Review

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Global Cardiac Surgery. Accessibility of Cardiac Surgery in Developing Countries: Objectives, Challenges and Solution

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Abstract: Cardiac surgery is a modern science in the history of medicine. The impact in cardiac disease, in term of treatment and prognosis, has made this discipline indispensable in the global health. In recent decades, the greatest investment has been dispensed in technological and material improvement, for increase the life expectancy. This surgery must address different epidemiological aspects dictated by the geography and economic-social conditions of the global populations. For this reason, it is progressively important to address the cardiac surgery accessibility disparity. Many scientific paper and international meetings have studied how cardiac surgery can increase accessibility in various countries around the world. In this review we analyze all the challenges, solutions and suggestions to make this surgery accessible to the entire global population, with the purpose to reducing the disparity across the all seven continents. For a long time, high-income countries have invested in technological capabilities and experimental advancement, not caring about unequal access in the rest of the world. We believe that it is time to reverse the growth trajectory, placing – as a priority – the accessibility and distribution of a surgical science, too significant for the right to health of all the people of the world. This is the real new challenge in cardiosurgery.

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1. Introduction

Machteld Huber & co. defined health as the *ability to adept and self-manage in the face of social, physical and emotional challenges.* With this definition, health becomes a "collective value" and no longer an individual one, and this outcome is only possible with an equitable distribution of rights and resources. Therefore, health is created when individuals, families and communities have income, education and full accessibility to basic rights to control their lives. In addition, their needs and rights are supported by systems, environments, and policies that enable and facilitate better health. [1,2].

JM's latest Dictionary of Public Health [3] teaches us that "*Health*" cannot be defined through the achievement of an absolute standard, but rather immersed in a social and community context. In 1990, WHO defined health inequalities as *"systematic differences in health status between different socio-economic groups; such inequalities are socially produced (hence modifiable) and unjust"*. This statement emphasizes systematicity, as opposed to randomness, in "social inequality in health, outlining perspectives for solution at the community rather than individual level." Health disparities, within and between countries, are thus judged to be unjust, avoidable, and unnecessary; they systematically burden populations made vulnerable by the social, political, economic, and legal structures present in these contexts. Brevan & co. [5] propose the concept of "*equity in health*": opportunities for fair and equitable access to services that provide the opportunity to be as healthy as possible, and this requires the removal of barriers such as poverty and discrimination. It is for these reasons that health inequalities are defined as systematic, avoidable and unfair differences that can be observed between individuals, between social groups or within the same population. Despite the considerable attention

given to the problem of health inequalities since the 1980s, significant differences within and between countries still exist today.

This text aims to examine the disparities present in accessibility to cardiac surgery, especially in developing countries. Evidence of disparity has been demonstrated by the 6 billion people lives in geographic areas without cardiac surgery access [9].

Despite numerous warnings to the political and social world by WHO, cardiovascular disease remains the leading cause of death worldwide, responsible for 17.5 million deaths per year, 80% of which occur in low- and middle-income countries.

