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Financial burden of complications following lung resection: a scoping review protocol

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ABSTRACT

Introduction Global healthcare expenditures are rising, driven largely by increased spending in both high- and low-income countries with hospitalisation as a primary contributor. Respiratory diseases, particularly lung cancer, pose significant public health and economic challenges with thoracic surgery as the standard curative treatment. Complications post resection, such as arrhythmias, infections and respiratory failure, result in substantial healthcare costs and resource demands. Although studies have explored the economic impact of surgeries, there is a limited comprehensive analysis of the financial burden of postoperative complications after lung resection surgery. To address this gap, this scoping review aims to map existing literature on lung resection complications and associated costs, providing insights for future research and healthcare policy.

Methods and analysis This scoping review will be conducting according to the Preferred Reporting Items for Systematic Review and Meta-Analysis Extension for Scoping Reviews standards. Eligible peer-reviewed articles and grey literature will be identified across Medical Literature Analysis and Retrieval System Online, Excerpta Medica Database and Cochrane Central Register of Controlled Trials. Cost data will be converted into US dollars as per the Federal Reserve Bank of St Louis and adjusted for inflation as per the US Bureau of Labor Statistics Consumer Price Index inflation calculator.

Ethics and dissemination Ethics approval was not required. The results will be communicated through established professional networks, conference presentations and publication in peer-reviewed journals.

STRENGTHS AND LIMITATIONS OF THIS STUDY

⇒ This is the first review to comprehensively evaluate the costs of complications after lung resection surgery.
⇒ The review will take a rigorous approach, adhering to Preferred Reporting Items for Systematic Reviews and Meta-Analyses Scoping Review guidelines.
⇒ The evidence generated may be important in redirecting health service funds.
⇒ A limitation is that only articles in English will be reviewed.
⇒ The ability to meaningfully synthesise data may be limited by the heterogenicity of the evidence.

INTRODUCTION

Healthcare expenditure is a matter of increasing global concern. In 2020, global health spending was measured at 10.8% of gross domestic product and preliminary data for 2021 demonstrated a per capita cost increase of 5.8%.[1] These trends, exacerbated by the pandemic-related economic crisis, are largely driven by heightened government spending in high-income countries and private domestic spending in low-income countries.[2] As global health sustainability is reliant on cost-effective resource allocation, there is increasing demand for high-quality healthcare economic assessments.

Understanding the distribution of healthcare costs across direct and indirect expenditure is crucial for informing cost-effectiveness evaluations. While direct costs include hospitalisation, medication and outpatient treatment, indirect costs pertain to the loss of economic resources due to disease-related disability or premature mortality.[3] According to the World Health Organisation, spending on inpatient care surged in 42 out of 50 countries according to available data in 2020 with an average 10% increase observed across high, middle and low-income countries.[1] This highlights hospitalisation as a primary expense driving escalating healthcare costs.

Vonlanthen *et al* identified postoperative complications as the strongest indicator for in-hospital expense and the best target for substantial cost savings.[4] Similarly, a systematic review emphasised intraoperative and perioperative complications in major procedures as an important economic burden for service providers.[5] It is well established that respiratory disease imposes a massive public health and economic burden.[6] Lung malignancy ranks as one of the five major contributing conditions and is of increasing significance in the setting of improved

control of communicable diseases.[1 2] Further, lung cancer has the second highest incidence of any malignancy in the USA in both men and women and accounts for more deaths than breast, prostate, colorectal and pancreatic cancer combined.[7] In the USA, Medicare spends more than US$12 billion each year on lung cancer care.[5] This cost burden is common across other countries and places considerable pressure on public health, academic institutions and clinical leaders to prioritise respiratory health research and provide valuable insights to inform policymakers.[8–10]

Thoracic surgery is considered a standard of care for lung malignancy providing the best curative intent treatment option for patients with resectable disease, despite advancements in outcomes attributed, in part, to the rise in minimally invasive surgery.[11–14] A notable rate of morbidity and mortality persists due to adverse events and postoperative complications.[5] While the association between complications following lung resection surgery and escalating hospital costs has been described,[15–18] the extent of the literature gap on the economic burden of such events remains unknown. Therefore, a better understanding of associated risk factors, general and specific complications and long-term survival is additionally required to adequately support patients and care providers in informed decision-making in lung resection surgeries.

