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REVIEW

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Surgical outcomes of congenital heart disease in African pediatric populations: a systematic review

Chidera Stanley Anthony[1], Ikponmwosa Jude Ogieuhi[2*], Alexander Idu Entonu[3], Nwamaka Chidera Bob-Ume[4], Olufemi Akinmeji[5], Osita Miracle Chukwuneke[6], Ayodeji Akinmeji[7], Victor Oluwatomiwa Ajekiigbe[8] and Chinonyelum Emmanuel Agbo[9]

Abstract

Background Congenital heart disease (CHD) is a major cause of child morbidity and mortality across Africa. Despite increased recognition of CHD as a significant public health challenge, surgical services remain geographically and institutionally limited. Individual reports and studies have shown widely varied surgical outcomes for pediatrics in Africa. Hence, there is a need to obtain consolidated evidence on these outcomes to guide policies. This study systematically analyzes the surgical outcomes of CHD among African pediatric populations.

Method Using the PRISMA guidelines, we searched databases including PubMed, Google Scholar, Scopus, Web of Science, and AJOL. Boolean operators (AND, OR) were used appropriately to combine the keywords. We then screened articles for eligibility, ensuring that only studies with surgical interventions comprising the pediatric African population were selected.

Results A total of 2,843 records were screened, of which 18 eligible studies were included. The median age of the included population ranged from about 2 years to 15 years. The postoperative mortality ranged from approximately 0% to 13%. In many cases, patients presented late, often with advanced disease and comorbidities. The median hospital stay ranged from 7 to 19 days. Centers with locally trained cardiac surgeons had better survival rates than those reliant solely on visiting international missions.

Conclusion There are wide systemic inequities in terms of the availability of surgical services and outcome measures such as mortality and complications. There is a need to invest adequately in pediatric cardiac programs to ensure the availability of highly-skilled local cardiologists and adequate infrastructure.

Keywords Surgical outcomes, Congenital heart disease, Pediatrics, Africa

*Correspondence:
Ikponmwosa Jude Ogieuhi
jude.ogieuhi@gmail.com
[1]University of Calabar, Calabar, Nigeria
[2]Northwestern Medicine McHenry Hospital, McHenry, USA
[3]University of Ilorin, Ilorin, Nigeria
[4]All Saints University College of Medicine, Kingstown, Saint Vincent and the Grenadines
[5]Olabisi Onabanjo University, Sagamu, Nigeria
[6]BPP University, London, UK
[7]New York Medical College, Valhalla, USA
[8]Ladoke Akintola University of Technology, Ogbomoso, Nigeria
[9]University of Nigeria, Nsukka, Nigeria

Background

Congenital heart disease (CHD) is a major cause of child morbidity and mortality across sub-Saharan Africa (SSA). It affects an estimated 8–12 per 1,000 live births in the region, leading to approximately 259,000 new cases each year [1–3]. Many children remain undiagnosed or untreated due to underdeveloped neonatal screening programs, a shortage of pediatric cardiology specialists, and weak diagnostic and referral systems, particularly in rural and underserved urban areas. As a result, CHD-related mortality in African children far exceeds global averages [1–5].

Congenital heart disease contributes significantly to the cardiovascular burden in Africa, with an estimated 3,000–5,000 DALYs lost per million people [6]. This translates into an annual economic loss exceeding USD 3–5 billion, highlighting the fact that CHD imposes a measurable socioeconomic cost beyond mortality percentages through lost productivity, premature death, and lifelong disability [6–9].

The burden is further compounded by limited surgical capacity. Sub-Saharan Africa, excluding South Africa, has one cardiothoracic surgeon for every four million people and fewer than one cardiac surgery facility per 38 million population, highlighting the severe shortage of trained specialists and equipped centers in the region [10]. Consequently, families often bear substantial financial and logistical burdens to access care, including travel across borders or enduring long waits for intermittent surgical missions [11].

Despite increased recognition of CHD as a significant public health challenge, surgical services remain geographically and institutionally limited. Many advanced pediatric cardiac programs are concentrated in a few urban tertiary hospitals, leaving many communities, particularly in rural settings, without reliable access to surgical care. This uneven distribution of services leaves many communities dependent on care systems that lack structured referral pathways, continuity of care, or postoperative monitoring [12, 13].

