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RESEARCH ARTICLE

Maintaining interventional cardiology services at times of war; experience of Sudan National Cardiac Center

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ABSTRACT

Background: Cardiovascular diseases is a major health challenge in Sudan as in other African countries. Percutaneous interventions are a major cornerstone in the management of cardiovascular diseases with many African countries struggling to provide these services to their affected population. Since April 2018 a national fully-supported government cardiac catheterization program was adopted to deliver all coronary interventions and some selected valve interventions free of charge through public and affiliated centers distributed nationwide. Sudan National Cardiac Centre (NCC) is the main body overlooking this program and participating centers. In mid-April of 2023 armed conflict broke out in Sudan with major disruption in healthcare provision including cardiac service. More than four million people have been displaced and more than one million fled to neighboring countries.

Aims: To report on the data of Sudan National Cardiac Center program for cardiac catheterization since inception and the impact of armed conflict on provision of services.

Methods: Annual data from Sudan National Cardiac Center were obtained and analyzed from 2018 to 2023 as well as monthly reports for from May 2023 to June 2024. Data collected were number of operational centers, total number of procedures performed, number of individual procedures performed, and the average annual cost of the program. Pre-conflict and post-conflict data were also compared.

Results: A total of 38,694 cardiac catheterization procedures were performed under the Sudan National Program from 2018 to 2023 with average annual frequency of 6449. Coronary angiography, percutaneous coronary interventions, permanent pacemaker insertion, percutaneous mitral commissurotomy and congenital interventions constituted 64.7%, 22.8%, 9.3%,1.3 % and 1.9% of the total procedures respectively.

Ten centers participated in the program, half of them located in the capital. By end of 2023 and mid 2024 the number of operational centers were 5 and 4 respectively.

In 2022 the monthly average volume was 674 compared to 385 in May-Dec 2023 and 256 in Jan-June 2024 constituting a 52% and 62% drop in volume. The average annual cost of the program was approximately 5.4 million US dollars.

Conclusion: Armed conflicts have significant impact on provision of healthcare services. A government funded program for interventional cardiac procedure in Sudan continues to operate despite the war, however with significant limitations. Re-allocation of professional work-force, funding medical supplies availability and management, patient freedom of movement and secure access to active centers remain the main obstacles.

Introduction:

Cardiovascular diseases (CVD) including atherosclerotic cardiovascular disease have shown a dramatic increase in Africa over the past decades and are now a major health problem.[1,2]In recent decades, about 80% of CVD deaths worldwide have occurred in developing countries. In 2019, more than 1 million deaths from CVD were reported in Sub-Saharan Africa, accounting for 5.4% of global CVD-related deaths and 13% of all deaths in the region.[3]Sudan is no exception with CVD being a leading cause of mortality with high prevalence of associated risk factors.[4,5]

Catheter-based interventions are a cornerstone in the management of CVD and have been shown to reduce mortality and improve patient outcomes and quality of life. However, interventional cardiac services are still not accessible to a large proportion of Africans. Provision of such services is challenging in Africa for various reasons including funding, infrastructure, and trained personnel. [6,7]

In Sudan, the government has increasingly focused on addressing the issue of inaccessibility to interventional services by a large sector of the population, through the establishment of a nationally supported interventional cardiac catheterization program. Initiated in April 2018, this program is fully funded by the government and managed by the Sudan National Cardiac Centre (NCC), a government institute which operates under the technical oversight of the Federal Ministry of Health (FMOH). The program aims to provide comprehensive coronary interventions and select valve interventions at no cost to patients through public and affiliated centers across the country. Funding for this critical initiative is provided by the Ministry of Finance, while procurement procedures are overseen by the National Cardiac Centre and the Sudan Medical Supplies Fund. Prior to this, patients were required to cover 30-50% of the cost for percutaneous procedures out-of-pocket, which posed a significant financial barrier for many. The removal of these financial constraints allowed for broader patient access and contributed to a more substantial reduction in the disease burden.

However, the outbreak of a deadly conflict on April 15 has led to a severe humanitarian crisis, displacing over 7 million people internally.[8] The ensuing war has brought the country's health system to near collapse, significantly impacting the provision of cardiac catheterization services. This disruption has also critically affected access to time-sensitive cardiovascular care.