To date, there are no systematic reviews addressing the cost burden of lung resection surgery complications. However, considering the suspected sparsity of literature surrounding this specific topic of interest, a scoping review holds greater value than a systematic review. This approach will enable a detailed examination of emerging evidence while posing further questions which may be subsequently addressed through systematic review.[19]

Accordingly, the key aims of this scoping review are to examine both peer-reviewed and grey literature articles surrounding lung resection complications and associated healthcare costs. The primary objective is to examine the healthcare costs of postoperative complications in adult patients who undergo lung resection surgery. We will identify, analyse and map the existing literature landscape across all types of lung resection surgeries. This review also aims to provide insight for guiding future research initiatives and to bridge knowledge gaps surrounding the economic burden imposed by lung resection complications.

Review objectives

The primary objective of this review is to examine the inpatient healthcare costs associated with postoperative complications in adult patients undergoing lung resection surgery. Healthcare costs are defined as expenses that are directly or indirectly incurred due to perioperative complications by the individual, hospital, organisation or society. The specific categories/groups of lung resections to be investigated include:

- Pneumonectomy including extrapleural pneumonectomy.
- Anatomical and non-anatomical lung resection with palliative intensive surgery.
- Anatomical and non-anatomical lung resection for small and non-small cell lung cancers and other rare malignant tumours.
- Lung resection for metastatic lung cancer.
- Lung resection for benign and inflammatory disease.

Both oncological and non-oncological pathologies will be included. The following procedures will be excluded:

- Pleurodesis.
- Pulmonary decortication.
- Procedures on the pleura.
- Tracheal and bronchial resections (parenchyma sparing resection).
- Endobronchial procedures on bronchus and trachea.
- Chest wall surgery of rib/s.
- Oesophagectomy.
- Mediastinal tumour resections/mediastinoscopy.

Specifically, the following outcomes across the categories/groups of lung resections will be examined:

- Direct costs that are related to complications following lung resection surgery. Direct expenses encompass various fees paid by different entities, such as patients, private insurance companies, government-subsidised insurance agencies or other healthcare providers. The calculation of direct costs would encompass several components including expenses related to theatre, pathology, radiology, pharmaceuticals, medical services such as rehabilitation, chemoradiotherapy, anaesthesia, surgical procedures, critical care physician services, other medical specialty fees, nursing and allied health expenditures.
- Indirect costs associated with lung resection surgery including the costs associated with delayed access to surgical or oncological treatment, costs incurred due to issues affecting the ability to resume work and resulting in income loss, reduced productivity in the workplace and extra health burdens such as quality-of-life expenses or any indirect costs to society as a consequence of developing a complication post lung resection surgery.
- Cost linked to both short-term (30 days) and long-term (>30 days to 5 years) consequences related to lung resection surgery.
- Inpatient, 30-day, 1-year, 5-year and 10-year mortality rates.

A comparative analysis of the cost disparities and differences across the following cohorts of patients will also be conducted:

- Oncological versus non-oncological resections.
- Open versus minimally-invasive procedures.
- Robotic versus video-assisted thoracoscopic surgery procedures.
- Palliative versus curative intent.
- Diagnostic versus therapeutic procedures.
- Public versus private hospital admissions.

- High-volume versus low-volume surgical centres.
- Cross-country cohorts.
- Long-term trends in healthcare costs adjusted for the consumer price index.
- Pneumonectomy versus lobectomy versus segmentectomy versus wedge resection.

METHODS

We will be following the scoping review methodology outlined first by Arksey and O'Malley[20] and later clarified by Levac *et al*.[21] To reduce bias and ensure rigour, The Preferred Reporting Items for Systematic Review and Meta-Analysis (PRISMA) extension for Scoping Reviews guidelines will be applied when relevant.[22] Our intention is that through the application of this framework, the review will be systematic and comprehensive.

Protocol and registration

This protocol centres around the broad research topic of describing the healthcare cost of postoperative complications following lung resection surgery, which was developed following engagement with expert thoracic surgeons, anaesthesiologists and perioperative physicians working in thoracic surgery. The measures of interest will focus on complication type, frequency, associated costs and patient outcome. The publication will allow for review transparency, dissemination and public accessibility as well as feedback from patients, carers and healthcare providers.

