehensively evaluate emergency system performance across the world. Data on consecutive patients of any age undergoing appendicectomy will be collected. Patients will be followed up at 30 days to collect outcome data. No changes will be made to routine patient care pathways/management or follow-up in this observational study. A mandatory hospital-level survey will explore available resources, infrastructure, surgical expertise, and relevant care protocols of sites participating in the study. It will allow us to account for variations in hospital capabilities and adjust analyses, improving the accuracy of cross-country comparisons and identifying system-level factors that may affect surgical success. Consultant Leads in each participating hospital will ensure appropriate study registration approval as per local regulations. This is mandatory for participation. There will be two optional sub-studies on waste management and sustainability and financing at select sites.

Discussion: This study will generate granular data on the global variability in appendicectomy management and outcomes, offering insights into access to emergency care, imaging, and minimally invasive surgery. The findings will guide recommendations for both high-income and low- and middle-income countries, informing government policy and improving patient outcomes.

Cite as: Anyomih, T. T. K., Mulliez, A., Elhadi, M., et al. Appendicitis Global Outcomes (AlliGatOr) Study Protocol: Identifying areas for whole systems strengthening in emergency care pathways. *Impact Surgery*, 2(6), 185-192. <https://doi.org/10.62463/surgery.204>

NIHR Global Health Research Unit on Global Surgery, Institute of Applied Health Research, University of Birmingham, Birmingham B15 2TH, UK

**A full list of authors is shown in the Supplement*

Introduction

The importance of a comprehensive system in managing emergency care is well-recognised, including by the World Health Assembly, which has called on its member states to strengthen the provision of emergency care to

ensure safe, timely, and life-saving care to acutely unwell patients, as part of efforts towards universal health coverage (UHC) ¹.

Appendicitis is the most common surgical emergency in the world, and appendicectomy is offered by most first-



level facilities². This makes the surgical management of appendicitis a suitable tracer condition for evaluating the performance of emergency health systems³. Globally, there is variation in presentation and management, although this is not well characterised⁴⁻⁷. Although guidelines recommend laparoscopic appendicectomy as the gold standard treatment for most patients with appendicitis, it is not available in all settings due to variation in resource availability and surgeon training². Pre-hospital factors influence the timing of presentation, and intra-hospital factors delay optimal management and affect patient outcomes. As it is a time-sensitive condition, any delays in access to safe care can significantly impact clinical outcomes and costs⁸. This study will generate granular global data that will guide recommendations for both high-income and low- and middle-income countries, informing government policy and improving patient outcomes.

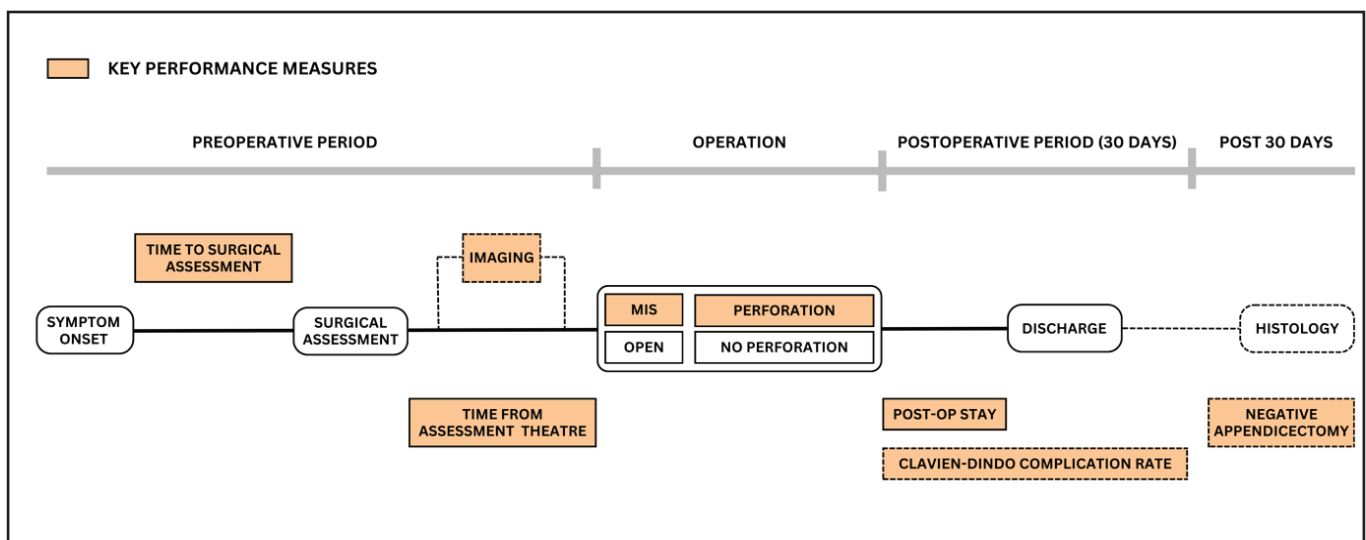
The primary aim is to evaluate variations in the presentation, diagnosis, and management of patients who have surgery for acute appendicitis, taking health system measures into consideration. The secondary aims of this study are to evaluate variations in access to imaging and minimally invasive surgery and their impact on patient outcomes. These would be assessed across groups stratified by human development index, hospital funding, urban/rural, and facility level.

