



Protocols

Adult cardiac surgical cost variation around the world: *Protocol for a systematic review*



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ARTICLE INFO

Article history:

Received 3 July 2020

Received in revised form 24 July 2020

Accepted 25 July 2020

Available online 3 August 2020

Keywords:

Cardiac surgery

Global health

Health policy

Health economics

ABSTRACT

Introduction: Globally, over one million cardiac operations occur each year, whereas cardiac surgery is expensive and largely inaccessible without insurance or philanthropic support. Substantial cost variation has been reported within cardiac surgery in the United States and among non-cardiac surgical procedures globally, but little is known on the global procedural cost variation for common adult cardiac surgical procedures.

Objectives and significance: This review seeks to assess variation in procedural costs of coronary artery bypass grafting (CABG), mitral valve repair, mitral valve replacement, aortic valve repair, aortic valve replacement, and combined CABG-mitral or CABG-aortic valve procedures between and within countries. Results may give insights in the scope and drivers of cost variation around the world, posing cost reduction lessons. Results may further inform the potential of economies of scale in reducing procedural costs, benefiting patients, hospitals, governments, and insurers.

Methods and analysis: A systematic review will be performed using the EconLit, Embase, PubMed/MEDLINE, Web of Science, and WHO Global Index Medicus databases to identify articles published between January 1, 2000 and June 1, 2020. Studies describing procedural costs for CABG, mitral valve repair, mitral valve replacement, aortic valve repair, aortic valve replacement, and combined CABG-mitral or CABG-aortic valve procedures will be identified. Articles describing other types of cardiac surgery, concomitant aortic surgery, only describing costs related to non-surgical care, or with incomplete cost data will be excluded from the analysis. No exclusion will be based solely on article type or language. Identified costs will be converted to 2019 USD to account for local currency unit inflation and exchange fluctuations.

Ethics and dissemination: This study protocol has been prospectively registered on the International Platform of Registered Systematic Review and Meta-analysis Protocols. This review requires no institutional review board approval. Results of this study will be summarized and disseminated in a peer-review journal.

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1. Introduction

Over one million cardiac surgical procedures take place around the world each year, a majority of which takes place in high-income countries (HICs) [1]. Cardiac surgery is expensive and

largely inaccessible without comprehensive public or private health insurance or philanthropic support to carry the financial burden for patients. Despite concerns regarding costs of cardiac surgery in low- and middle-income countries (LMICs) and small island developing states (SIDS), initial data suggest favourable cost-effectiveness to establish and operate local cardiac centers in LMICs and SIDS alike [2–4].

In the United States, substantial cost variation has been observed for various surgical procedures across and within

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different states, due to variation in local case volume, billing practices, health networks, insurers, practice patterns, and surgical outcomes [5,6]. Similarly, non-cardiac surgical procedures have large differences in cost around the world, especially due to differences in health systems and insurance models, surgical supply chains, (de-)centralization, and modern health care technologies [7,8]. However, little is known about the variation in costs for adult cardiac surgical procedures around the world.

Overall, procedural costs are lower in LMICs compared to HICs, in part due to reduced staff and overhead costs and the common reliance on donated or discounted surgical supplies. However, the lack of public health insurance, health care infrastructure, and lower socioeconomic status introduce substantial barriers to accessing care [9]. Nevertheless, lessons may be drawn from country-level variation to reduce surgical costs around the world and, subsequently increase international access to life-saving cardiac surgical services.

Here, we aim to perform a systematic review of medical and economic literature to assess cost variation of common adult cardiac surgical procedures (coronary artery bypass grafting (CABG), mitral valve repair and replacement, aortic valve repair and replacement, and combined CABG-mitral or CABG-aortic valve procedures) around the world in order to better understand global disparities and draw lessons to reduce procedural costs and improve the cost-effectiveness of cardiac surgery.

2. Objectives and significance

The main objective of this review is to assess the variation in procedural costs of CABG, mitral valve repair, mitral valve replacement, aortic valve repair, aortic valve replacement, and combined CABG-mitral or CABG-aortic valve procedures between and within countries. These procedures are chosen based on their common occurrence globally, including the repair-oriented focus in LMICs, where prosthetic valves, reinterventions, and anticoagulation introduce longitudinal difficulties in ensuring optimal context-specific patient outcomes. Results of these analyses may give insights into the scope and drivers of procedural cost variation around the world, enabling potential cost reduction. This is important in light of the overall high costs associated with cardiac surgical episodes and the financial barriers these impose for uninsured or under-insured patients. In LMICs, where the overall human development index and socioeconomic status is comparatively lower, financially disadvantaged patients are even more common. Results from this review may also illustrate the potential of economies of scale in reducing procedural costs, benefiting patients, hospitals, governments, and insurers.