Considering that access to cardiac surgery is absent in low-income countries and limited in middle-income countries, it appears that more than *75% of the world's population has limited/absent access to a health service* that, if provided with adequate infrastructure, human resources, and financial coverage, could prevent a huge number of deaths. "Global cardiac surgery" refers to that area of study, research, practice, and advocacy that prioritizes improving health outcomes and achieving health equity worldwide and for all people with heart disease. The proportions of this absurd difference are highlighted by the observation that in sub-Saharan Africa, excluding South Africa, there is 1 cardiac surgery centre for every 38 million people; in contrast, in North America and Europe there is one for every 120,000 people [10]. To redress this global socio-health imbalance, Global Cardiac Surgery aims to map current global cardiac surgery capacity, support health systems strengthening, and establish a framework for developing sustainable programs to reduce the lack of accessibility to cardiac surgery. The success of this health utopia is linked to the development and strengthening of cardiac surgery systems as part of broader health systems strengthening through national surgery programs. Only integration into national health systems and their subsequent strengthening will move cardiac surgery toward universal health coverage. In addition, a collaborative effort between nongovernmental organizations (NGOs) or other association and local governments is needed to facilitate adequate cardiac care in low-income countries. In developing countries, the needs for cardiac surgical care to ensure an equitable and qualitative responses are many: infrastructure, choice of geographically favourable areas for strengthening hospital presidia, and qualified and trained human resources. The solutions being proposed aim at specific cardiac learning programs, identification of non-conflict zones designated and secured by local governments, funding for facilitating resource mobilization and local autonomy. We want to emphasize that disparities are present in all countries, and this is precisely why a comprehensive approach is needed to solve problems of resource allocation and access to care. This approach must be dictated by shared (government institutions, NGOs, international programs) and widespread efforts *based on scientific evidence* and guided by data *repositories* and *resources*. Sharing international databases (WHO, local governments, NGOs, professional societies) is essential to increase research knowledge and innovation, coupled with equitable financial distributions. Prevention and treatment of cardiovascular disease cannot be a priority only for rich countries. Therefore, policies aimed at 'health systems innovation in low-income countries coupled with lifestyle changes in high-income countries should combine in an intersectoral benefit of improving global well being. The 2018 *Cape Town Declaration* on Access to Cardiac Surgery in the Developing World [11] highlights the need in these countries for the creation of surgical conditions and nonsurgical elements in local health systems. Pursuing policies aimed at strengthening health systems will advance cardiac surgery along with other health services and not at their expense. Involvement of physicians in political, economic and social aspects is essential to support the interests of the world's poorest communities: such outreach must be directed toward promoting the highest quality of health care regardless of the economic means of the patient being treated.

Only support by individuals and global cardiac surgery professionals will lead to a substantial reduction in cardiovascular disease mortality worldwide. Such a movement must be global and multidisciplinary following the simple and well-delineated goals of 'education, research, and self-sustainability, resulting in a truly global international coalition apt to cooperation and uncluttered by competition. This is the next real challenge of modern cardiac surgery.

2. Global Cardiac Surgery

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Global cardiac surgery refers to that area of study, research, practice and advocacy that prioritizes the improvement of health outcomes and the achievement of health equity for all people who are affected by cardiac surgical pathologies in all the world.

The lack of concern in this specific surgery is unfortunately the result of the perceived difficulty for the cardiac surgery introduction in low-income settings given the complexity of the follow-up, the request for intensive human resources training and the financial high costs. Given the worldwide growing burden of cardiovascular disease, including the epidemiological transition from communicable to non-communicable diseases in low and medium income countries (LMIC), its perception becomes vital for sustainable development and universal health coverage.

Cardiovascular disease is the primary global cause of death, accounting approximately 17.5 million deaths each year, 80% of which are in low- and middle- income countries (LMIC). Despite, the high prevalence of cardiovascular disease in LMIC, the low accessibility of diagnostic services and the health systems deficiency, it certainly underestimates the true global state. The data show that around 17 million people die each year from *"predictable surgical conditions"*, and only 6% of the 313 million global surgeries take place in LMIC.

After the second half of the 900', rheumatic pathology and congenital heart disease represented the challenges of cardiac surgery. During industrialization and new technology relationships investment, in the Western world, a decrease in rheumatic pathology and an increasingly effective response in congenital surgical pathology were noted. In recent decades, the epidemiological transition has highlighted the shift towards degenerative pathology linked to lifestyle. This change has led to the surgical need sharp division between high-income countries (HIC) and low- and middle-income countries (LMIC). In the first group (HIC), the development of increasingly advanced techniques and progress in interventional modalities constituted an adequate response to the epidemiological change, while the lack of development and training of human resources in LMIC, has maintained the rheumatic and congenital disease at the same levels since the post-war period. This epidemiological panorama is placed within a "*global care capacity deficient*", associating access to cardio-thoracic surgery proportionally to the economic conditions of the continents. 4.5 million people haven't access to cardiac surgery. This is a definition of "healthcare accessibility discrimination".