Methods

Study design

This prospective, multicentre, global cohort study will capture patients from 3 February 2025 to 25 May 2025. Any hospital performing appendicectomy worldwide will be eligible to participate, collecting data over 14 days for consecutive patients undergoing appendicectomy for suspected or confirmed acute appendicitis. The primary outcomes will be measured at 30 days following surgery. No changes will be made to routine patient care pathways, management, or follow-up in this observational study. The project will be delivered through the NIHR GlobalSurg Collaborative Network. This network has facilitated several multicentre, international prospective cohort studies, including GlobalSurg, COVIDSurg, and HIPPO studies⁹⁻¹¹. GlobalSurg 1 highlighted significant variability in outcomes following emergency abdominal surgery across different countries, and COVIDSurg studies identified elective care as a priority globally for the immediate future. The HIPPO study demonstrated significant disparity in access and quality and identified targets for elective surgical system strengthening¹⁰. The AlliGatOr study has been designed to identify gaps in emergency systems across the world and make recommendations to improve the emergency care pathway.

Figure 1: Key Performance Measures and the emergency care pathway





Eligibility Criteria

All consecutive patients undergoing appendicectomy for suspected or confirmed appendicitis are eligible for inclusion and should be captured in the study. The full inclusion and exclusion criteria are detailed in Table 1.

Key Performance Measures (KPMs)

There is no single outcome measure that can produce a full picture of emergency care pathways. Through a consensus process, the steering group (Supplement section 1) of diverse surgical and perioperative care practitioners across the world pre-defined a series of KPMs to produce a more comprehensive picture (Table 2). These measures (Time from symptom onset to first surgical assessment, Perforation rate, Imaging, Laparoscopy rate, Time from assessment to theatre, Negative appendicectomy rate, Post-operative length of stay (LOS) and 30-day overall Clavien-Dindo complications) have been integrated into the emergency care pathway in Figure 1.

Audit standards

AlliGatOr will assess several audit standards against which the study's KPMs have been mapped (Table 3). These audit standards are based on the World Society of Emergency Surgery appendicitis guidelines (WSES) ².

Patient-level data collection

The overall data collection window will be from 3 February to 25 May 2025; this could be extended by the steering committee for a further month if required. Teams of up to 3 collaborators will collect data on consecutive eligible patients. For patients seen by the surgical team with a planned return for either assessment and/or imaging before their surgical procedure, this should all count as a single episode of care. To simplify administration, 14-day data collection periods have been pre-specified (Supplementary Table S1). Each participating team may choose to collect data over multiple data collection periods. Within participating hospitals, multiple teams may collect data in distinct data collection periods. If separate surgical teams deliver adults and paediatric