Search strategy

Eligible articles will be identified using the Medical Literature Analysis and Retrieval System Online (MEDLINE) via Ovid, Excerpta Medica Database (EMBASE) via Ovid and the Cochrane Central Register of Controlled Trials (CENTRAL) databases. To ensure thorough coverage, references tracking of articles deemed eligible will be examined. We will include grey literature produced by hospital annual reports and government documents that report on the costs of complications post lung resection surgery.

The proposed search strategy for MEDLINE Ovid, EMBASE Ovid and CENTRAL is available in online supplemental table 1. Grey literature will be searched using the following search terms: 'lung surgery', 'lung resection', 'lung', 'cost', 'expenditure' and 'complication'. All studies published prior to 15 November 2024 will be eligible. The timeline for the scoping review is (1) screening of articles (1 October to 20 November 2024), (2) analysis (1 December 2024 to 31 January 2025), (2) completion and journal submission (1 February 2025).

Eligibility criteria

Eligible primary empirical research will include randomised control trials, cohort studies, cross-sectional studies and case reports. Full-text articles and conference proceedings will also be included. Protocols for planned studies, abstracts, posters, editorial articles and dissertations will be excluded as well as articles for which the full-text or an English version cannot be accessed. No date limits will be applied to the literature used in this review. The details of the inclusion and exclusion criteria are displayed in table 1.

Screening procedure

The study selection will be approached systematically through the application of the inclusion and exclusion criteria described. All documents displaying potential for inclusion will be screened in two stages. First, two reviewers will independently assess the titles and abstracts of articles arising from the search. To quantify the agreement between reviewers and increase reliability, a pilot test will be performed on a random sample of 50 articles from the initial screening. Calculation of a kappa statistic will then be performed and interpreted as follows: Values ≤0 as indicating no agreement, 0.01–0.20 as none to slight, 0.21–0.40 as fair, 0.41–0.60 as moderate, 0.61–0.80 as substantial and 0.81–1.00 as almost perfect agreement. A kappa value of 0.8–0.90 (ie, a strong level of agreement) will be the defined threshold for acceptance. A full-text screening of eligible documents will follow, determining final inclusion. The reasons for the exclusion of studies that underwent full-text assessment will be documented.

Throughout both stages, any disparity among authors on the appropriateness of studies will be resolved through discussion or via consultation with a third reviewer. EndNote X9 (Clarivate Analytics, Pennsylvania, USA) software will be used to manage citations throughout the selection process via merging of papers and removal of duplicates. The results of each stage of the planned search will be presented in detail through a PRISMA flow diagram in the final report.

Data extraction

From each study, we will extract all available data pertaining to the following outcomes:

- Methodology and study characteristics (study design, aims, inclusion and exclusion criteria, sample size, dates of data collection, institution, country, sources of sponsorship).
- Population demographics (age, sex, ethnicity, socioeconomic status, public or private health facility, private health insurance status).
- Operative indication.
- Treatment with neoadjuvant chemotherapy or radiotherapy.
- Preoperative screening, prehabilitation or pulmonary rehabilitation.
- Health status, functional status, physical status and respiratory function.
- Type of lung resection surgery.
- Surgical approach (open, video-assisted, robotic, hybrid or other).
- Definitions of costs and complications used within the study.
- Incidence of complications (severity and type).

Table 1 Review of eligibility criteria based on adult population, concept, context and types of evidence

	Inclusion criteria	Exclusion criteria
Evidence types	► Randomised control trials. ► Cohort studies. ► Cross-sectional studies. ► Case reports. ► Full-text articles. ► Full-text conference proceedings. ► Abstracts for posters. ► Grey literature including hospital annual reports and government documents reporting on costs of complications post lung resection surgery.	► Articles of which the full text cannot be accessed. ► Abstracts written in a language other than English. ► Protocols for planned studies. ► Editorial articles.
Population	Adult patients (≥18 years) undergoing: ► Pneumonectomy including extrapleural pneumonectomy. ► Anatomical and non-anatomical lung resections with palliative intensive surgery. ► Anatomical and non-anatomical lung resections for small and non-small cell lung cancers and other rare malignant tumours. ► Lung resection surgery for metastatic lung cancer. ► Lung resection surgery for benign and inflammatory disease.	Excluded procedures will include ► Pleurodesis. ► Pulmonary decortication. ► Procedures on the pleura. ► Tracheal and bronchial (parenchyma sparing resections. ► Oesophagectomy. ► Mediastinal tumour resections/ mediastinoscopy. ► Endobronchial procedures on the bronchus and trachea. ► Surgery on the chest wall and/or ribs.
Concept	► Studies that evaluate the cost burden of complications after lung resection surgery.	► Studies that collect economic and psychosocial information surrounding the outcomes of patients undergoing lung resection surgery.
Context	► Exploring economic burden and costs of complications associated with post pneumonectomy, lobectomy, segmentectomy and wedge resection complications.	