3. Congenital Heart Disease

In the last century the diagnostic and treatment capabilities of congenital heart disease have greatly improved. Several studies show an evident improvement survival in the more developed regions of the world, thanks to early diagnostics and treatment techniques development. However, such studies have not had the same success rates in developing regions. For example, advances in paediatric cardiology and heart surgery have made it possible to repair or palliate most o congenital heart disease, including complex ones, but many analyses have shown that "infant survival rates" depend on the geographic location of the child's birth.

Where screening, early diagnosis and treatment is available, the child has a 95% chance of surviving to adult life and achieving good long-term outcomes. These advanced treatments are virtually unavailable for more than 90% of babies born in developing countries [1]. In 2016, the General Congress of the United Nations, across the Sustainable Development Goals (SDGs) declaration [2], sets the neonatal mortality-freeing goal to less than 12 deaths for every 1000 live births. This objective will be achieved by reducing premature mortality from no – communicable diseases (NCDs) by 30% through 2030. Congenital heart disease accounts for one third of all NCDs and is therefore an integral part of reducing preventable childhood deaths. 90% of the world's children born with congenital heart disease live in places where there is little or no cardiac surgery treatment. [3]. This inequality is emphasised by Hoffman and colleagues by showing that LMIC infants with severe congenital heart disease and without access to surgical treatment are more likely to die before their fifth birthday than those in HIC [4]. To optimize resources for screening, treatment, and cost-effective treatment strategies, there is a need for an accurate assessment of the absolute and relative burden of congenital heart disease around the world. The *Global Burden of Disease, Injuries,*

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and Risk Factor Study (*GBD*) is the result of a collaboration of international researchers who annually estimate the prevalence and mortality of congenital heart disease all over the world. This report shows that CHD deaths and mortality are highest in LMIC, while rates of improvement have followed rates of economic development, with fatal outcomes decreasing by at least 60% since 1990 in high-income countries [5]. More in-depth data and studies are needed to update the burden of disease across continents and are essential to monitor progress and encourage funding for sustainable solutions to deliver high-quality care to all children in need. The estimates made in recent years on CHD provide a critical and indispensable point of view with respect to the health of the global population, contributing to a better investment of health resources in order to increase access to cardiovascular care especially in less developed countries, where progress and resources in care, diagnostics and rehabilitation have been largely stagnant.

The United Nations Organization has emphasized the priority of reducing NCD premature deaths; however, to achieve this goal, health policies will have to develop specific responsibilities aimed at breaking down accessibility barriers by improving access to cardiac diagnosis and treatment. As noted above, most children with heart disease (CHD or RHD) living in developing countries with quality care lack access. It is well established that treatment of CHD and RHD is cost effective, justifying the concept of paediatric cardiac care. However, a number of barrier-filled challenges must be overcome before the average child living in a developing country can access comprehensive heart care. Early diagnosis requires community and health care provider awareness of paediatric heart disease, but it is only the beginning. The management of paediatric patients with CHD or RHD requires significant expenditure and infrastructure; but currently resources are not only limited, but also sometimes used sub-optimally. The challenges of providing the best care for the average child with heart disease are unparalleled, and will lead to innovations and opportunities; but this will require a collective effort by governments, non-governmental organizations, physicians and other health professionals for continuous improvement in health care delivery.

One of our experiences is involved is the city of Benghazi (Libya). This region, inserted in a post-war socio-economic context, refers all patients with congenital heart disease to a single private hospital, not guaranteeing equal and widespread accessibility. For this reason, a long-term project has been developed, with various regional and international healthcare stakeholders, which promotes cardiac surgery accessibility for the cardiac congenital patients [13]. The project ambitions aim to achieve regional surgical autonomy, privileging the local staff training, the centres interconnection and the targeting of the right healthcare investments. This intercontinental network project follows the principles global cardiac surgery keys, extending international health rights by reducing social and economic disparities care.