Table 1: Inclusion and exclusion criteria

Hospital eligibility
Hospital surgical capability: Any hospital that performs appendectomies is eligible to participate if they are able to commit to identifying and following up all consecutive eligible patients during their selected 14-day block(s).
Study registration: Participating hospitals must register the study according to local and national requirements before commencing data collection.
Team composition: Each hospital must have an identified Consultant Lead.
Patient eligibility
Inclusion criteria
Age: There are no age restrictions, although if appropriate, participating hospitals can choose to only include children or only adults based on an age cut-off of their choice.
Procedure: All patients undergoing appendicectomy for <u>suspected or confirmed</u> appendicitis by any surgical approach should be included. This includes patients who went to theatre with suspected appendicitis even if the intraoperative or pathology results found a different diagnosis, so long as an appendicectomy was performed. It also includes patients who went to theatre for reasons other than suspected appendicitis but were found to have appendicitis intraoperatively and underwent appendicectomy. This includes interval appendicectomy and right hemicolectomy if performed for acute appendicitis.
Approach: Both open and minimally invasive (laparoscopic and robotic) interventions are eligible for inclusion. Laparoscopic and robotic converted to open cases are also eligible.
Exclusion criteria
Indication: Appendicectomy for any indication other than suspected or confirmed appendicitis should be excluded. For example, patients having appendicectomy for known appendiceal neoplasm.
Procedure: Patients having appendicectomy as part of another surgical procedure should be excluded. For example, patients having appendicectomy as part of a colon cancer procedure are not eligible for inclusion.
Approach: Natural orifice surgery and endoscopic treatment for suspected appendicitis are excluded.
Previous appendicectomy: Patients having surgery for stump appendicitis are excluded.
Return to theatre: Patients should be entered into the study only once. A patient returning to theatre after appendicectomy should not be re-entered as a new patient.



Table 2: Key Performance Measures

KPM	Title	Definition	Rationale
Access and coverage			
1	Time from symptom onset to first assessment by the surgical team	Duration from onset of symptoms to first assessment by the surgical team	Direct measure of access to timely essential emergency surgical care
2	Perforation rate	Proportion of all patients with histology-confirmed appendicitis who had a perforated appendix on histology	Indirect measure of access to timely essential emergency surgical care
3	Imaging	Proportion of all patients having preoperative cross-sectional (CT/MRI) imaging	Direct measure of diagnostic capacity
4	Laparoscopy rate	Proportion of all patients undergoing a laparoscopic approach for appendicectomy	Recommended by WSES, SAGES and EAES guidelines ^{1,2}
Quality and safety			
5	Time from first assessment to theatre	Duration from decision to operate to knife to skin	Direct measure of efficiency of in-hospital pathways
6	Negative appendicectomy rate	Proportion of all patients with a histologically normal appendix	Indirect measure of diagnostic capacity
7	Post-operative length of stay	Length of stay (in days) in hospital after appendicectomy. Day of surgery is considered day 0.	Indirect measure of safety
8	30-day overall Clavien-Dindo complications	See Supplement Table S3.	Direct measure of safety

surgery, then sites can register separate consultant leads for both specialties. In that case, there will be mini- teams for each specialty per distinct data collection period.

Data points

Data will be collected on patient demographics and comorbidities, diagnostics pathways including presentation, clinical, radiological, and biochemical information, intraoperative variables, and postoperative outcomes such as complication rates, readmissions, and mortality. A full list of required data fields captured on the case report form, study definitions, and a detailed Data guide are provided in Supplementary Tables S2, S3, and S4, respectively.

Hospital-level data collection

The hospital-level survey is mandatory for all hospitals participating in the AlliGatOr cohort study. It will provide essential context for interpreting patient-level outcomes across different settings. This survey explores available resources, infrastructure, surgical expertise, and relevant care protocols of hospitals participating in the study. Collecting this information will allow us to account for variations in hospital capabilities and adjust analyses, improving the accuracy of cross-country comparisons and identifying system-level factors that may affect

surgical success. It will be completed by the hospital Consultant Lead and/or hospital co-lead at the point of confirming final authorship details at the end of the study. The AlliGatOr hospital-level survey is in Supplementary Table S5.

Sub-studies

Two sub-studies have been nested into the main cohort study and will be delivered in selected sites only. It will involve collecting patient-level data for at least 5-10 consecutive patients at any point during the data collection window of the main AlliGatOr study.

