**Global Cardiac Surgery and the COVID-19 Pandemic: Bouncing Back, Higher Than Before?**

Dominique Vervoort, MD1

**Affiliation**

1 Johns Hopkins Bloomberg School of Public Health, Baltimore, Maryland, United States

**Corresponding Author**

Dominique Vervoort, MD

Johns Hopkins Bloomberg School of Public Health

615 North Wolfe Street, 21205 Baltimore, Maryland, USA

+1 857-415-9747

[vervoortdominique@hotmail.com](mailto:vervoortdominique@hotmail.com)

**Word Count:** 2,288

**Keywords:** COVID-19; Coronavirus; Global Health; Global Surgery

**Funding Source**: None.

**Conflicts of Interest**: None.

**One-Sentence Summary**

The COVID-19 pandemic has a substantial impact on the availability of the already scant cardiac surgical services in low- and middle-income countries, but opportunities arise for post-COVID-19 cardiac surgical care expansion through a health systems lens.

**Introduction**

The coronavirus disease 2019 (COVID-19) pandemic has not left anyone untouched. By the end of June 2020, over 10 million people were confirmed to have been infected with COVID-19, resulting in national and regional lockdowns and other contingency measures across the globe. Since March 2020, elective surgical procedures have been postponed or cancelled in large numbers around the world, leading to a backlog of nearly 30 million procedures in just 12 weeks.[1](https://paperpile.com/c/8QtwDz/qZxs) In low- and middle-income countries (LMICs), where surgical care delivery is already constrained by reduced availability of workforce, infrastructural capacity, geographical distance, and financial barriers, the COVID-19 pandemic may have even larger consequences.[2](https://paperpile.com/c/8QtwDz/esDM)

Five billion people worldwide live without access to safe, timely, and affordable surgical care when needed, especially concerning for individuals living with cardiac surgical conditions in LMICs.[3,4](https://paperpile.com/c/8QtwDz/N7jA+qDPw) Traditionally, access to surgical care has been defined through four major determinants, being accessibility, capacity, quality, and affordability.[5](https://paperpile.com/c/8QtwDz/VCyq) Additionally, the Three Delays Framework has been frequently used to assess barriers underlying access to surgical care and can be dissected in terms of the delays in seeking care, reaching care, and receiving care.[6](https://paperpile.com/c/8QtwDz/zjei) Regardless of the framework applied, barriers have been significantly increased due to COVID-19. Here, an analysis of the barriers to cardiac surgical care in LMICs is performed to better understand the impact of the COVID-19 pandemic on cardiac surgical services around the world and to identify opportunities for increased attention to scale services during and beyond the pandemic (**Table 1**).

**Pre-COVID-19**

*Accessibility*

Today, many countries around the world remain without cardiac centers. Estimates suggest that there are little over 4,000 centers around the world, mostly located in high-income countries: North America has one cardiac center per 120,000 people, whereas there is only one per 16 million people in Asia and one per 33 million people in sub-Saharan Africa.[7](https://paperpile.com/c/8QtwDz/kE8v) The few LMIC centers have commonly become regional centers serving neighboring countries but patients are faced with significant delays and costs due to waiting lists, distance to centers, extended time away from work, and financial barriers.[8,9](https://paperpile.com/c/8QtwDz/SGzw+c4Rm)

*Capacity*

In line with the maldistribution of cardiac centers around the world, cardiac surgeons are scarce in LMICs. High-income countries, while reported to face a shortage in cardiac surgeons themselves, have a more than 100 times higher density of cardiac surgeons compared to low-income countries.[4,10,11](https://paperpile.com/c/8QtwDz/rTfB+tDP0+qDPw) Where high-income countries can rely on 7.15 cardiac surgeons per million population, low-income countries have only 0.04 per million.[4](https://paperpile.com/c/8QtwDz/qDPw) For children, similar disparities are clear: high-income countries have 9.51 pediatric cardiac surgeons per million pediatric population, compared to only 0.07 per million children in low-income countries. Non-governmental organizations (NGOs) have been successful in partially bridging the volume and capacity-building gaps in LMICs but much remains to be done to empower and ensure local independent or quasi-independent services.[12](https://paperpile.com/c/8QtwDz/2MWR)