Several African-led studies have begun to map the scale of these systemic shortcomings. In Nigeria and Uganda, 30-day perioperative mortality for pediatric CHD surgeries ranges from 1.17% to 8%, which is unacceptably high [13, 14]. A study from Tanzania documents frequent postoperative complications, including infections, prolonged hospital stays, and ICU limitations, often linked to inadequate critical care infrastructure and suboptimal follow-up [15].

However, emerging cost-effectiveness analyses offer encouraging insights. A Rwandan study suggests that establishing local pediatric cardiac surgery programs, supported by government investment and regional partnerships, may offer better survival rates and long-term benefits than models heavily reliant on external providers [16, 17].

This systematic review evaluates surgical outcomes for congenital heart disease in African pediatric populations. Additionally, it identifies and assesses outcome measures such as mortality and recovery and clinical and system-level factors contributing to variation across African countries. These findings will guide clinicians, policymakers, and funders in efforts to reduce CHD mortality and strengthen care systems. They may also inform investments in surgical training, infrastructure, and long-term follow-up services for affected children.

Methodology

Search strategy

This study was conducted in line with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines to ensure transparency and rigor. A comprehensive literature search was conducted from July 12th to 15th, 2025, across databases including PubMed, Scopus, Google Scholar (Using Harzing's Publish or Perish app), Web of Science, and African Journals Online (AJOL). Other data were sourced from grey literature sources, including policy documents, the World Health Organization (WHO) Global Health Observatory, World Bank Health Statistics, government health reports, and Non-governmental Organization (NGO) publications related to pediatric cardiac care.

Search terms were combinations of: Congenital heart disease OR congenital heart defect OR pediatric cardiology; Africa OR Sub-Saharan Africa OR North Africa; Cardiac surgery OR catheterization OR surgical outcomes. Modifications of the search were made with Boolean operators (AND, OR), and MeSH terms applied were appropriate. Hits from each database were imported into Rayyan, where title and abstract screening was done. Full-text screening followed this stage, where the included studies were selected. Figure 1 illustrates the PRISMA flowchart.

Eligibility criteria

Using the PICO framework, we set some criteria that guided the selection of the included studies:

- Population (P): Pediatric patients (0–18 years) diagnosed with congenital heart disease in African countries.
- Intervention (I): Surgical procedures (example: open-heart surgery, palliative surgery, and catheter-based interventions).
- Comparison (C): Outcomes compared across different procedures, centers, or timeframes where applicable.