The results from this review may further inform future studies by generating novel research questions. For example, follow-up studies may look at pre- and post-procedure costs, the location of recovery after hospital discharge, the impact on patients' employment status, and the variations of all of these factors within and between countries.

3. Methods

3.1. Literature search

A systematic review will be performed according to the PRISMA guidelines using the EconLit, Embase, PubMed/MEDLINE, Web of Science, and WHO Global Index Medicus databases to identify articles published between January 1, 2000, and June 1, 2020 (Fig. 1) [10]. The search strings per database include combinations of the keywords "cardiac surgery" and "cost". The [Supplementary Materials](#) present individual database queries and their respective

yields. We will further manually review reference lists of all articles that will be included after screening. Articles describing other types of cardiac surgery, concomitant aortic surgery, only describing costs related to non-surgical care, or with incomplete cost data will be excluded from the analysis. No exclusion will be done solely based on article type or language, whereas eligible procedures with a concomitant maze procedure will be included.

3.2. Screening and data extraction

Literature search yields will be uploaded and screened in Covidence by six independent reviewers in a way that every article is screened by two reviewers in the abstract and full-text screening stages. Screening conflicts will be resolved by a third independent reviewer. Articles included after screening will be extracted for information regarding the study design, costing method, country, hospital, procedures, costs per procedure and, where available, costs of overall hospital stay, individual (non-medical) expenses, operating time, length of stay, perioperative mortality, and perioperative complications. Upon the extraction of a study's country, the health care system model (Beveridge, Bismarck, National Health Insurance, or out-of-pocket) is identified.

3.3. Costing comparisons

All identified costs will be converted to 2019 USD to account for local currency unit (LCU) inflation and LCU-USD exchange fluctuations. Exchange rates, for USD per LCU and year-specific data, will be obtained from the World Bank World Development Indicators database. Country-level comparisons will be made between HICs and LMICs as defined by the World Bank Country and Lending Groups classification.

3.4. Data analysis

Cost variables are assumed to have non-normal distributions. For other variables, normality of data will be assessed using the Shapiro-Wilk's test. Continuous variables will be analyzed using the independent student's t-test (normality) or Mann-Whitney U test (non-normality). Categorical variables will be analyzed using chi-square or Fisher's exact tests. Multi-set comparisons will be performed using ANOVA or Kruskal-Wallis tests. Continuous variables will be reported as mean with standard deviation (if normally distributed) or median with interquartile range (if non-normality). Categorical variables will be reported as counts and percentages. R Statistical Software version 4.0.1 (R Foundation for Statistical Computing, Vienna, Austria) will be used to perform the data analysis. Statistical significance will be accepted at p-values < 0.05.

3.5. Quality assessment

Due to the variation in study designs (no exclusion is done based on study design) and the primary outcome of interest (i.e., direct procedural costs), no appropriate quality assessment checklist has been identified. Instead, quality assessment will be performed by the authors based on the following criteria: 1) is there a clear description of the procedure performed and does it fit the procedures eligible for inclusion, 2) is there a clear description of the cost definitions (procedural costs versus total hospital costs), 3) is the study sample representative for the patient population studied, and 4) is data reporting complete?