3.1. Inequality

The walls to establishing cardiac surgery programs in LIC are numerous and complex, often with the sustainability of investment efforts as the primary challenge.

Recent epidemiological studies have identified no-communicable diseases, in particular cardiovascular disease (CVD), as the first cause of worldwide death.

The greatest burden (up to 80%) of death and disability from cardiac surgery occurs in low- and middle-income countries (LMICs) characterized by a gross national income per capita of less than $10 per year (data from 2004). These alarming trends have led to several attempts to develop strategies to address this great global challenge. Such strategies, by definition, require an integrated approach that includes preventive and high-tech medicine program that feed into and benefit from each other.

The importance of high-tech medicine, including cardiac surgery, has been highlighted in previous “Institute Medicine reports” as one of the recommendations for promoting cardiovascular health in the developing countries. However, the goals and recommendations outlined in these reports remain largely unfulfilled. Over the past 50 years, following the pioneering work, cardiac surgery has matured into an extremely sophisticated specialty dedicated to serving patients and science with an increasing role in improving patient care and in influencing survival and the globally

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quality of life. Cardiac surgery is an intensive and cost labour discipline, requiring great commitment and planning strategic of structured and funded training. Given the severely limited government budgets for healthcare in the LMIC countries, this objective was initially achieved with the creation of non-governmental organizations (NGOs) including a wide range of specialists. This can be significantly supported through the existing international networks of cardiology, cardiac surgeon and, above all, cardiac anaesthesia and professional societies. In these cases it was essential to involve the community in both the receiving and donor countries at all stages.

The introduction of disease-specific research programs and population studies significantly increases the strength and impact of such efforts and, importantly, contributes to the development of local practice guidelines, tailored to address problems and uniqueness environmental.

The ultimate target is the building of cardiac centres capable of offering high-quality sustainable services, free or at affordable prices, to all the inhabitants of their catchment area. The pioneering efforts of Casteñada in Guatemala [14], Carpentier in Vietnam [15], or Strada in Sudan [16] aid as inspiring models for offering cardiac surgery to populations in underserved areas. While the burden of cardiovascular disease varies significantly among these countries, they share scarcity of resources (financial and human), underdeveloped infrastructure, lack of accurate cost-effectiveness studies that can guide policy makers on optimal allocation of funds and, above all, huge unmet clinical demands.

3.2. Role of Cardiosurgery Society

In 2018, the Society of Thoracic Surgeons (STS), the American Association for Thoracic Surgery (AATS), the European Association for Cardio-Thoracic Surgery (EACTS), the Asian Society Cardiovascular and Thoracic Surgery (ASCVTS), the Pan -African Society of Cardiac and Thoracic Surgeons (PASCaTS) and the World Heart Federation have collectively established the Cardiac Surgery Intersociety Alliance (CSIA).

With the understanding that surgery is, and will remain, an integral part of the management of rheumatic heart disease, as already described in previous chapters, the Cape Town Declaration on Access to Cardiac Surgery in the Developing World, was adopted, signed and published in all the main cardiac surgery journals. The Cardiac Surgery Intersociety Alliance (CSIA) was created following the guidelines of the first objective of the Cape Town Declaration to be the operational arm of that project. The CSIA is made up of delegates from the major cardio-thoracic societies, the World Heart Federation and a representative from the pharmaceutical industry. This association is responsible for evaluating, approving, mentioning and monitoring potential centres in less developed countries to increase access to cardiac surgery; it is also delegated to organize the training of suppliers in these sites.

To achieve this goal, a list of criteria for selecting the CSIA intervention program was created. This list has been reviewed and ratified by the leadership of all societies whose members make up the CSIA: these principles embody the central message of the Cape Town Declaration. The list of criteria was created with the aim of being collaborative with the sites that are chosen, so that their commitment, involvement, transparency and sustainability are guaranteed. Each chosen centre should ideally be based on the 5 pillars of the supported projects, which are:

"Pilot" Centre
Local guarantor
Sponsor
Training site
Academic Partner

The initial plan is to select 2-3 pilot sites to launch the project. Once success and feasibility are demonstrated, CSIA will expand this project to other locations. The purpose of this association is to search for sites that are dedicated and determined to establish long-lasting and sustainable partnership relationships. The goal of the CSIA is primarily to enable surgeons and cardiac centres in developing countries to increase their long-term clinical and academic capacity through professional and financial support.