*Quality*

Although the delivery of cardiac surgical services in LMICs is limited, quality ought to be maintained throughout. Low-quality care may be more dangerous than no care, which is especially of concern with complex interventions as cardiac surgery.[13](https://paperpile.com/c/8QtwDz/8bms) However, despite the misperceptions arising from cardiac surgery in LMIC settings, excellent outcomes have been observed in distinct programs in LMICs.[14](https://paperpile.com/c/8QtwDz/3ogW) The quality of care and surgical outcomes vary widely in LMICs, ranging from comparable outcomes in high-income countries to worse or palliation-oriented outcomes. Nevertheless, the good outcomes perceived in many LMICs suggest the feasibility of high-quality perioperative and early postoperative outcomes. This may suggest that it is not necessarily a lack of skills or training of local surgeons--who are often trained in specialized centers abroad--but rather widespread resource constraints, insufficient postoperative care capacity, and/or choice of different (e.g., palliative) techniques due to patients’ context amidst limited follow-up capacity and financial constraints.

*Affordability*

Cardiac surgery is expensive and imposes a substantial financial burden on patients without health insurance or other means of financial risk protection. Whilst procedural costs are lower in LMICs compared to high-income countries, the lack of coverage mechanisms and the proportionally higher costs relative to individuals’ income introduce nearly insurmountable financial barriers. To bridge this, several mechanisms have been introduced across different LMICs. *First*, dedicated government schemes may be in place to cover costly lifesaving interventions. For example, in Nepal, the young, the elderly, and the impoverished are covered by the “Poor Patients Relief” program, in particular for rheumatic heart disease patients. *Second*, co-financing models may allow for wealthier patients to pay a slightly higher charge to enable poorer patients to undergo surgery. Narayana Health, for example, has leveraged such a mechanism in India in parallel with its unique economy of scale, reducing actual procedural costs to as low as $1,500 per surgery. *Third*, NGOs and other visiting teams generally operate through models providing free or low-cost surgical care to local patients, thereby mitigating part of the financial barriers associated with it.

**During COVID-19**

*Accessibility*

As a result of lockdowns and travel restrictions, regional centers have been less able to treat patients from abroad. For example, the Salaam Cardiac Center in Khartoum, Sudan, operated for free on patients from across the African continent but saw a substantial drop in foreign patients whilst also supporting Sudan’s COVID-19 response. Similarly, the lockdown in India led to a decline in services at Narayana Health for both domestic and, especially, foreign patients. Additionally, visiting teams and NGOs have had to reduce or even completely halt services for an indefinite amount of time, majorly affecting local cardiac surgical volume.[15](https://paperpile.com/c/8QtwDz/PGEJ) Lastly, whereas high-income countries were commonly able to make a distinction between “hot” (COVID-19 treatment) and “cold” centers (no COVID-19 patients) within a single city or through nearby collaboration, LMICs often rely on a single center for the entire country or for multiple neighbouring countries and have a smaller health system bandwidth to cope with a surge in COVID-19 infections. These limitations lead to the need for LMIC centers to adapt to treat COVID-19 patients and reduce cardiac surgical services to a bare minimum, if not having to completely cease services to support the COVID-19 response.