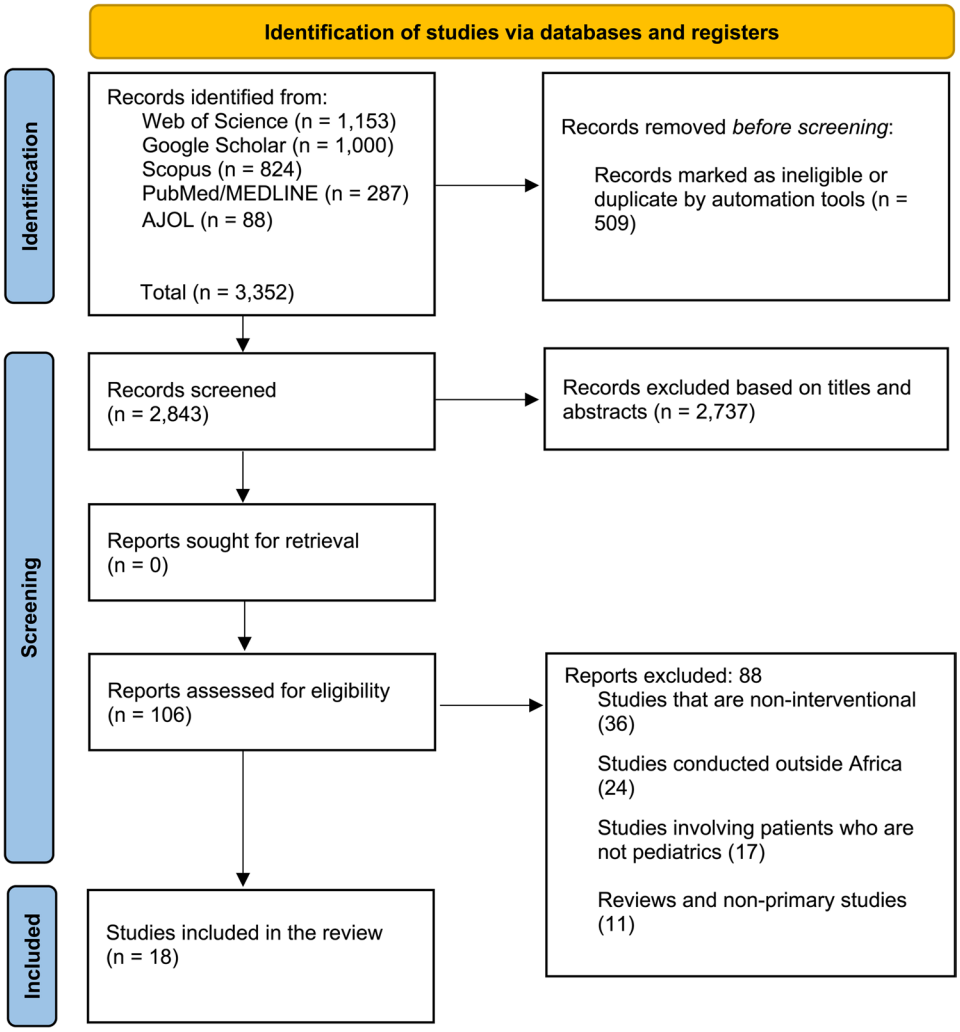

Fig. 1 PRISMA flowchart of Included Studies

- Outcome (O): Mortality; morbidity; survival rates; complication rates like arrhythmias, pleural/pericardial effusion, bleeding, sepsis, and surgical site infection; reintervention rates; length of hospital stay; and quality of life.

Only primary studies published in peer-reviewed journals within the last 15 years were included. This was done to capture contemporary outcomes rather than outdated practices because there have been significant improvements in diagnostic modalities and surgical techniques over the past 15 years.

Studies were excluded if they:

- Focused exclusively on epidemiology or genetics without surgical outcomes.
- Were conducted outside Africa, or if procedures were not performed on African patients.
- Are not primary studies (reviews, editorials, commentaries, or letters).

Study selection

Study selection was done using titles and abstracts, which were screened for eligibility by two independent reviewers [C.S.A and V.O.A]. Full-text articles of potentially relevant studies were further assessed by the same reviewers using predefined inclusion criteria. Discrepancies were resolved through discussion or consultation with a third reviewer [I.J.O].

Data extraction

Data were extracted using a standardized form with columns such as author & year, study design, country/region, patient characteristics (age, sex, sample size, and diagnosis), type of surgical or interventional procedure performed, perioperative considerations, reported

outcomes (mortality, morbidity, complications, and survival), follow-up duration, and reported challenges.

Data synthesis

Findings were synthesized thematically and quantitatively where data permitted. Key themes analyzed included types of procedures performed, perioperative mortality and morbidity, long-term survival, and regional disparities in outcomes. Narrative synthesis was applied as the heterogeneity of the included studies precluded meta-analysis. Descriptive statistics were used where applicable.

Quality assessment

The quality of the included studies was assessed by two independent reviewers [C.S.A and V.O.A]. The Newcastle-Ottawa scale (NOS) was used for cohort studies, the Critical Appraisal Skill Program (CASP) tool for Descriptive/cross-sectional studies, and the Joanna-Briggs Institute (JBI) quality assessment tool for case series and analytical cross-sectional studies.

Results

Demographics and clinical characteristics

Across the 18 reviewed studies [3, 12, 15, 17–30], over 5,000 pediatric patients with congenital heart disease (CHD) were evaluated across multiple countries in sub-Saharan Africa and North Africa. The median age of the included population ranged from about 2 years to 15 years. There was a slight male predominance in most cohorts, with male representation ranging from 51% to 65.7% in various series from Tanzania, Uganda, Cameroon, Ghana, and Egypt [12, 13, 15, 18, 19, 23, 28]. The median age at diagnosis varied widely between institutions. For instance, the Ugandan Heart Institute reported a median age of 4 years among their Tetralogy of Fallot (TOF) cohort, while the Tanzanian JKCI study had a median age of 3 years [15, 28]. However, in many cases, patients presented late, often with advanced disease. In the South African series by Murigo-Shumba et al., only 19.6% of patients were under one year of age at the time of surgery, with a median presentation age of 24 months [18]. Furthermore, comorbidities were prevalent. Underweight status was common in Tanzanian and Ethiopian series, with reports of up to 90% of TOF patients being malnourished [15, 25]. Infectious comorbidities included HIV, malaria, and sickle cell disease, although their frequencies were relatively low (< 3%) in most reports [12, 15]. Several studies reported cyanotic spells (14.5%–45.2%), infective endocarditis, and brain abscesses as significant preoperative issues, particularly among patients with delayed diagnosis [13, 18, 19, 25]. Additionally, echocardiography was the principal diagnostic modality across all studies, often accompanied by cardiac catheterization in more complex or ambiguous cases. Advanced imaging modalities like CT angiography or cardiac MRI were infrequently used, being largely unavailable in many centers except for a few in Egypt and South Africa [12, 21, 29]. See Table 1.