- ► Reported directed or indirect costs of any complications (as outlined above).
- ► Length of hospital stay, rate of return to theatre, rate and duration of admission to the ICU.
- ► Rate and duration of unplanned readmissions to hospital following discharge.
- ► Postoperative pain outcomes.
- ► Quality of life outcomes and requirement for allied health services in managing complications.
- ► Perioperative and postoperative mortality.

Data synthesis

The costs associated with complications will be determined by either identifying the specified value published in the studies or if not published but calculating the disparity in costs between the groups that had problems and those who did not.

Comparison across studies will be achieved through the conversion of all costs into US dollars (US$) as determined by the annual average conversion rate as per historical data from the Federal Reserve Bank of St Louis. To adjust costs for inflation (to October 2024) the US Bureau of Labor Statistics Consumer Price Index calculator will be used.

Where studies specify a year for which adjusted costs were reported, the annual conversion rates for the specified year will serve as the exchange rate along with adjustments for inflation. Where articles have converted reported costs to an alternative currency, the year of conversion will be used as the base currency year for adjusting costs to an October 2024 US$ equivalent. In cases where no currency year is specified, an average annual conversion rate across all years for which the study had collected cost data will be used for currency conversion and inflation adjustment.

Data analysis

We will employ a mixed-methods approach to analyse qualitative and quantitative data to provide a comprehensive understanding of both direct and indirect costs associated with various surgical interventions and complications. Drivers of direct and indirect costs will be described using a qualitative analysis framework. We will systematically identify and categorise cost drivers, patterns and themes from narrative data. Where appropriate, we will use thematic analysis techniques to organise qualitative data into meaningful categories ensuring that the findings reflect the diverse factors influencing costs.

Summative costs will be presented using descriptive statistics such as means, medians, SD and ranges. Formal comparative analysis will be applied to compare costs between groups/categories, for example, complications versus no complications, oncological resections versus non-oncological resections or cost differences between surgical techniques.

Appropriate statistical tests (eg, analysis of variance, Kruskal-Wallis or χ^2 tests for categorical comparisons and t-tests or Mann-Whitney U tests for continuous variables) will be used according to the data distribution and variance.

To facilitate the identification of factors driving cost differences and inform strategies for cost containment, any trends in costs over time or across subgroups will be analysed to identify patterns and predictors of cost variability. Regression analysis or time-series analysis will be used to explore relationships between surgical techniques, complications and cost outcomes.

Ethics and dissemination

Given this proposed study will not involve human participants or unpublished secondary data, approval from the Human Research Ethics Committee is not required. The findings of the scoping review will be presented at a national or international conference and published in a scientific journal. The authors anticipate that this analysis of the current literature surrounding the costs of lung resection complications will help to guide further research and bring awareness to this healthcare expenditure.

Patient and public involvement

This study centres on existing research studies and therefore involves no patients or members of the public.

DISCUSSION

To our knowledge, this review is the first to examine the healthcare cost of complications post lung resection surgery. By summarising the literature body and disseminating the findings to national and international stakeholders, the evidence generated may be important in addressing lung resection complications and redirecting health service funds. This review is also expected to direct future research. While this scoping review will effectively explore the field of the cost burden of lung resection complications, further reviews may be required to comprehensively investigate the economic burden of lesser resections or to address specific techniques of practice.