*Capacity*

The scarcity of health workers in LMICs requires the shift of specialists to care for critically ill patients in times of a surge, as was needed in specialty-dense areas such as Lombardy and New York City. Additionally, the conversion of operating rooms and ICU beds is needed to handle rapid growth in complicated COVID-19 cases, reducing centers’ ability to maintain surgical services.[2,16,17](https://paperpile.com/c/8QtwDz/2GD3+esDM+dXsO) In addition to this, conventional supply chains and surgical donations have been complicated by border closures and travel restrictions, reducing the availability of much-needed equipment and consumables. Meanwhile, the elevated infection risk for health workers, especially those involved with invasive care, is significant with COVID-19 and may shift health workers from disease curers to vectors.[18](https://paperpile.com/c/8QtwDz/9Ohg) High-income countries such as the United States quickly faced shortages in personal protective equipment, issues that are felt even more in countries and areas with lesser established supply chains and financial constraints. Disturbingly, not only does infection put surgeons out of service, fatal outcomes inevitably have unfathomable consequences for entire countries or regions. During the Ebola outbreak, the largest hospital in Sierra Leone lost 25% of its general surgery workforce.[19](https://paperpile.com/c/8QtwDz/VS97) Losing one cardiac surgeon in LMICs may mean the loss of the single cardiac surgeon in a country or group of countries, with all its consequences for the continuity of domestic services.

*Quality*

The unique pathophysiological impact of COVID-19 has led to worse outcomes among COVID-19-positive patients, both in those infected before and after their operations.[20,21](https://paperpile.com/c/8QtwDz/vJNn+F8aU) Early reports highlight the high and more commonly fatal respiratory and coagulopathic complication rates after cardiac surgery as a result of COVID-19 infection.[22](https://paperpile.com/c/8QtwDz/YU7h) However, there is still limited knowledge of the exact outcomes in patients undergoing different cardiac surgical procedures and how specific risk factors affect outcomes. Given the increased burden of COVID-19 on existing intensive care units and hospitals, and the more complicated disease course if COVID-19-positive, more investigation is urgently warranted to optimize outcomes in patients requiring cardiac surgical care in the midst of the outbreak.

*Affordability*

As a result of lockdowns, furloughs, dismissals, and reduced services in many sectors, millions of people worldwide lost their jobs. In LMICs, informal jobs such as sales on markets are common and enforced lockdowns may then take away the single source of income for many individuals or some entire families. Additionally, due to lower government budgets per capita in LMICs, financial support for LMIC populations in times of crisis is limited. Having to pay out-of-pocket for expensive treatments such as cardiac surgical care is not straightforward and becomes an even larger risk for financial hardship than before the pandemic. Moreover, the lower per-center surgical volume may increase procedural costs due to lower turnover and the persistently high overhead costs. Lastly, the reduction in visiting teams reduces the number of philanthropic (subsidized) cases, thereby putting more families at a financial dilemma.

**Post-COVID-19**

Many of the aforementioned implications of the COVID-19 pandemic will have major residual consequences for cardiac surgical care delivery around the world. In LMICs, large baseline gaps in access to cardiac surgery have been aggravated by the pandemic and nimble responses by all stakeholders are needed to mitigate the volumetric decline and ensure adequate resurgence after the pandemic. Pre-COVID-19, cardiac surgery in LMICs was found to be very cost-effective, especially compared with many other global and public health priorities.[14,23](https://paperpile.com/c/8QtwDz/G3X3+3ogW) This may not be all that surprising, given the large and often earlier-onset (e.g., congenital heart defects at birth, rheumatic heart disease in adolescents, and ischemic heart disease in younger adults) cardiovascular surgical burden in LMICs.