Surgical outcomes

CHD surgical care is comprised predominantly of open-heart corrective repairs. TOF was the most commonly addressed lesion, followed by Ventricular Septal Defect (VSD), Atrial Septal Defect (ASD), Patent Ductus Arteriosus (PDA), and Atrioventricular (AV) canal defects. Most surgical centers utilize the transatrial or right atrial approach for TOF repair, with the transannular patch (TAP) employed in cases of significant right ventricular outflow tract (RVOT) obstruction. In Uganda, TAP was used in only 8% of TOF repairs, while in Cameroon and Libya, it was used in over 80% of patients undergoing TOF correction [13, 22, 26]. Notably, operative mortality rates varied significantly by country and institutional capacity. Tanzanian and Nigerian studies reported in-hospital mortality of 5.9% and 9.7%, respectively, following complete TOF repair [12, 15]. In Uganda, 30-day postoperative mortality was 8%, and in South Africa, it was 5.1% [13, 18]. Lower mortality rates were noted in more developed centers; for example, an Egyptian multicenter study involving 400 VSD patients reported a perioperative mortality of 2.5% [20]. In contrast, palliative surgeries, including modified Blalock-Taussig (mBT) shunts, were associated with higher mortality. In one Nigerian series, both patients who underwent mBT shunts died, while 23.1% of medically managed palliative cases also succumbed [12]. Similarly, in Ethiopia, 8.1% of patients had palliative shunts, mostly due to delayed presentation or resource limitations [25]. Moreover, postoperative complications were frequent. Arrhythmias were observed in 14.5% to 22.6% of patients across several cohorts, with junctional ectopic tachycardia (JET), heart blocks, and PVCs being the most common [12, 13, 28]. Pericardial and pleural effusions occurred in over 30% of patients in some series, particularly in Nigeria and Ethiopia [12, 25]. Infections such as sepsis and pneumonia were commonly reported, with frequencies as high as 26.1% in Uganda and 48% in Nigeria [12, 13]. Correspondingly, median ICU stay ranged from 48 h in Egypt to 7.5 days in Nigeria, depending on the severity of the condition and postoperative complications [3, 28]. The median hospital stay ranged between 7 and 19 days across the various settings.

Functional outcomes and quality of life

Functional outcomes following surgery were variably reported. Postoperative echocardiographic assessments indicated preserved or mildly impaired ventricular

Table 1 Overview of included studies

Author/year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/complications	Outcomes and Findings	Follow-up duration	Challenges reported
Majani et al., 2024 [15]	Retrospective cohort	Tanzania	102 children with classical Tetralogy of Fallot (TOF), Median age 3 years, 65.7% male,	102 Primary complete TOF repair via trans-atrial approach Ventriculotomy procedure with use of glutaraldehyde-treated autologous pericardial patch, transannular patch (TAP) when necessary	Comorbidities: Underweight: 90% Medical illnesses (e.g., HIV, sickle cell, malaria): Present in 2.9%	Operative Mortality (in hospital): 5.9% No 30-day post-discharge deaths Complications: Bacterial sepsis: 5.8% Surgical site infection: 0.9% Surgical bleeding: 2.9% Reoperation: 0% ICU Stay Median of 72 h and median hospital stay of 8.5 days	30 days	Insufficient capacity to operate on all diagnosed patients (180 TOF cases, only 102 operated) Specialist shortage: limited local surgeons No full classification of TOF severity due to missing echocardiography, CT/cath lab data Late Presentation: as only 19.6% of patients < 1 year of age at time of surgery