- (1) *Sustainability and Waste Management sub-study:* This substudy aims to characterise current sustainable practices already used in operating theatres globally, with a focus on the management of waste. It will assess the entire waste management cycle in operating theatres across several hospitals, exploring waste generation, sorting, reuse, recycling, and waste disposal, and how this complies with standard measures. Relevant patient-level data points will be captured on three broad areas of anaesthesia, waste management, including reuse of textiles and equipment, and energy. The detailed CRF is shown in Supplementary table S6.



Table 3: Audit standards for AlliGatOr

Diagnosis
Ultrasound imaging: ‘Ultrasound scan is an appropriate first-line diagnostic tool in both adults and children if an imaging investigation is indicated based on clinical assessments’ (WSES recommendation 1.10, mapped to KPM 3). The gold standard for the overall imaging rate based on previous UK audit data is $\geq 50\%$. ¹²
CT scan: ‘CT scan is recommended for adolescents and young adults with suspected acute appendicitis and negative ultrasound findings’ (WSES recommendation 1.11, mapped to KPM 3). The gold standard for the overall imaging rate based on previous UK audit data is $\geq 50\%$. ¹²
Timing of surgery
In-hospital delays: ‘For both adults and children with uncomplicated appendicitis, appendectomy should be performed within 24 hours of admission or earlier for complicated appendicitis’ (WSES recommendations 3.1, 3.2, 3.3, mapped to KPM 1 & 5). The gold standard is 100%.
Surgical treatment
Surgical approach: ‘For both adults and children, an initial laparoscopic appendectomy is the preferred approach over open procedure where the laparoscopic equipment and expertise are available unless contraindicated. This should be the case for both uncomplicated and complicated appendicitis’ (WSES recommendations 4.1 and 4.2, mapped to KPM 4). The gold standard is $\geq 90\%$.
Length of stay: ‘Outpatient laparoscopic appendectomy for uncomplicated acute appendicitis is feasible and safe without any difference in morbidity and readmission rates’ (WSES recommendations 4.5, mapped to KPM 7 & 8). The gold standard is $\geq 30\%$.
Histopathology
Histopathology: ‘Routine histopathology after appendectomy should be standard of care’ (WSES recommendation 5.1, mapped to KPM 2). The gold standard is 100%.
Negative appendectomy rate: Based on previous UK audit data, the overall negative appendectomy rate in adults should be $< 20\%$ (mapped to KPM 6). The gold standard is $\leq 20\%$. ¹²

Finance substudy: This substudy aims to evaluate catastrophic expenditure in patients undergoing appendectomy and compare the costs of open vs laparoscopic appendectomy. This substudy will be delivered in selected hospitals within the NIHR Global Surgery Unit Hub countries (Benin, Ghana, India, Mexico, Nigeria, Rwanda, and South Africa). All patients undergoing appendectomy in these selected sites are eligible to take part in this substudy. To evaluate catastrophic expenditure, we will consider the three thresholds that have been described for it: out-of-pocket payments greater than 10%, 25% or 40% of patients’ annual household income¹². This study will provide data to support region-specific financial protection strategies in surgical care by assessing catastrophic expenditure at multiple thresholds. To compare the costs of open vs laparoscopic appendectomy from the healthcare perspective, we will use clinical data, including approach, length of stay, surgical site infection, and readmission length of stay. We will primarily collect cost data from the operation type (open and laparoscopic) and the cost of a one-night stay in the hospital. The cost of surgical

site infection will be used from previous studies, also led by the NIHR Global Health Research Unit on Global Surgery¹³. To compare the costs from a societal perspective, we will calculate the productivity loss associated with each approach using the Human Capital Approach¹⁴. We will primarily collect the absenteeism, defined as the number of days out of work and the monthly income of each working patient. The detailed CRF is shown in Supplementary table 6. The summary equations are: Health care cost = operation cost + (LOS*daily cost) + (Surgical Site Infection(SS I)*SS I cost) + (LOS*daily cost; Productivity lost=absenteeism x daily income

Sample size

Based on previous NIHR-GSU prospective cohort studies, this study is anticipated to include around 500 hospitals. Based on an average of one appendectomy per day and two 14-day data collection blocks per hospital, we anticipate capturing data for minimum of 14,000 patients. We expect a plausible range of 8,000–20,000 depending on site uptake.