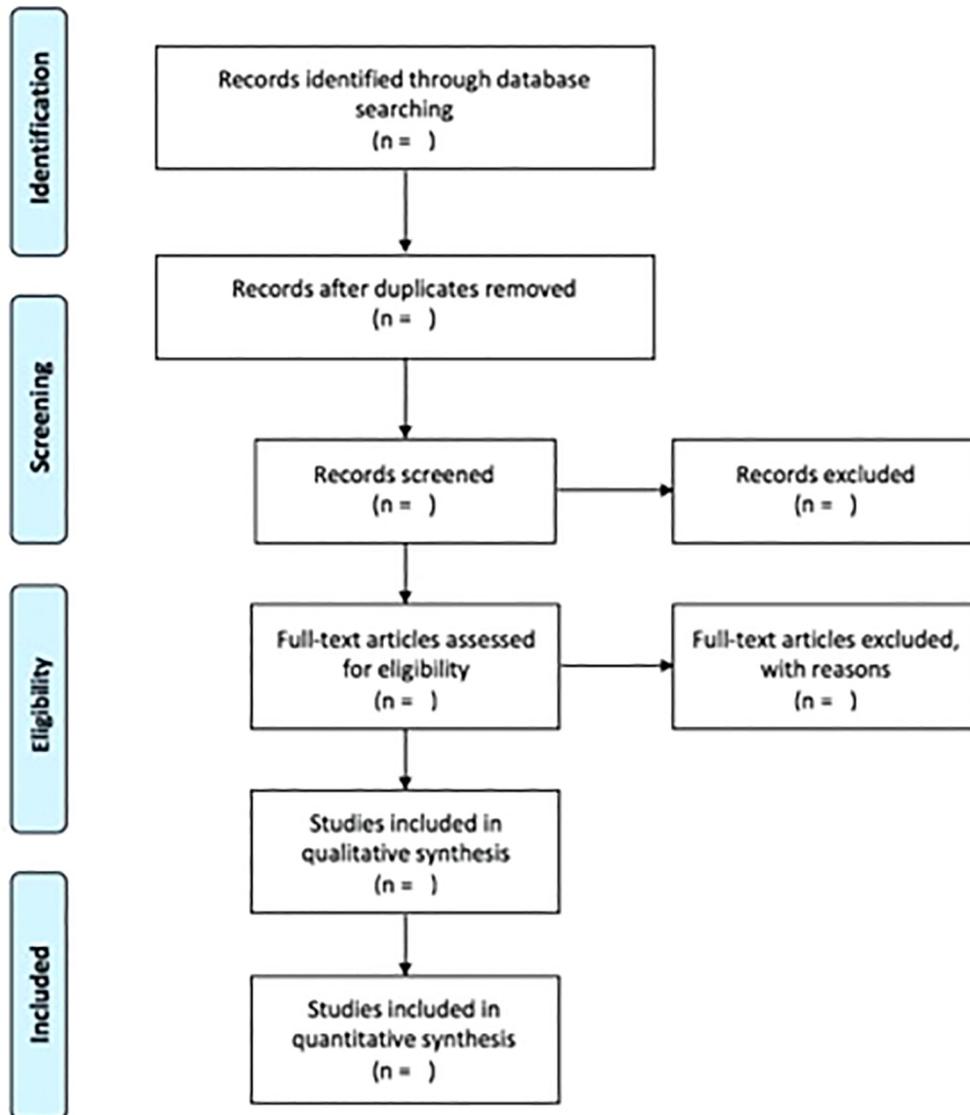


Fig. 1. PRISMA systematic review flowchart.

3.6. Registration

This study protocol has been prospectively registered on Research Registry (Review Registry UIN reviewregistry949).

4. Ethics and dissemination

This study uses peer-reviewed published literature; as a result, there is no need for institutional review board approval. Results of this study will be summarized in English and disseminated by submission for publication in a peer-review journal.

5. Limitations

This review is anticipated to have several limitations. First, our analysis will focus on direct procedural costs, rather than pre- and postoperative costs and non-medical expenditure. These costs are commonly of great burden to patients (if paying completely or partially out-of-pocket) and insurers, but not commonly included in procedure-based cost analyses. Second, in some studies, charges (the price paid by patients, governments, or third-party payers)

and costs (true costs for hospitals) are often used interchangeably. However, in most countries, the cost-to-charge variation is stable and costs and charges approximately equal, and, therefore, we anticipate little impact thereof on the results that will be obtained from this review. Third, our search did not include grey literature (e.g., Ministry of Health reports on government spending, non-governmental organization data on per-procedure costs) due to the overall lack of granularity of cost reporting in such reports.

Funding

None.

CRediT authorship contribution statement

Dominique Vervoort: Conception and design, Methodology, Writing, Critical review and approval. **Camila R. Guetter:** Methodology, Writing, Critical review and approval. **Lena Trager:** Methodology, Writing, Critical review and approval. **Priyansh Shah:** Methodology, Writing, Critical review and approval. **Carlos Eduardo Diaz-Castrillon:** Methodology, Writing, Critical review

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Guarantor

Dominique Vervoort.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.isjp.2020.07.004>.

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