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Bamigboye-Taiwo et al., 2022 [12]	Retrospective audit	Nigeria	72 patients (37 males, 35 females) with classic TOF. Mean age: 4.7 ± 4.0 years	33 surgical interventions (31 corrective surgeries and 2 palliative Modified Blalock-Taussig (mBT) shunt, 39 patients received medical management only	Comorbidities include Polycythaemia (most common among medically managed patients, 97.4%) Right coronary cusp prolapses (41%) Right Ventricular dysfunction (25.6%) Others: pneumonia, stroke, cerebral abscess, Echocardiography (2D Doppler) used in diagnosis and CCT/catheterization in unclear cases	Surgical group mortality Corrective surgery: 3 (9.7%) mBT shunt: 2 (100%), 23.1% mortality in palliative medically managed group and 19.4% overall mortality. Complications Post surgery: Malaria: 80.6% Arrhythmias: 22.6% Cardiac dysfunction: 19.4% Pericardial effusion: 48.4% Pleural effusion: 58.1% Pulmonary regurgitation (free): 48.4%	2 months to 4 years Follow-up Echocardiography: Done at 1-, 3-, 6-, and 12-weeks post-op	Lack of dedicated Cardiac ICU limited access to advanced imaging (CMRI/CCT) Cost is subsidized but still unaffordable for many Late diagnosis common and disease advanced at time of intervention
Murigo-Shumba et al., 2024 [18]	Retrospective, descriptive, and analytical observational study	South Africa	292 patients with TOF, Median age 24 months at presentation, 63.7% males.	Surgical intervention in all participants Right atrial approach for VSD closure in 94.2% 22 patients (7.7%) had initial palliation (systemic-pulmonary shunt) 12 emergency surgeries, 280 electives	Comorbidities: Hypercyanotic spells: 132 (45.2%) Infective endocarditis (5 patients), brain abscess and Cardiac arrest due to hypercyanotic spell seen in one patient each.	5.1% operative mortality Complication rates: 17.5% Infections, 11.6% Arrhythmias, 3.8% early reoperations, Median ICU stay of 3 days, 3.8% reoperation rate, 43.5% with severe Pulmonary regurgitation 34.2% with severe RVOT (Right Ventricular Outflow Tract) gradient	Not consistently reported; assessment mainly at first post-operative follow-up	Limited cardiac surgical and ICU services and equipment Delays in diagnosis and surgery

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Tchoumi et al., 2011 [19]	Retrospective study	Cameroon	22 patients (14 males, 8 females) with classical TOF. Mean age: 9.18 ± 6.5 years,	All patients underwent complete TOF repair, Trans-annular patch in 12 patients and Infundibular patch in 10 patients	Comorbidities: 5 patients (25%) symptomatic with hypoxic spells 1 patient had lower limb hypotony due to prolonged immobility	9% Operative mortality Complication rates: Mild pericardial effusion (4 cases) Pleural effusion (3 cases) Chylothorax (1 case), Mean ICU stay of 5 ± 3 days, Mean hospital stay: 15 ± 7 days Functional Outcomes: RV function normal in 95%, mildly depressed in 5% Mild/ moderate pulmonary regurgitation: 3 patients (13.7%) Mild RVOT obstruction in 1 patient (25–35 mmHg gradient) All patients in sinus rhythm; 2 had first-degree AV block	32 ± 9 months, Range of 8 months to 6 years	Facilities shortages and diagnostic limitations delayed diagnosis and care, Limited Surgical Infrastructure Cultural beliefs and poverty.

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Khainza et al., 2024 [13]	Retrospective cohort	Uganda	104 total patients with TOF; however, only 88 records were analyzed (84.6%), Median age of 4 years, 51.1% females	All 88 patients had surgical intervention Trans-atrial approach (69.3%) Transannular patch used in only 8.0%	Comorbidities: severe RVOT (90.9%) Chronic hypoxia common (median preop oxygen saturation: 86%; in deceased: <70%),	8% 30-day operative mortality, Post op complications: 39.8% Residual VSDs, 37.5% RV dysfunction, 30.7%- Pulmonary regurgitation, 30.0% RVOT obstruction, 27.3% Pleural effusion And arrhythmias (JET, heart block, PVCs) each, 26.1% Infections (sepsis, pneumonia, wound infections), Median ICU and Hospital stay of 4 and 16 days respectively. 1 patient required reoperation RV function impaired in 37.5% LV dysfunction in 10.2% One seizure case with partial limb weakness post-discharge	30-day post-surgery	Reliance on visiting international surgeons initially Single center (UHI) with limited surgical capacity No ECMO support; lack of dialysis options beyond peritoneal Late Presentation; median age 4 years due to delayed access