This paper aims to review the interventional cardiology program of the NCC in Sudan from its inception in 2018 through 2024 and to assess the impact of the ongoing conflict on the sustainability of these services.

Research methods:

1. STUDY DESIGN:

A cross-sectional retrospective facility-based study that investigated the records of the Sudan NCC fully-government supported interventional cardiac catheterization program between April 2018 -June 2024.

2. STUDY SETTINGS:

Sudan has 18 states with Khartoum as its capital and a population of 49.4 million in 2024. [9] The interventional cardiac services are provided through a network of public, public-private, and fully private centres/hospitals.

This study was conducted in ten centres that provide fully government-supported interventional cardiac catheterization services distributed nationwide. Five centres are located in Khartoum. These are Al-Shab Teaching Hospital, Sudan Cardiac Centre, Ahmed Gasem Hospital, Omer Sawi Complex and Omdurman Teaching Hospital. The remaining five centres are located outside. These are Madani Cardiac Center at Aljazeera state (Central region), Daman Marowe Hospital in Northern state (Northern region), Mac Nemer Center and Atbara Medical Complex at River Nile state (Northern region), and Daman Alobeid Hospital at North Kordofan state (Western region).

3.STUDY POPULATION AND SAMPLE SIZE:

Annual data from NCC were obtained from 2018 to 2023. Monthly report since the conflict started were also obtained from May 2023 to June 2024. Data collected were number of operational centres, total number of procedures performed, number of individual procedures performed, and the average annual cost of the program.

4. METHODS OF DATA COLLECTION:

A structured extract forms were used to compile and summarize data and information from the available documents and records.

5. DATA ANALYSIS

Data were entered, cleaned, analysed, and displayed using an Excel spreadsheet. Pre-conflict and post-conflict data were also compared.

6. ETHICAL CONSIDERATION:

The technical and ethical approval of the study was obtained from the National Cardiac Centre Research Committee.

Results:

1. SUDAN INTERVENTIONAL CARDIAC CATHETERIZATION PROGRAM: PARTICIPATING CENTRES AND PROCEDURES TYPE AND VOLUME (2018-2023)

Ten centers were involved in the program; five were located in the capital Khartoum and the rest distributed nation-wide. A new cardiac catheterization lab was inaugurated after the war in Atbara city. A map of Sudan with locations of participating centers at different timelines is depicted in Figure 1.