Contributors All authors contributed meaningfully to the preparation, drafting and editing of this scoping review protocol. LW (guarantor) conceived the idea and guided the research team throughout the protocol development. AF and LW (corresponding author) conceptualised the research questions, core research plan details and data extraction tool, subsequently generating the initial draft of this manuscript. Following multiple rounds of editing and iterations, all authors (JB, HS, SB, RC) reviewed and endorsed the final version of the submitted manuscript and agreed to be accountable for all aspects of this protocol.

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REFERENCES

1 World Health Organization. Global spending on health: rising to the pandemic's challenges. 2022.
2 World Health Organization. Global spending on health 2020: weathering the storm. 2020.
3 Barathe PC, Haridas HT, Soni P, *et al*. Cost of breast cancer diagnosis and treatment in India: a scoping review protocol. *BMJ Open* 2022;12:e057008.
4 Vonlanthen R, Slankamenac K, Breitenstein S, *et al*. The impact of complications on costs of major surgical procedures: a cost analysis of 1200 patients. *Ann Surg* 2011;254:907–13.
5 Patel AS, Bergman A, Moore BW, *et al*. The economic burden of complications occurring in major surgical procedures: a systematic review. *Appl Health Econ Health Policy* 2013;11:577–92.
6 Ferkol T, Schraufnagel D. The global burden of respiratory disease. *Ann Am Thorac Soc* 2014;11:404–6.
7 Siegel R, Naishadham D, Jemal A. Cancer statistics, 2012. *CA Cancer J Clin* 2012;62:10–29.
8 Health AIo, Welfare. *Health System Expenditure on Cancer and Other Neoplasms in Australia 2008-09*. Canberra: AIHW, 2013.
9 Goldsbury DE, Yap S, Weber MF, *et al*. Health services costs for cancer care in Australia: Estimates from the 45 and Up Study. *PLoS One* 2018;13:e0201552.
10 Estimating the cost of cancer to Australia's health services: cancer council. n.d. Available: https://www.cancercouncil.com.au/research-pt/estimating-the-cost-of-cancer-to-australias-health-services/
11 Lim E, Batchelor TJP, Dunning J, *et al*. Video-Assisted Thoracoscopic or Open Lobectomy in Early-Stage Lung Cancer. *NEJM Evid* 2022;1:EVIDoa2100016.
12 Medbery RL, Perez SD, Force SD, *et al*. Video-assisted thoracic surgery lobectomy cost variability: implications for a bundled payment era. *Ann Thorac Surg* 2014;97:1686–92.
13 Lipińska J, Wawrzycki M, Jabłoński S. Comparison of costs of hospitalization of patients with primary lung cancer after lobectomy with access through classic thoracotomy and VATS in the conditions of financing based on diagnosis-related groups. *J Thorac Dis* 2019;11:3490–5.
14 Bendixen M, Kronborg C, Jørgensen OD, *et al*. Cost-utility analysis of minimally invasive surgery for lung cancer: a randomized controlled trial. *Eur J Cardiothorac Surg* 2019;56:754–61.
15 Benzo R, Kelley GA, Recchi L, *et al*. Complications of lung resection and exercise capacity: a meta-analysis. *Respir Med* 2007;101:1790–7.
16 Alloubi I, Jougon J, Delcambre F, *et al*. Early complications after pneumonectomy: retrospective study of 168 patients. *Interact Cardiovasc Thorac Surg* 2010;11:162–5.
17 Farjah F, Varghese TK, Costas K, *et al*. Lung resection outcomes and costs in Washington State: a case for regional quality improvement. *Ann Thorac Surg* 2014;98:175–81.
18 Varela G, Jiménez MF, Novoa N, *et al*. Estimating hospital costs attributable to prolonged air leak in pulmonary lobectomy. *Eur J Cardiothorac Surg* 2005;27:329–33.
19 Munn Z, Peters MDJ, Stern C, *et al*. Systematic review or scoping review? Guidance for authors when choosing between a systematic or scoping review approach. *BMC Med Res Methodol* 2018;18:143.
20 Arksey H, O'Malley L. Scoping studies: towards a methodological framework. *Int J Soc Res Methodol* 2005;8:19–32.
21 Levac D, Colquhoun H, O'Brien KK. Scoping studies: advancing the methodology. *Implement Sci* 2010;5:69.
22 Tricco AC, Lillie E, Zarin W, *et al*. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. *Ann Intern Med* 2018;169:467–73.