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Amah et al., 2023 [3]	Descriptive, cross-sectional study	Nigeria	73 children Mean age of 78.14 ± 52.86 months, 53.42% males, Patients had different types of CHD	All children underwent open-heart surgeries, which included VSD closure (26.85%) Total correction of TOF (21.30%) PDA ligation, ASD closure, infundibular resection, mitral valve repair	12.33% had comorbidities including Down's syndrome > 1 year duration of wait time before surgery in 67.12%	6.9% operative mortality Complications, including complete heart block and CVA in 4.11% Mean ICU stay duration of 7.53 days	No long-term follow-up outcome documented	Limited surgical infrastructure, Late presentations, High cost; surgeries were subsidized or free through missions Shortage of specialists
Azab et al., 2013 [20]	Prospective, multicenter observational study	Egypt	400 pediatric patients with isolated VSD. Mean age of 3 ± 3.29 years, 59% males	All 400 patients underwent open-heart surgical closure of VSD Surgical approaches: transatrial (97.5%) transpulmonary (6 cases), transaortic (2 cases)	Perioperative mortality: 2.5% (10 patients), mostly from low cardiac output syndrome (LCOS)	2.5% operative mortality, 3.5% required permanent pacemaker Complete Heart Block (CHB) linked to a large perimembranous VSD and low weight Mean ICU stay duration of 3 ± 2 days, mean hospital stay of 19 days and 8.3 days in CHB group and non-CHB group respectively, CHB associated with morbidity due to PPM and prolonged stay	The follow-up period was only during hospitalization, 100% were followed during hospital stay	Limited follow up period preliminary results and possible delayed heart block, need to be confirmed by a larger trial and by long-term follow-up Absence of objective assessment for choice of surgical technique and was left at the discretion of the surgeon

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Tandia et al., 2022 [21]	Cross-sectional, observational study	Morocco	61 patients with TOF. Median age not reported	All patients underwent surgical corrective TOF repair which included VSD closure, infundibular resection via right atrial approach and RVOT enlargement	Comorbidities included associated CHD anomalies and diagnosis was via preoperative echocardiography	Pulmonary Insufficiency reported in 56.14% of cases (Strong correlation with RVOT enlargement ($p < 0.005$) 10.52% Residual Pulmonary Stenosis 3.2% residual VSD	Echocardiography performed 6–12 months post-surgery	Lack of MRI access for full right ventricular function assessment Lack of evaluation of the right ventricle dysfunction given the cardiac echo-Doppler's low sensitivity. Postoperative complications needing lifelong follow-up
Mve Mvondo et al., 2024 [22]	Retrospective decriptive	Cameroon	105 children, Median age 3 years Male-to-female ratio: 1.39 CHD included were TOF ($n = 96$) TOF + PDA ($n = 5$) TOF + ASD ($n = 4$)	Surgical intervention carried out open-heart surgery via CPB (95.2%) Procedures performed includes Total TOF correction: 100/105 (95.2%) BT shunt (palliative): 5/105 (4.8%) TAP/infundibular patches in 89 (84.8%) RVOT conduit in 11(10.5%)	15% had genetic syndromes 10.5% with digital clubbing Preoperative transthoracic echocardiography used for diagnosis	5.7% Operative mortality within 30 days Complications were Bleeding which led to re-exploration: 5.7% Respiratory distress: 4.8% Arrhythmias: 14.2% RV/LV dysfunction: 4.8% Renal failure: 0.9% Low cardiac output syndrome: 3.8% Median hospital stay of 7 days	Follow up duration not specified	Shortage of pediatric cardiac surgeons and specialists Late diagnosis common; most patients present > 1 year