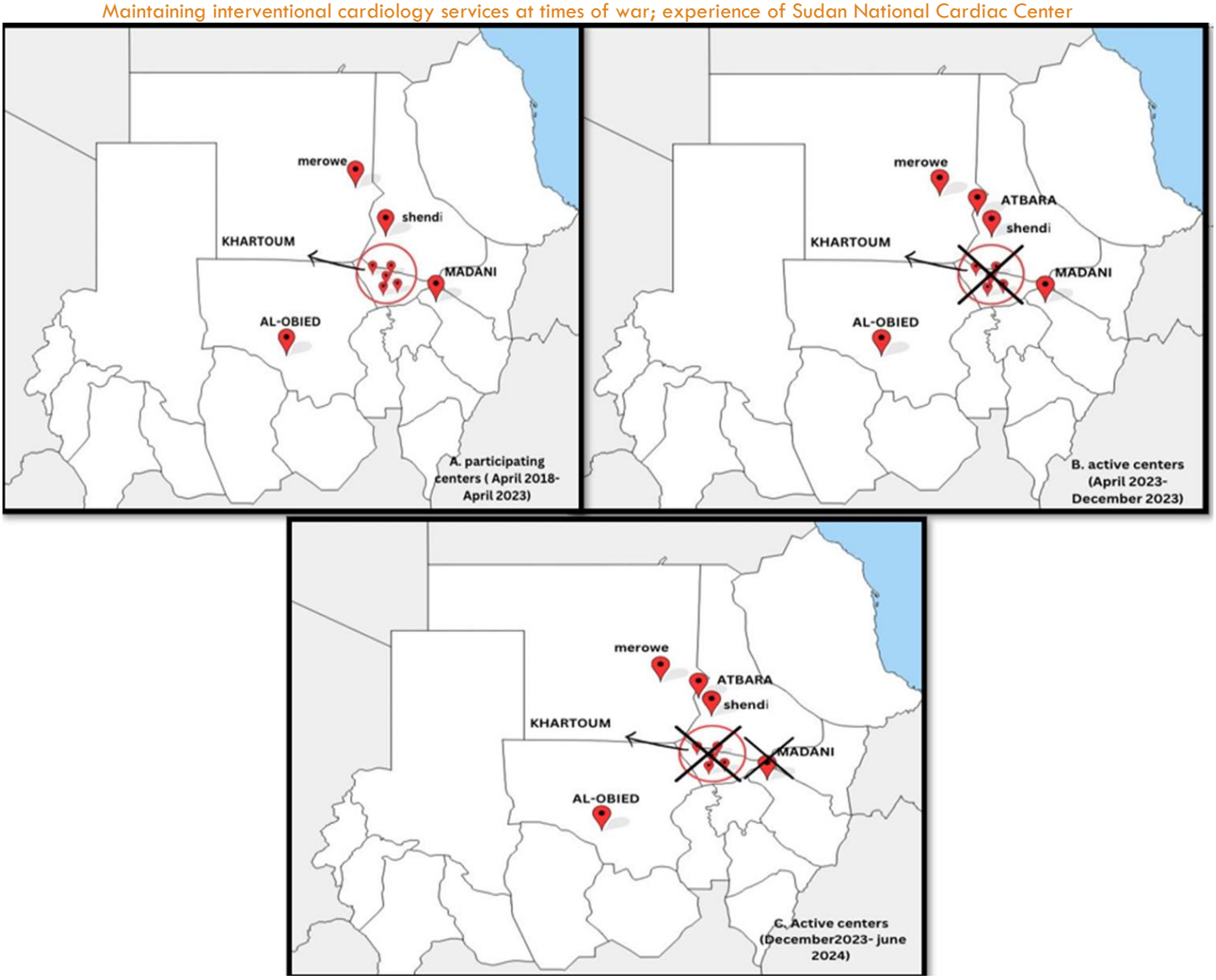


Fig. 1. Map of Sudan showing the locations of participating centers at different timelines. (A) April 2023 (B) December 2023 (C) June 2024

Since the adoption of fully-government supported interventional cardiac catheterization program in April 2018 up to December 2023 a total of 38,694 cardiac catheterization procedures were performed with an average annual frequency of 6449. Of these 32,365 (83.6%) were performed in the capital and 6329 (16.4%) performed outside the capital.

The percutaneous procedures covered by the government program were coronary angiography (CAG), percutaneous coronary interventions (PCI), permanent pacemaker (PPM) implantation, percutaneous mitral commissurotomy (PTMC), congenital interventions primarily for atrial septal defect, patent ductus arteriosus, and pulmonary stenosis and these constituted 64.7%, 22.8%, 9.3%,1.3 % and 1.9% of the total procedures respectively.

A total of 33,861 coronary procedures were performed; 25,034 and 8,827 were CAG and PCI respectively. The average annual rate for CAG and PCI were 4,172 and 1,472 respectively with PCI to CAG ratio of 1:2.8.

PPM constituted 9.3% with a total of 3,603 devices and an annual average of 601 devices. Single lead pacemakers were 57.4 % and dual chamber devices were 42.6 %

Percutaneous mitral commissurotomy were 496 cases and congenital interventions were 734 cases, constituting1.3%, 1.9 % of the total procedures respectively.

The annual frequency of the different cardiac procedures from 2018 to 2023 is shown in Figure 2.