To move forward, a health systems lens will need to be applied to global cardiac surgical scaling due to the need for continuity of care from the community-level (e.g., screening of patients) to tertiary specialty care (e.g., advanced imaging, cardiac surgery, and intensive care) to long-term follow-up mechanisms and the availability of essential medicines--all embedded within adequate referral systems and financial risk protection mechanisms.[24](https://paperpile.com/c/8QtwDz/XnQH) Emergency preparedness and health system resilience are proxies of robust health systems and the development of high-quality cardiac surgical services may not only strengthen cardiovascular care capacity and other surgical care delivery but also enable prompt responses to critically-ill patients during outbreaks. Unfortunately, on the national level, health policies have long omitted cardiovascular services.[25](https://paperpile.com/c/8QtwDz/69ry) The development of National Surgical, Obstetric, and Anesthesia Plans (NSOAPs) by Ministries of Health is increasingly occurring by LMICs across the globe to systematically strengthen the surgical ecosystem under the umbrella of existing national health plans; however, all countries but one have omitted cardiac surgery from their NSOAPs, leading to persistent gaps in cardiac care delivery whilst other surgical pillars are strengthened.[25](https://paperpile.com/c/8QtwDz/69ry) As such, cardiovascular stakeholders urgently need a seat at the table to ensure their voice is not left unheard in this growing discourse and health systems strengthening intervention. Additionally, government collaborations can help support the training of cardiac surgeons and entire cardiac teams in countries with existing training programs, as informally already done at a smaller scale to date.[26](https://paperpile.com/c/8QtwDz/9Km3) Similarly, quality improvement collaborations between centers will allow for pre-, peri-, and postoperative care optimization in growing centers. Internationally, the political commitment to expanding curative cardiovascular services, especially pertaining to cardiac surgical and interventional cardiology care, has been scant despite a growing recognition of the burden of rheumatic heart disease, noncommunicable disease, and surgical conditions as a whole.[27](https://paperpile.com/c/8QtwDz/Zj6L) Reprioritization and stakeholder engagement is necessary to meet the true needs of countries around the world. Moreover, earmarked funds have led to decades of vertical disease silos with limited attention to local needs but directed by the funding sources’ focus.[28](https://paperpile.com/c/8QtwDz/j2Rq) Ensuring health systems strengthening will require either reducing earmarking, integrating systemwide components, or, ideally, both.

**Conclusion**

Every year, millions of people are dying and millions more are becoming disabled due to treatable cardiac surgical diseases. Surgical capacity is unevenly distributed around the world and disproportionally affects populations in low- and middle-income countries. COVID-19 increases barriers for access to cardiac surgical care and high-level action is urgently needed to not only expand cardiac services around the world but also ensure health systems strengthening to manage patients during and after the pandemic.