However, many other opportunities arise:

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1.1 *Workforce mapping:* Substantial disparities exist in the availability and distribution of cardiac surgery providers around the world.

Low-income countries have only 0.04 adult and 0.07 paediatric cardiac surgeons per million inhabitants, compared to high-income countries, which have 7.15 adult and 9.51 paediatric cardiac surgeons per million inhabitants.

In other words, high-income countries have 179 times more adult cardiac surgeons and 134 times more paediatric cardiac surgeons than low-income countries. Improving the accuracy of this data and monitoring it periodically is necessary to ensure that societies and countries can adequately develop training programs and fill key gaps in the availability of surgical workers.

2.1 *Gender equity*: In high-income countries, relatively few female cardiac surgeons practice this discipline, making cardiothoracic surgery one of the most disproportionate subspecialties of medicine in this respect. For example, in the United States, only 3% of credentialed cardiothoracic surgeons are women (17). These disparities are even more evident within less developed countries, as non-cardiac surgical subspecialties seem to indicate (18).

Women working in cardiac surgery are forced to face much more onerous barriers than their male colleagues, both in terms of the wage gap, unconscious bias, academic performance and advancement, and family planning (19). Cardiac societies can and should take the lead in better understanding and reducing such sex-based barriers, thus paving the way towards gender equity.

3.1 *Training programs*: Centralization and high costs of cardiac surgery training programs create significant barriers to training surgical personnel in low-income countries.

While high-income countries already prove "frugal" in training cardiac surgeons due to the importance of hands-on education time and a relatively low (compared to other specialties) need for surgeons per million population, low-income countries they are often even completely devoid of training programs.

Most aspiring heart surgeons in sub-Saharan Africa, for example, are forced to leave their country because training programs in the region only exist in North Africa, South Africa, Ghana and Kenya (most often with only one or two places available each year for foreign apprentices). Moving to North America, Europe or Australia is generally difficult, due to language barriers, bureaucratic regulations (diplomatic visas), or accreditation requirements at foreign academies. The development of more regional training programs, such as those promoted by the College of Surgeons of Eastern, Central, and Southern Africa (COSECSA) and the West African College of Surgeons (WACS) for non-cardiac surgical sub-specialties, will allow for more large and standardized population of qualified cardiac surgeons in the region and will mitigate the potential migration of professionalized staff.

3.3. Rheumatic Disease

Rheumatic heart disease (RHD) is estimated to affect more than 33,000,000 individuals worldwide, with a prevalence equal to that of the human immunodeficiency virus. Rheumatic disease is a chronic autoimmune disease that occurs as a result of a streptococcal infection of the throat or skin that can affect the heart, with its primary effects of scarring, fibrosis, and calcification of the heart valves. It is a leading cause of heart failure in the underdeveloped world. Rheumatic disease is the most common cause of cardiovascular disease among young people and is a major cause of cardiovascular mortality and morbidity, causing approximately 300,000 deaths per year. The international community has previously formally committed itself to improving and reducing the burden of rheumatic disease through a focus on primary and secondary prevention. Between 1990 and 2015, the estimated number of deaths decreased from 347,500 to 319,400 (8.1% decrease). Nonetheless, the burden of rheumatic disease remains high; there are estimated to be 300,000 deaths per year and the need for 200 operations for million populations in low-income countries, where it is estimated that more than more than 6 billion individuals have little or no access to cardiac surgery. In light of this pressing situation, the Cape Town Declaration (CTD) has been drafted, approved and signed by all major cardiac surgery societies, as well as key company representatives, signalling the commitment of the global cardiac surgery and cardiology communities, as well as the medical industry and relevant government bodies, to improve access to cardiac surgery care around the

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world. This project proposes overcoming the inaccessibility of cardiac surgery in rural populations, the unavailability of valve devices for replacement and the difficulties in administering anticoagulants.