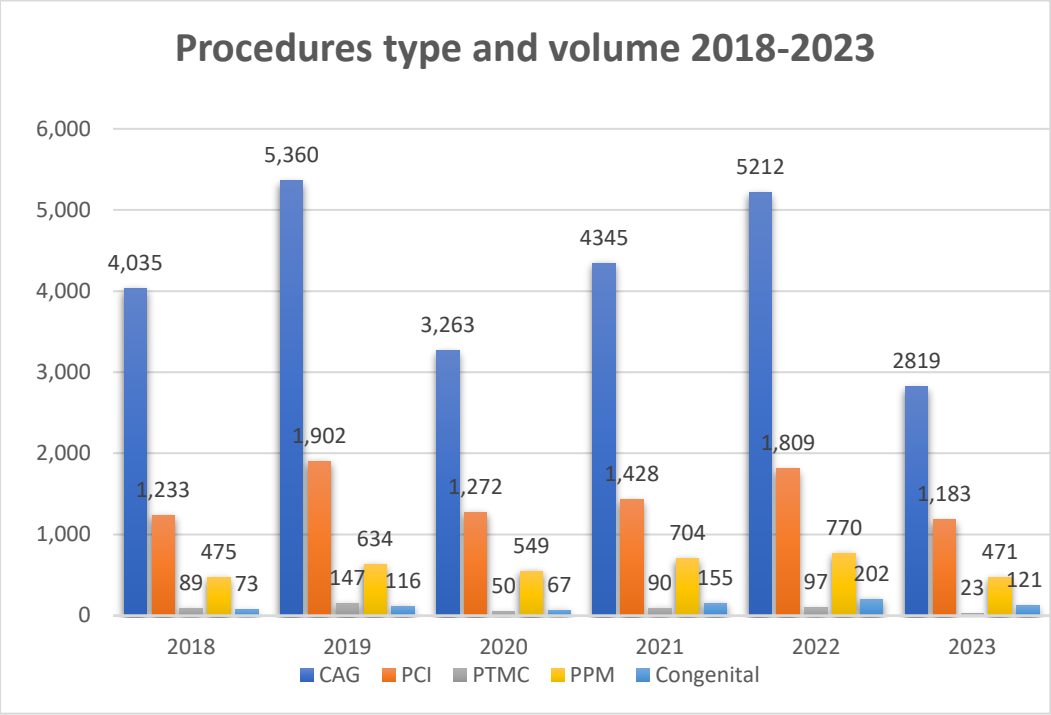


Fig. 2: Interventional cardiac procedures performed 2018-2023. CAG= coronary angiography; PCI= percutaneous coronary intervention; PTMC= percutaneous mitral commissurotomy; PPM= permanent pacemaker.

2. SUDAN INTERVENTIONAL CARDIAC CATHETERIZATION PROGRAM FUND AND DIRECT MEDICAL COST:

There are two main direct costs to the program; cost of the consumables and direct financial incentives to the participating centers. The cardiac catheterization consumables were procured through tenders and quotations proceeded by the National Medical Supplies Fund. The whole budget was provided by the Federal Ministry of Finance through the National Cardiac Center and Federal Ministry of Health.

The program average annual total cost was approximately 5,369,937.695 (US Dollar) for the years 2018 to 2022, utilized for procurement of medical consumables and providing incentives to the participating centers. Medical consumables constituted 50% of the total cost of the program for years 2018-2020: however, due to inflation and devaluation of local currency it accounted for 91% and 76% of total expenditure for 2021 and 2022 respectively.

Figure 3 shows the total cost of medical consumables purchased by the National Medical Supplies Fund from 2018-2022. Data for 2023 and 2024 are not available.