Ethical consideration, Study registration, and dissemination

The study will be carried out in accordance with national and international guidelines, as well as the basic principles of the protection of the rights and dignity of Human Beings, as set out in the Helsinki Declaration (64th Assembly Fortaleza, Brazil, in October 2013), and according to locally applicable legislation. Ethical approval for AlliGatOr has been granted by the University of Birmingham Science, Technology, Engineering, and Mathematics Committee (Reference number ERN_3201-Oct2024). Hospital leads will be responsible for ensuring all relevant national and/or local approvals are in place prior to any data collection. The full protocol and supporting documents translated to 15 different languages are available at <https://www.globalsurgeryunit.org/clinical-trials-holding-page/project-alligator/>.

The study is registered on clinicaltrials.gov with registration ID NCT06774001. This protocol has been reported in accordance with the SPIROS (Standard Protocol Items for Randomized Observational Studies) checklist, which is provided as supplementary material (Table S7).

Data analysis and publication

The data will be mapped to country income groups, which were defined according to the World Bank into four categories: low-income countries (LICs), lower-middle-income countries (LMICs), upper-middle-income countries (UMICs), and high-income countries (HICs)¹⁵. Continuous data will be presented as mean and standard deviation if normally distributed, and median and IQR if not normally distributed. Categorical variables will be described using frequency tables and percentages. The rates from the KPMs will be presented by income group, and differences between patient, disease, and operative-specific factors will be tested using Student's t-test for continuous data (p-value) and χ^2 for categorical data (reported as χ^2 , p-value). A multilevel regression with random intercepts for hospital nested within country will be used, which will account for clustering and naturally limits the influence of any single, high-volume site multilevel models (hospital nested in country). A formal statistical analysis plan will be finalised prior to data analysis. All statistical analyses will be performed using R (version 4.0.2). A p-value of less than 0.05 will be deemed statistically significant. The Steering Committee

will make the final decision on which key performance measure(s) will be included in the first publication. Remaining KPMs and substudy findings will be reported in subsequent papers.

Discussion

Access to emergency surgical care remains inadequate globally, especially in low-income countries (LICs) and lower-middle-income countries (LMICs). Effective emergency surgical pathways are important for addressing delays and system bottlenecks impacting timely patient care, especially after the COVID-19 pandemic¹⁶⁻¹⁸. The AlliGatOr study will provide granular, real-world data mapping patient journeys through emergency care pathways for acute appendicitis, offering valuable insights into global variability in management, access to imaging and minimally invasive surgery, and patient outcomes.

A unique strength of AlliGatOr is the ability to contextualize findings against existing global surgical benchmarks provided by previous studies. In particular, COVIDSurg-Cancer evaluated the performance of elective cancer surgery pathways during substantial healthcare system duress caused by the COVID-19 pandemic^{19,20}. In contrast, the HIPPO study assessed elective surgical pathways in stable healthcare settings, establishing baseline disparities in quality and access¹⁰. The AlliGatOr study complements these analyses by examining emergency pathways under routine pressures, thus contextualizing how well emergency surgical systems respond under normal but inherently stressful conditions. This approach can highlight specific system weaknesses unique to emergency surgery and facilitate targeted interventions.

An important aspect of the AlliGatOr study is its integration of focused sub-studies addressing contemporary health system challenges; environmental sustainability and financial barriers to care. The Sustainability and Waste Management substudy investigates operating theatre practices, capturing global variability in waste generation, sorting, recycling, and disposal practices. Given that operating theatres account for a substantial portion (50-70%) of the total hospital²¹ waste and represent one of the most energy-intensive components of hospital care, data from this substudy will be important for formulating targeted strategies to reduce carbon footprints and waste generation without compromising patient outcomes^{22,23}.



Similarly, the Finance substudy addresses the critical economic dimensions of emergency surgical care by examining catastrophic expenditures incurred by patients undergoing appendicectomy. Financial constraints and catastrophic health expenditure remain major barriers to accessing timely and effective surgical care globally, particularly in low- and middle-income countries (LMICs)^{24 25}. The substudy will specifically compare the healthcare and societal costs associated with open versus laparoscopic appendicectomy, building on prior evidence from high-income and limited LMIC settings (e.g., Nigeria) that have shown minimally invasive appendicectomy to be potentially cost-effective in practice²⁶. By evaluating catastrophic expenditure across various thresholds (10%, 25%, and 40% of household income), the findings will inform targeted financial protection strategies and health system investments in minimally invasive surgical techniques appropriate to specific contexts.