**References:**

1. Nepogodiev D, Omar OM, Glasbey JC, Li E, Simoes JF, Abbot TE, et al. Elective surgery cancellations due to the COVID-19 pandemic: global predictive modelling to inform surgical recovery plans. [Br J Surg. 2020 May 12;10.1002/bjs.](https://doi.org/10.1002/bjs.11746)
2. Ma X, Vervoort D, Reddy CL, Park KB, Makasa E. Emergency and essential surgical healthcare services during COVID-19 in low- and middle-income countries: A perspective. [*Int J Surg*. 2020;79:43-46.](https://dx.doi.org/10.1016%2Fj.ijsu.2020.05.037)
3. Meara JG, Leather AJM, Hagander L, Alkire BC, Alonso N, Ameh EA, Bickler SW, et al. Global Surgery 2030: evidence and solutions for achieving health, welfare, and economic development. [*Lancet*. 2015;386(9993):569-624.](http://dx.doi.org/10.1016/)
4. Vervoort D, Meuris B, Meyns B, Verbrugghe P. Global cardiac surgery: Access to cardiac surgical care around the world. [*J Thorac Cardiovasc Surg*. 2020;159(3):987-996. E6.](https://doi.org/10.1016/j.jtcvs.2019.04.039)
5. Vervoort D. [Moving the needle: a guide to solving the global cardiac surgery puzzle for surgeons, societies, students, and researchers](https://www.ctsnet.org/article/moving-needle-guide-solving-global-cardiac-surgery-puzzle-surgeons-societies-students-and). CTSNet. February 2020. [doi:10.25373/CTSNet.11872425.](https://doi.org/10.25373/ctsnet.11872425.v1)
6. Vervoort D, Kpodonu MDJ. Using technology and innovation to address the three delays in access to cardiac surgery. [*AATCVS*. 2018;13(1):5-9.](https://doi.org/10.5897/AATCVS.9000033)
7. Cox JL. Presidential address: changing boundaries. [J Thorac Cardiovasc Surg. 2001;122(3):413-418.](https://doi.org/10.1067/mtc.2001.118489)
8. Vinck EE, Vervoort D. Cardiac surgery air-bridging in the Caribbean. [*Semin Thorac Cardiovasc Surg*. 2020 May 16;S1043-0679(20)30126-X.](https://doi.org/10.1053/j.semtcvs.2020.05.002)
9. Vervoort D, Kpodonu J. Cardiac surgery in West Africa: the tipping point. [*Cardiol Young*. 2020;30(1):148.](https://doi.org/10.1017/s104795111900310x)
10. Moffatt-Bruce S, Crestanello J, Way DP, Williams TE Jr. Providing cardiothoracic services in 2035: Signs of trouble ahead. [*J Thorac Cardiovasc Surg*. 2018;155(2):824-829.](https://doi.org/10.1016/j.jtcvs.2017.09.135)
11. Vanderby SA, Carter MW, Latham T, Ouzounian M, Hassan A, Tang GH, et al. Modeling the cardiac surgery workforce in Canada. [*Ann Thorac Surg*. 2010;90(2):467-473.](https://doi.org/10.1016/j.athoracsur.2010.04.056)
12. Nguyen N, Jacobs JP, Dearani JA, Weinstein S, Novick WM, Jacobs ML, et al. Survey of nongovernmental organizations providing pediatric cardiovascular care in low- and middle-income countries. [*World J Pediatr Congenit Heart Surg*. 2014;5(2):248-255.](https://dx.doi.org/10.1177%2F2150135113514458)
13. Kruk ME, Gage AD, Arsenault C, Jordan K, Leslie HH, Roder-DeWan S, et al. High-quality health systems in the Sustainable Development Goals era: time for a revolution. [*Lancet Glob Health*. 2018;6(11):e1196-e1252.](https://doi.org/10.1016/s2214-109x(18)30386-3)
14. Vervoort D. The neglected component of cardiovascular care: dispelling the myths. [*Glob Heart*. 2019;14(3):281-283.](https://doi.org/10.1016/j.gheart.2019.04.006)
15. Novick W, Cardarelli M. [COVID-19 disruption of pediatric cardiac surgery services in low and middle income countries.](https://www.ctsnet.org/article/covid-19-disruption-pediatric-cardiac-surgery-services-low-and-middle-income-countries) CTSNet. June 2020. [Doi:10.25373/ctsnet.1254193.](https://doi.org/10.25373/ctsnet.12541493.v1)
16. Peters AW, Chawla KS, Tumbull ZA. Transforming Ors into ICUs. [*N Engl J Med*. 2020;382(19):e52.](https://doi.org/10.1056/nejmc2010853)
17. Ma X, Vervoort D. Critical care capacity during the COVID-19 pandemic: global availability of intensive care beds. [*J Crit Care*. 2020;58:96-97.](https://dx.doi.org/10.1016%2Fj.jcrc.2020.04.012)
18. Luc JGY, Vervoort D, Han JJ, Sade RM. Part of the cure or spreader of the disease? [*Ann Thorac Surg*. May 2020. Epub ahead of print.](https://dx.doi.org/10.1016%2Fj.athoracsur.2020.03.103)
19. Bundu I, Patel A, Mansaray A, Kamara TB, Hunt LM. Surgery in the time of Ebola: how events impacted on a single surgical institution in Sierra Leone. [*J R Army Med Corps*. 2016;162(3)212-216.](https://dx.doi.org/10.1136%2Fjramc-2015-000582)
20. Nepogodiev D, Bhangu A, Glasbey JC, Li E, Omar OM, Simoes JFF, et al. Mortality and pulmonary complications in patients undergoing surgery with perioerative SARS-CoV-2 infection: an international cohort study. [*Lancet*. 2020 May;396(10243):27-38.](https://doi.org/10.1016/S0140-6736(20)31182-X)
21. Vervoort D, Nguyen TC. Commentary: coronary artery bypass grafting in patients with coronavirus disease 2019 (COVID-29): darkness cannot drive out darkness. [*J Thorac Cardiovasc Surg*. 2020 June 4. Epub ahead of print.](https://dx.doi.org/10.1016%2Fj.jtcvs.2020.05.061)
22. Salna M, Polanco A, Bapat V, George I, Argenziano M, Takeda K. A Case of COVID-19 Presenting after Coronary Artery Bypass Grafting. [*J Thorac Cardiovasc Surg*. June 2020. Epub ahead of print.](https://dx.doi.org/10.1016%2Fj.jtcvs.2020.05.060)
23. Cardarelli M, Vaikunth S, Mills K, DiSessa T, Molloy F, Sauter E, et al. Cost-effectiveness of humanitarian pediatric cardiac surgery programs in low- and middle-income countries. [*JAMA Netw Open*. 2018;1(7):e184707.](https://doi.org/10.1001/jamanetworkopen.2018.4707)
24. Vervoort D. Global cardiac surgery: a wake-up call. [*Eur J Cardiothorac Surg*. 2019;55(5):1022-1023.](https://doi.org/10.1093/ejcts/ezy319)
25. Vervoort D. National surgical, obstetric, and anesthesia plans: bridging the cardiac surgery gap. [*Thorac Cardiovasc Surg*. March 2020. Epub ahead of print.](https://doi.org/10.1055/s-0039-1700969)
26. Vervoort D, Velazco-Davila LD. Closing the gap by filling the gaps: Leveraging international partnerships to train the world’s cardiac surgical workforce. [J Thorac Cardiovasc Surg. 2020 May;160(2):E51-E52.](https://doi.org/10.1016/j.jtcvs.2020.03.143)
27. Vervoort D, Parikh UM, Raj A, Swain JD. Global cardiovascular care: an overview of high-level political commitment. [*Asian Cardiovasc Thorac Ann*. 2020 June;28(5):258-265.](https://doi.org/10.1177/0218492320930844)
28. Jumbam DT, Vervoort D, Park KB. Development assistance for health in low-income countries. [*JAMA*. 2019;322(15):1517-1518.](https://doi.org/10.1001/jama.2019.12922)