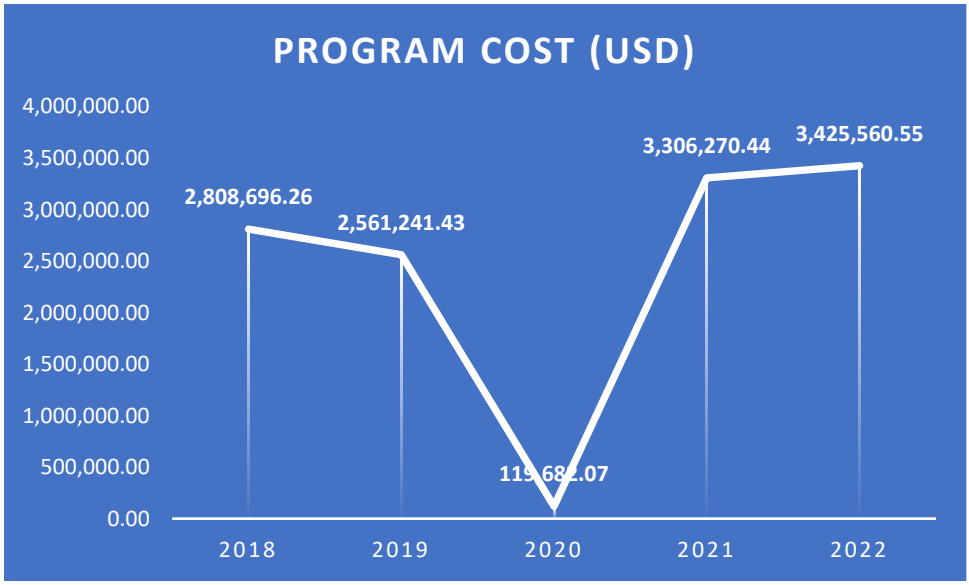
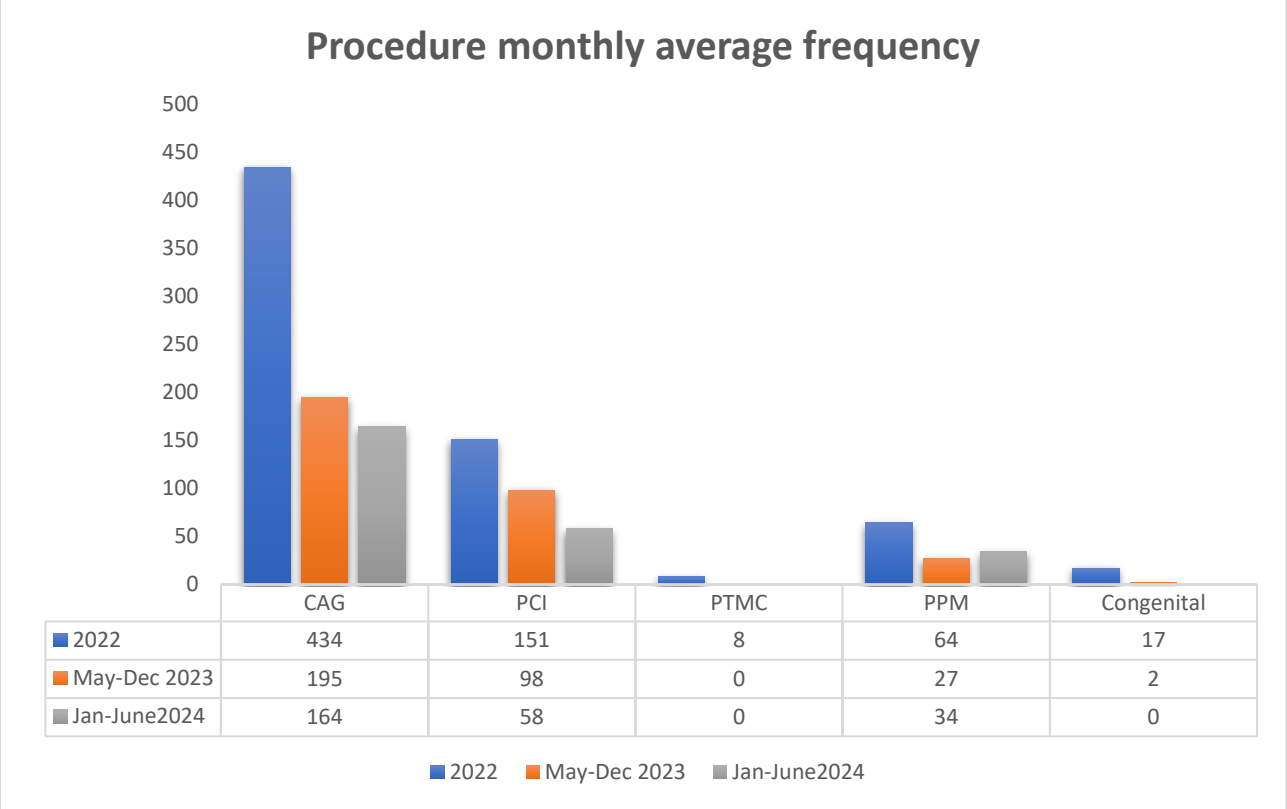


Fig. 3: Cath lab consumables cost 2018-2022 in US dollars.