Nevertheless, this study has several limitations. First, it does not capture individuals who never reach healthcare because of financial, geographic, or system barriers, which may underestimate the true burden of disease and the magnitude of access inequities. Second, by design we enrol only surgically managed cases and exclude non-operative management; although non-operative treatment is used for a minority of patients in most settings, its exclusion narrows external validity to the surgically treated population. Third, we do not collect detailed decision-to-surgery intervals, limiting our ability to separate clinical decision-making delays from system-level delays. Fourth, postoperative events that occur at other hospitals may not be captured where records are not interoperable; as a result, re-presentations (e.g., readmission, re-operation, postoperative infection) may be under-ascertained. Finally, variation in data collection quality across diverse global hospitals may affect the accuracy of comparisons despite standardised protocols and training.

AlliGatOr will advance an understanding of global variations and deficiencies in emergency surgical pathways, especially concerning acute appendicitis management. The study's findings are anticipated to inform tailored, evidence-based policy recommendations for high-, middle-, and low-income settings, guiding future strategies to strengthen emergency surgical care delivery globally, improve resource allocation, and ultimately enhance patient outcomes.

Funding: AlliGatOr Study is funded by the National Institute for Health and Social Care Research (Grant Numbers 156087). The funder has no role in the study design or writing of this protocol. 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.

Data sharing: there is no additional data from this paper.

References

1. The World Health Assembly resolution on integrated emergency, critical, and operative care for universal health coverage and protection from health emergencies: a golden opportunity to attenuate the global burden of acute and critical illness. *Intensive Care Med* 2023;49(10):1223-25. doi: 10.1007/s00134-023-07176-8 [published Online First: 20230814]
2. Di Saverio S, Podda M, De Simone B, et al. Diagnosis and treatment of acute appendicitis: 2020 update of the WSES Jerusalem guidelines. *World J Emerg Surg* 2020;15(1):27. doi: 10.1186/s13017-020-00306-3 [published Online First: 20200415]
3. Kamarajah S, El Boghdady M, Anyomih T, et al. State of the Art Review: Evidence based management of acute appendicitis. *Impact Surgery* 2024;1:35-40. doi: 10.62463/surgery.45
4. Trends and levels of the global, regional, and national burden of appendicitis between 1990 and 2021: findings from the Global Burden of Disease Study 2021. *Lancet Gastroenterol Hepatol* 2024;9(9):825-58. doi: 10.1016/s2468-1253(24)00157-2 [published Online First: 20240717]
5. Bhangu A, Søreide K, Di Saverio S, et al. Acute appendicitis: modern understanding of pathogenesis, diagnosis, and management. *Lancet* 2015;386(10000):1278-87. doi: 10.1016/s0140-6736(15)00275-5
6. Appendicitis risk prediction models in children presenting with right iliac fossa pain (RIFT study): a prospective, multicentre validation study. *Lancet Child Adolesc Health* 2020;4(4):271-80. doi: 10.1016/s2352-4642(20)30006-7 [published Online First: 20200213]
7. Lizzi V, Chean C. Evaluation of clinical examination and preoperative imaging in patients with right iliac fossa pain and a medium or high risk score for appendicitis (RIFT-2). *Impact Surgery* 2024;1:46-54. doi: 10.62463/surgery.34
8. Kulasekera DA, Royan R, Shan Y, et al. Appendicitis Hospitalization Care Costs Among Patients With Delayed Diagnosis of Appendicitis. *JAMA Netw Open* 2024;7(4):e246721. doi: 10.1001/jamanetworkopen.2024.6721 [published Online First: 20240401]
9. Mortality of emergency abdominal surgery in high-, middle- and low-income countries. *Br J Surg* 2016;103(8):971-88. doi: 10.1002/bjs.10151 [published Online First: 20160504]