|  |  |  |  |
| --- | --- | --- | --- |
|  | **Pre-COVID-19** | **During COVID-19** | **Post-COVID-19?** |
| **Accessibility** | * ~4,000 cardiac centers * Few, if any, centers in LMICs * Regionalization of centers within and between LMICs | * Lockdowns and travel restrictions impede travel to regional centers * No “hot” versus “cold” centers | * Temporary regionalization of cardiac care * Inclusion of cardiac care within NSOAPs |
| **Capacity** | * High-income countries 180x higher cardiac surgeon density than low-income countries * NGO and visiting team support | * Shift to COVID-19 care * Use of resources for COVID-19 care * Risk of health worker infection | * Government collaborations to train cardiac surgeons and cardiac teams in countries with existing training programs * Optimizing supply chains in collaboration with industry * Fostering local economies of scale |
| **Quality** | * Widely variable outcomes mostly defined by resource constraints * Excellent outcomes suggest feasibility of cardiac surgery | * COVID-19 complicates postoperative disease course * Limited knowledge of COVID-19 in cardiac surgery | * Maintain and expand quality improvement mechanisms to support pre-, peri-, and post-operative care delivery |
| **Affordability** | * Limited financial risk protection * High procedural costs relative to living standards * Subsidized procedures by NGOs and visiting teams | * Furloughs, unemployment, limited government support * Reduced subsidized services by NGOs and visiting teams | * Integration of cardiac surgical care in universal health coverage and financial risk protection models * Innovative financing mechanisms |

**Table 1**. Assessment of access to cardiac surgical care in low- and middle-income countries (LMICs) before and during the coronavirus disease 2019 (COVID-19) pandemic, and opportunities for post-COVID-19 cardiac surgical scaling. *NGOs = non-governmental organizations*. *NSOAPs = National Surgical, Obstetric, and Anesthesia Plans.*