3. IMPACT OF THE ARMED CONFLICT ON SERVICES (MAY 2023- JUNE 2024)

By the end of 2023 and mid 2024 the number of operational centers dropped to 5 and 4 centers respectively (Fig 1). In 2022 the monthly average volume was 674 procedures compared to 385 in May-Dec 2023 and 256 in Jan-June 2024 constituting a 52% and 62% drop in volume. Figure 4 shows the monthly averages for different procedures in 2022, compared with May-December 2023 and January-June 2024.



	CAG	PCI	PTMC	PPM	Congenital
2022	434	151	8	64	17
May-Dec 2023	195	98	0	27	2
Jan-June2024	164	58	0	34	0

Fig. 4. Monthly average of procedures before and after war. CAG= coronary angiography; PCI= percutaneous coronary intervention; PTMC= percutaneous mitral commissurotomy; PPM= permanent pacemaker

Certain procedures including congenital interventions and percutaneous mitral valvotomy are no longer performed. In the months following the war (May- December), PCI rate has dropped only by 30% and PCI: CAG ratio rose to 1:1.3. In 2024, PCI:CAG ratio was 1:2.8, similar to 2022.

Discussion:

OVERVIEW OF SUDAN NCC INTERVENTIONAL CARDIOLOGY PROGRAM 2018-2023

This is a unique program in Africa that provides interventional cardiology services free of charge for Sudanese nationals based on their national identification number in a number of public and affiliated centers across the country. Despite the high burden of CVD in the continent and the rising need for interventional procedures, these services are limited due to various reasons including lack of infrastructure, trained personnel and funding. [6,10] Some of the leading African countries like Egypt and South Africa have publicly funded programs though not without their own challenges. [11,12]

Prior to the program, there was a co-payment system whereby 30-40% of the procedures cost was funded by the government through the National Insurance or Social Security Fund and the rest was out-of-pocket expenses for patients. However, this still remained a catastrophic expenditure for the vast majority of patients for life saving interventions that have to be performed in a timely manner.

The procedures covered by the program were based on pre-existing data from cardiac centers and coronary procedures were the most commonly performed under the program. This probably reflects the increasing burden of ischemic heart disease in Sudan as in other African and low-income countries. [13,14] In 2022, with an estimated population of 46.87 million, the PCI per million population was 37.8. Taking into consideration that most procedures performed in Sudan were under the NCC program, this represents a low number compared to international figures and still greatly unmet need. Data from the European Society of Cardiology Atlas in Interventional Cardiology quote 2338.3 and 1056.8 PCI per million population per year for high-income and middle-income countries respectively. [15]

PPM implantation was the second procedure in terms of frequency. In 2022, 202 PPM were implanted with a rate of 4.3 per million population. This is in alignment with data reported by PASCAR (Pan African Society of Cardiology) in Europace in 2017, whereby 26% of African countries had no access to pacing with a median implantation rate of 2.66 per million population per country which is 200-fold less than in Western Europe. [16] The lack of infrastructure and funding for this greatly needed procedure in Africa was also highlighted by a recent report from AFHRA (Africa Heart Rhythm Association).[17] The paper also emphasized the importance of the training programs within the continent in which Sudan was a part of. This reflects that how the benefits of the NCC program in Sudan can cross borders and help train cardiologists from neighboring countries.

Funding and direct cost of the program

The funding for the program was provided by the Federal Ministry of Finance of Sudan. The NCC, which is under the Federal Ministry of Health, would provide its projection for the upcoming year and consumables would be procured by the National Medical Supplies Fund, a government agency, which purchases in bulk via tenders and hence reducing cost. Part of the budget of the

program is paid directly to participating centers, and the hospital staff involved in the provision of services including operators, allied professionals, and other staff involved in local management. This strategy has solved the issue of funding and consumable provision. However, this alone would not have made the program possible without two other important factors. The program benefited from the available infrastructure of cardiac centers equipped with cardiac catheterization labs in the public sector and affiliated hospitals. [18] The other crucial element was the availability of trained cardiologists and allied professionals. A national cardiology fellowship training program by the Sudan Medical Specialization Board graduated its first batch in 2014.[19]

A median annual budget of about 5.4 million US dollars constitutes the total direct medical cost including total cost of the annual tenders and incentives to hospitals and staff. With the available data, it is difficult to ascertain the direct cost for each individual procedure and compare it to international figures.