10. Access to and quality of elective care: a prospective cohort study using hernia surgery as a tracer condition in 83 countries. *Lancet Glob Health* 2024;12(7):e1094-e103. doi: 10.1016/s2214-109x(24)00142-6 [published Online First: 20240523]
11. Mortality and pulmonary complications in patients undergoing surgery with perioperative SARS-CoV-2 infection: an international cohort study. *Lancet* 2020;396(10243):27-38. doi: 10.1016/s0140-6736(20)31182-x [published Online First: 20200529]
12. Nguyen HA, Ahmed S, Turner HC. Overview of the main methods used for estimating catastrophic health expenditure. *Cost Eff Resour Alloc* 2023;21(1):50. doi: 10.1186/s12962-023-00457-5 [published Online First: 20230808]
13. Monahan M, Glasbey J, Roberts TE, et al. The costs of surgical site infection after abdominal surgery in middle-income countries: Key resource use In Wound Infection (KIWI) study. *J Hosp Infect* 2023;136:38-44. doi: 10.1016/j.jhin.2023.03.023 [published Online First: 20230421]
14. Neumann PJ, Russell LB, Siegel JE, et al. Using Cost-Effectiveness Analysis in Health and Medicine: Experiences since the Original Panel. *Cost-Effectiveness in Health and Medicine*: Oxford University Press, 2016:0.
15. Bank W. World Bank Country and Lending Groups 2025 2025 [cited 2025 13-3-2025]. Available from: <https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups>.
16. Alkire BC, Raykar NP, Shrima MG, et al. Global access to surgical care: a modelling study. *Lancet Glob Health* 2015;3(6):e316-23. doi: 10.1016/s2214-109x(15)70115-4 [published Online First: 20150427]
17. The Lancet R. Too long to wait: the impact of COVID-19 on elective surgery. *Lancet Rheumatol* 2021;3(2):e83. doi: 10.1016/s2665-9913(21)00001-1 [published Online First: 20210128]
18. Uimonen M, Kuitunen I, Paloneva J, et al. The impact of the COVID-19 pandemic on waiting times for elective surgery patients: A multicenter study. *PLoS One* 2021;16(7):e0253875. doi: 10.1371/journal.pone.0253875 [published Online First: 20210706]
19. Glasbey JC, Nepogodiev D, Simoes JFF, et al. Elective Cancer Surgery in COVID-19-Free Surgical Pathways During the SARS-CoV-2 Pandemic: An International, Multicenter, Comparative Cohort Study. *J Clin Oncol* 2021;39(1):66-78. doi: 10.1200/jco.20.01933 [published Online First: 20201006]
20. Effect of COVID-19 pandemic lockdowns on planned cancer surgery for 15 tumour types in 61 countries: an international, prospective, cohort study. *Lancet Oncol* 2021;22(11):1507-17. doi: 10.1016/s1470-2045(21)00493-9 [published Online First: 20211005]
21. MacNeill AJ, Lillywhite R, Brown CJ. The impact of surgery on global climate: a carbon footprinting study of operating theatres in three health systems. *Lancet Planet Health* 2017;1(9):e381-e88. doi: 10.1016/s2542-5196(17)30162-6 [published Online First: 20171208]
22. Reducing the environmental impact of surgery on a global scale: systematic review and co-prioritization with healthcare workers in 132 countries. *Br J Surg* 2023;110(7):804-17. doi: 10.1093/bjs/znad092
23. Pietrabissa A, Pugliese L, Filardo M, et al. My OR goes green: Surgery and sustainability. *Cir Esp (Engl Ed)* 2022;100(6):317-19. doi: 10.1016/j.cireng.2022.06.013
24. Haakenstad A, Bintz C, Knight M, et al. Catastrophic health expenditure during the COVID-19 pandemic in five countries: a time-series analysis. *Lancet Glob Health* 2023;11(10):e1629-e39. doi: 10.1016/s2214-109x(23)00330-3
25. Catastrophic expenditure and treatment attrition in patients seeking comprehensive colorectal cancer treatment in India: A prospective multicentre study. *Lancet Reg Health Southeast Asia* 2022;6:None. doi: 10.1016/j.lansea.2022.100058
26. Adisa A, Kachapila M, Ekwunife C, et al. A Prospective, Observational Cost Comparison of Laparoscopic and Open Appendectomy in Three Tertiary Hospitals in Nigeria. *World J Surg* 2023;47(12):3042-50. doi: 10.1007/s00268-023-07148-5 [published Online First: 20231011]