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Edwin et al., 2016 [23]	Retrospective institutional analysis	Ghana	166 diagnosed patients with (77 ≤ 2 years) with conotruncal defects Median age of 3 years	70 patients had surgical intervention 50 intracardiac repairs (TOF repair ($n=36$; double-outlet right ventricle (DORV) repair ($n=14$)) + 20 Blalock-Taussig (BT) shunts	Transthoracic echocardiography main stay of preoperative diagnosis Wait time to surgeries averagely 6 months for shunt, 4 years for repair	Operative mortality of 4% for intracardiac repair and 0% for BT shunts Complications included Chylothorax: 6% Residual VSDs: 10% (small, non-reoperated) Pulmonary regurgitation: Mild-Moderate (17.8%), Free PR (4.4%) Mean ICU stay of 4.9 ± 3.1 days and and hospital stay of 11.3 ± 6.2 days (repair), 8.1 ± 2.3 (shunt)	Follow up period was during period of hospitalization	Major financial barrier leading to average delays of 6 months to 4 years Severe access delays: only 6 of ~ 1,234 expected cases received care within 2 years (~ 0.5% access) Equipment adequate for surgery, but limited diagnostic access outside Accra
Agwar and Tekleab, 2022 [17]	Retrospective descriptive study	Ethiopia	A total of 58 patients were operated for CHD, mean age of 15 years, 62% female	All patients underwent surgeries including Repairs include ASD/VSD closures, TOF, AVSD	32/33 had comorbidities (mostly diabetes/hypertension) Some had LVEF < 35%, renal failure, anemia Echocardiography used in preoperative diagnosis	No 30-day mortality in patients Stroke with focal neurologic loss in 0.03% ($n=2$)	30 days	Limited ICU drugs Limited cardiac ICU staffing Delayed surgery due to lack of consumables Unstable philanthropic funding model

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Aliku et al., 2014 [24]	Retrospective	Uganda	A total of 124 patients with CHD and mean age of 9.39 years 53.2% male	All patients underwent surgical intervention: ASD/ VSD repairs, TOF repairs, Bidirectional Glenn for Tricuspid Atresia, TAPVR repair, Subaortic membrane resection, Valve replacement (RHD), Ross procedure, AV canal repairs and Atrial myxoma excision	Comorbidities included CHF, valvular lesions, complex CHD	3.2% operative mortality (30-day) Complications were Arrhythmias (10.6%) LV dysfunction (4.9%), pericardial effusion (4.9%), reoperation due to bleeding/sepsis/ abscess (4.9%) and sepsis (1.6%)	Up to 42 days post-op	Lack of pediatric cardiac ICU and intensivists Ventilators unsuitable for infants < 10 kg Few trained local surgeons and anesthesiologists Procurement delays and shortages Lack of direct government financial support as 96.8% surgeries funded by NGOs

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Tefera et al., 2019 [25]	Retrospective cohort study	Ethiopia	A total of 62 patients, Median age of 7 years 51.6% males All patients had TOF, 1 with TOF + absent pulmonary valve syndrome	Primary total TOF repair: 57 patients (91.9%) Palliative shunt: 5 patients (8.1%) Procedures done included TAP repair: 22 patients (35.5%) Non-TAP repair: 39 patients (62.9%) Conduit repair (RV-PA): 2 patients Monocusp TAP: Used in some	Comorbidities were cyanotic spells in 14.5%	12.9% operative mortality which were from Low cardiac output syndrome (LCOS) + Multi organ dysfunction (MODS) Complications rates were 14.5% Residual VSDs: (only one re-operated), 17.7% arrhythmias, 19.4% Pericardial effusion and 17.7% Pleural effusion Median ICU and hospital stay of 3 and 7 days respectively Risk factors for mortality include Long CPB and aortic cross-clamp times, small pulmonary valve annulus, multiple phlebotomies (proxy for advanced cyanosis)	1 month – 6 years 100% of follow up was achieved	Reliant on foreign teams due to limited local surgical expertise Limited cardiac catheterization and imaging access