Impact of the armed conflict on services:

The armed conflict erupted in the capital Khartoum rendering all cardiac centers in the capital, and half of all nationwide centers which contributed by more than 83% of the total program volume, out of service immediately. The concentration of services in the capital is probably due to the population density in the capital as well as a form of inequality of healthcare distribution. One year after the conflict, the program is running at 40% of its previous capacity with more burden on centers located outside the capital and central region; a de facto decentralization of services. Reduction in the number of active centers, loss of skilled professionals, funding, and freedom of patient movement all contributed. A similar experience was seen during the Tigray conflict in neighboring Ethiopia where cardiac catheterization procedures dropped by more than 50% as reported by Weldegerima and his colleagues. [20]

Certain procedures that require special skills like percutaneous mitral valvotomy and interventions for congenital defects were no longer performed probably due to the loss of skilled operators or difficulty obtaining necessary consumables.

Despite the very well-known impact of armed conflict on health care systems, it is still remarkable that such a publicly funded program continues to operate despite ongoing armed conflict.[21-24]The presence of a central body that is able to secure government funding and reallocate resources to centers in safe zones played a vital role.

Conclusions:

A government funded program in Sudan has provided free of charge interventional cardiology services since 2018 with ten centers nationwide. Procedures covered included coronary angiography, percutaneous coronary intervention, permanent pacemaker implantations and certain valve and congenital defects interventions with an annual budget of around 5.4 million UD dollars. The program was a partnership between the Federal Ministry of Health, National cardiac Center and National Medical Supplies Fund.

The armed conflict had a significant impact on the program yet it continues to operate. Presence of a central organizing body, the National cardiac center, that was able to secure funding and reallocate available resources was crucial to mitigate the profound devastating effect of war.

Limitations: The data used in this article were primarily intended for administrative and planning purposes. Demographic and clinical data, outcome and quality measures were not included in this article as access to this data was not possible due to security situation.

Conflict of interest: The authors have no conflicts of interest to declare.

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References:

1. Minja NW, Nakagaayi D, Aliku T, et al. Cardiovascular diseases in Africa in the twenty-First Century: Gaps and priorities going forward. *Frontiers in Cardiovascular Medicine*. 2022;9. doi:10.3389/fcvm.2022.1008335
2. Opie LH, Mayosi BM. Cardiovascular disease in sub-Saharan Africa. Circulation. 2005 Dec 6;112(23):3536-40. doi:10.1161/CIRCULATIONAHA.105.597765. PMID: 16330692.
3. Keates AK, Mocumbi AO, Ntsekhe M, Sliwa K, Stewart S. Cardiovascular disease in Africa: epidemiological profile and challenges. Nat Rev Cardiol 2017;14:273–293.
4. Mohamed AA, Fourie JM, Scholtz W, Scarlatescu O, Nel G, Subahi S. Pascar and WHF Cardiovascular Diseases Scorecard Project. *Cardiovascular Journal of Africa*. 2019;30(5):305-310. doi:10.5830/cvja-2019-063
5. Suliman A. The state of heart disease in Sudan. Cardiovasc J Afr. 2011 Jul-Aug;22(4):191-6. doi: 10.5830/CVJA-2010-054. PMID: 21881684; PMCID: PMC3721897.
6. Aderinto N, Olatunji D. Assessing the condition of percutaneous coronary intervention services in Africa: Challenges and prospects for advancement – A Review. Annals of Medicine & Surgery. 2023;85(6):2814-2820. doi:10.1097/ms9.0000000000000924
7. Stassen W, Wallis L, Lambert C, Castren M, Kurland L. Percutaneous coronary intervention still not accessible for many South Africans. Afr J Emerg Med. 2017 Sep;7(3):105-107. doi: 10.1016/j.afjem.2017.04.009. Epub 2017 Apr 19. PMID: 30456119; PMCID: PMC6234190.
8. Sudan. UNHCR. Accessed August 9, 2024. https://www.unhcr.org/countries/sudan.
9. World population dashboard -Sudan. United Nations Population Fund. Accessed August 9, 2024. https://www.unfpa.org/data/world-population/SD.
10. Minja NW, Nakagaayi D, Aliku T, et al. Cardiovascular diseases in Africa in the twenty-First Century: Gaps and priorities going forward. *Frontiers in Cardiovascular Medicine*. 2022;9. doi:10.3389/fcvm.2022.1008335
11. Magdy A, Shawky A, Mohanad A, Shaheen S. Egypt: Coronary and structural heart interventions from 2010 to 2015. *EuroIntervention*. 2017;13(Z). doi:10.4244/eij-d-16-00832
12. Holmes DR Jr, King S, Gershlick AH, Marco J, Koolen J, Pichard A, Bassand JP, Kettles DI, Wijns W, Ntsekhe M. Invasive cardiovascular needs in South Africa: a view from afar up close. EuroIntervention. 2018 Oct 20;14(8):852-855. doi: 10.4244/EIJV14I8A153. PMID: 30339131.
13. Taha AM, Roshdy MR, Abdelma'amboud Mostafa H, Abdelazeem B. Ischemic heart disease in Africa: An overnight epidemiological transition. *Current Problems in Cardiology*. 2024;49(2):102337. doi:10.1016/j.cpcardiol.2023.102337
14. Gaziano TA, Bitton A, Anand S, Abrahams-Gessel S, Murphy A. Growing epidemic of coronary heart disease in low- and middle-income countries. Curr Probl Cardiol. 2010 Feb;35(2):72-115. doi:10.1016/j.cpcardiol.2009.10.002. PMID: 20109979; PMCID: PMC2864143.
15. ESC Atlas in Interventional Cardiology. Available at https://eatlas.escardio.org/Atlas/ESC-Atlas-in-Interventional-Cardiology/Interventional-cardiology-procedures/sipcp_pci_1m_r-percutaneous-coronary-interventions-pci-per-million-people. Last accessed August 9th, 2024.
16. Bonny A, Ngantcha M, Jeilan M, et al. Statistics on the use of cardiac electronic devices and interventional electrophysiological procedures in Africa from 2011 to 2016: Report of the Pan African Society of Cardiology (PASCAR) cardiac arrhythmias and Pacing Task Forces. *EP Europace*. 2017;20(9):1513-1526. doi:10.1093/europace/eux353
17. Jeilan M, Rwebembera J, Aden H, et al. The inaugural meeting of the Africa Heart Rhythm Association (AFHRA). *Cardiovascular Journal of Africa*. 2020;31(3):54-56. doi:10.5830/cvja-2020-019
18. Suliman AA. Development and current status of Interventional Cardiology in Sudan. *European Heart Journal*. 2020;42(13):1190-1191. doi:10.1093/eurheartj/ehaa1056
19. Khalil SI. Sudan Cardiology. *International Cardiovascular Forum Journal*. 2015;2(1). doi:10.17987/icfj.v2i1.92
20. Weldegerima AH, Tesfay H, Berhane S, Leuner CJ. Tigray siege and its impact on cardiology services in Mekelle University Hospital: A call to action. *European Heart Journal*. 2022;43(33):3095-3097. doi:10.1093/eurheartj/ehac295
21. Mesfin B, Mersha Demise A, Shiferaw M, Gebreegziabher F, Girmaw F. The Effect of Armed Conflict on Treatment Interruption, Its Outcome and Associated Factors Among Chronic Disease Patients in North East, Amhara, Ethiopia, 2022. Patient Relat Outcome Meas. 2023;14:243-251.https://doi.org/10.2147/PROM.S388426
22. Arage, M.W., Kumsa, H., Asfaw, M.S. et al. Exploring the health consequences of armed conflict: the perspective of Northeast Ethiopia, 2022: a qualitative study. BMC Public Health 23, 2078 (2023). https://doi.org/10.1186/s12889-023-16983-z
23. Murray CJ, King G, Lopez AD, Tomijima N, Krug EG. Armed conflict as a public health problem. BMJ. 2002;324(7333):346–9.
24. Ekzayez, A., Alhaj Ahmad, Y., Alhaleb, H. et al. The impact of armed conflict on utilisation of health services in north-west Syria: an observational study. Confl Health 15, 91 (2021). https://doi.org/10.1186/s13031-021-00429-7