At the 97th meeting of the American Association for Thoracic Surgery in Boston, key leaders from major international cardiac surgery societies, along with other global stakeholders, gathered to focus on developing a dialogue on the topic of increasing access to cardiac surgery in developing countries. This convening was timed to address the large disparity in access to cardiac surgery that exists between the developed and developing world. The deliberations of the assembled participants were summarized and published in the *"Cape Town Declaration on Access to Cardiac Surgery in the Developing World."* This document was adopted by major international cardiac surgery societies and published simultaneously in nine international journals. The mission of this document is to urge all relevant entities within the international cardiac surgery, industry and government sectors to commit to developing and implementing an effective strategy to address rheumatic heart disease in the developing world through greater access to cardiac surgery.

The non-obvious objective was a "*build local capacity*", while also encouraging a concerted effort and continuous dialogue between developing and high-income countries. This objective can be achieved through the formation of international working groups (coalition) composed of people from cardiac surgery societies and representatives of industry, cardiology and government in order to evaluate and support the development of cardiac surgical care in low-risk countries and middle income. The embodiment of this purpose enshrined in the Cape Town Declaration is the CSIA. The first step was the approval of cardiac surgery centres in order to enhance their development capacity. Additionally, the CSIA established and published the criteria by which potential clinical sites would be evaluated for possible approval.

Ultimately, interdisciplinary and cross-sector collaborations among all stakeholders will be needed to develop effective regionalization models for training LDC cardiac teams and to develop low-cost technologies to improve training and care delivery in LDCs. developed. In a field as complex and expensive as cardiac surgery, in order to optimize results the need to reduce costs and increase the volume of procedures (per supplier and per center) will be increasingly strong (20).

Severe inequities in the provision of cardiac care persist around the world. In an era when North American and European practitioners continue the search for the most innovative technologies to improve patient outcomes, less developed countries struggle to provide conventional open-heart surgery to those who need it at the rates needed.

As professional societies, healthcare providers, researchers and advocates, we have a moral imperative to rid ourselves of unacceptable inequities within cardiac surgery worldwide in the name of global health. Six billion people around the world do not have access to safe, timely and affordable heart surgery care when needed, and their fate should not be determined by the country or prosperity into which they were born.

4. Challenges

Currently, five times more people live in low- and middle-income countries (LMICs) than in high-income countries (HICs).

In low- and middle-income countries, rheumatic heart disease remains the single most common cardiovascular disease in young adult and adolescent patients requiring cardiac surgery, outnumbering other indications such as congenital heart defects by almost 4-fold.

Compared to high-income countries (HICs), with their predominance of calcific aortic stenosis in older adults, mitral valve surgery is required in more than 90% of (largely young) patients with rheumatic heart disease in low-income countries (LIC) and in 70% of often middle-aged patients in middle-income countries (MICs). Although recent government initiatives in LICs have led to the creation of local, independent cardiac surgery services that have gradually replaced fly-in missions, these centres still only cover less than 2% of the needs of their populations. In MICs, cardiac surgical needs continually increase with the emergence of degenerative diseases. As such, despite the

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concomitant growth in cardiac surgical capacity, fewer than half of the estimated patients in need have access.

Capacities in LICs vary from 0.5 to 7 cardiac operations/million population; 100-481/million in MICs and >1,200/million in HICs such as the USA and Germany. While a new level of awareness of the scope and scale of the problem has begun to emerge in low-income countries and the creation of local cardiac surgery capacity has offered a sign of hope, the challenges of expanding these territorial surgical sustainability services in the long term they still seem insurmountable to a significant part of the population. The challenges in MICs are, on the one hand, the growing gap between private cardiac medicine for the few patients and overburdened public services for the many and, on the other hand, the urban-rural divide with the underestimation of the current dominance of rheumatic heart disease in the rural and poor population.

Low- and lower-middle-income countries such as Mozambique, Sudan, Tanzania, Zimbabwe, Zambia, Ivory Coast, Uganda, Ethiopia, Namibia, Senegal, Ghana, Kenya or Bangladesh have all taken the first significant step of establishing functioning local heart surgeries regardless of fly-in missions. Other countries such as Rwanda have demonstrated the feasibility of open-heart surgery by training their first "local" heart surgeon in South Africa. Even remote societies like Myanmar have identified and quantified the need for open-heart surgery. Along with this sustainable local and territorial development, the international cardiac surgery communities have recently united behind efforts to assist these highly complex, innovative programs. While urbanization has led to a slow but steady shift towards degenerative cardiovascular disease, the single dominant disease driving the need for open-heart surgery in less developed countries is still rheumatic heart disease (RHD). Although congenital heart defects take centre stage from an “emotional” perspective, rheumatic heart disease remains the most common cardiovascular disease in young adult and adolescent patients requiring surgery in sub-Saharan Africa and LICs globally. The overall number of patients requiring cardiac surgery in low-income countries (LICs) is almost 4 times lower than in high-income countries (HICs) due to a sharp increase in degenerative diseases contradicting a decline in rheumatic patients in middle-income countries (MICs) during the epidemiological and socioeconomic transition from developing to industrialized countries. The major exception to this development is the surgical requirement for congenital heart defects (CHD), where the overall disease burden is thought to be relatively constant. However, since this observation refers to "live births", the de-facto incidence in congenital patients is higher in a country like Chad where the crude birth rate (average number of births in a year per 1000 residents) is 43 compared to Italy where it is less than 8. There are also real, circumstantial factors that decrease needs in low-income countries.

For example, significantly lower levels of postnatal diagnosis must be taken into account. At the same time, it is a disheartening reality that the 30% of children with congenital heart defects who suffer from complex defects would die without diagnosis or remain incarcerated in the lower tier of the referral system in the absence of highly specialized referral centres. Therefore given the dramatic difference in birth rates, the theoretical need for congenital heart surgery in LICs is approximately 1.1-1.3 times higher (80-110/million population/year) than the level currently provided by countries such as the UK or Germany (60-95/million inhabitants/year). In the face of these relatively well-defined needs for congenital heart surgery, rheumatic heart disease still remains the dominant indication for cardiac surgery in adults and adolescents.

5. Conclusions

Cardiac surgery as a discipline is destined to remain and be a protagonist in less developed countries. Caught between the need to reach industrialized countries and the eventual demise of the discipline in its traditional form, cardiac surgery in LMICs will be on a growth trajectory for a long time to come. Although it has already begun to contract as a surgical specialty in high-income countries, high unmet needs, population growth, and on-going epidemiological transition will require continued growth of this lagging discipline in both LICs and MICs.

The challenge for middle-income countries (MICs) will be not to underestimate the need for rheumatic valve surgery, even if the urban population (totally subsumed by the epidemiological

transition) and its command of most of the available resources, obscures the view on an issue that is still significant.

The challenge for low-income countries (LIC) will be towards the advancement of their own, sustainable and independent surgical services, but also their implementation in accessibility to patients.

The upheavals in the world economy will hit the weakest the most and will make specialist services such as heart surgery "inaccessible and prohibitive". However, even without these upheavals, the expensive nature of consumables produced at high profit margins in the developed world will maintain a degree of dependence in LICs and MICs that can only be resolved by a collective collaborative effort rather than futile, hyped-up help. . A new level of awareness of the scope and magnitude of this problem has begun to emerge, and LICs' commitment to establishing independently operating cardiac surgeries on the one hand and signs of a new dawn of awareness in high-income countries such as the "Cardiac Surgery Intersociety Alliance" (CSIA) are promising glimmers of hope.

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