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Madany et al., 2024 [26]	Descriptive, cross-sectional study	Libya	374 patients with CHD Median age group of 1–3 years	All patients underwent a total of 374 operations which were either corrective or palliative cardiac surgery Surgeries done included VSD closures, TOF repairs, PDA ligations, MVR. Transcatheter closures used for ASD and PDA in the Western region	Diagnosis was via Echocardiography along with ECG, and X-ray,	2.9% operative mortality with the highest mortality in AVC (7.4%), TOF (4%), and CCHD (4.8%)	30 days post op	Few local pediatric cardiac surgeons Heavy reliance on foreign cardiac missions
Ejigu and Amare, 2023 [27]	Retrospective cohort study	Ethiopia	A total of 76 patients with CHD and a mean age of 4 ± 5 years at diagnosis. 54% females	All patients had surgical intervention (both open-heart and closed-heart surgeries) Surgical procedures included: PDA ligation (30.3%), VSD repair (27.2%), ASD repair (14.1%), TOF complete repair (5%)	59% had severe pulmonary hypertension Diagnosis was via echocardiography Mean wait time from diagnosis to surgery was 3 years	2.6% operative mortality Complications were Arrhythmia (6.8%), pneumonia (4.1%) multiorgan failure (4.1%), reoperation, renal failure, bleeding, pericardial effusion, seizures (1–2% each) Median ICU and hospital stay of 3 and 6 days, respectively	30 days	Only one national pediatric cardiac surgery center Only 5 cardiac surgeons and 12 pediatric cardiologists in the country Late presentation

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Mohamed et al., 2024 [28]	Prospective, non-randomized cross-sectional study	Egypt	A total of 200 patients with a median age of 22.5 months.	All patients underwent 200 VSD surgical closure Closure via right atrial approach using polytetrafluoroethylene (PTFE) (57.5%), pericardium, bovine pericardium, Dacron patch	14.5% of patients had Down syndrome, Preoperatively, 1.5% of patients were admitted in NICU and 1% required ventilation Preoperative imaging with Echocardiography and ECG	2.0% operative mortality, 20.5% Post-op arrhythmia incidence, 12%, Sinus bradycardia with junctional escape, 2% 2nd-degree block, 1% 3rd-degree block Rhythm normalization in most; pacemakers needed in a few Residual VSD in 5.5% (all managed conservatively) Longer bypass/cross-clamp time linked to ECG changes Median ICU and hospital stay of 48 h and 5 days respectively	In-hospital postoperative period Long-term follow-up not reported	Academic center with varied care teams leading to variation in care

Table 1 (continued)

Author/ year	Study design	Country	Patient characteristics	Intervention type	Preoperative considerations/ complications	Outcomes and Findings	Follow-up duration	Challenges reported
Sarma et al., 2025 [29]	Retrospective cross-sectional study	South Africa	1701 patients, median age of 1.92 years	2222 surgeries performed in all patients (including 521 repeat operations) Surgeries were definitive repairs, palliative procedures, complex surgeries (TOF repairs, VSD, AV canal repairs)	Comorbidities were renal dysfunction, poor nutrition, pulmonary hypertension, infection, genetic syndromes, ventricular dysfunction	11% Operative Mortality, which were 41% in the palliative group, 10.6% in the AV Canal repair group, and 18.6% in patients undergoing Complex repairs Predictors of mortality were prolonged CPB time, ICU stay duration, aortic cross-clamp time, ventilator days, high STAT 2020, and RACHS-2 scores.	Follow up period was in hospital only	Underfunded public health system, long waiting lists, lack of national cardiac surgery infrastructure, shortage of pediatric cardiologists Lack of robust training, staff retention leading to training gaps Delays and late referrals particularly in the public sector
Bellanti et al., 2023 [30]	Prospective descriptive study	Libya	91 CHD patients, Median age group of 1 to 5 years 52% male 12% had Down syndrome	All patients underwent a total of 91 open-heart surgeries Procedures performed were VSD closure (29%), TOF total correction (27.4%), ASD closure (16%) Others included AVC repair, CoA repair, PDA ligation, valvotomy, Rastelli procedure	Preoperative diagnosis was via Echocardiography, ECG, and catheterization in select cases 6 cases of pre-op mortality	9.8% operative 30-day mortality 25% mortality in the AVC repair group, 12% mortality in the TOF group 6.6% wound infection was the common complication. Others were acute kidney injury (4.3%), Heart block (2.1%), unstable sternum (4.3%), limb ischemia (2.1%)	30 days	Limited Surgical Infrastructure Shortage of Pediatric Surgeons/ Cardiologists Delayed surgery

ASD: Atrial septal defect; *AV:* Atrioventricular; AVC: Atrioventricular canal defect, *AVSD* – Atrioventricular septal defect, *BT* shunt/*BT* – Blalock–Taussig shunt, *CCHD* – Critical congenital heart disease, *CCT* – Cardiac computed tomography, *CHB* – Complete heart block, *CHD* – Congenital heart disease, *CHF* – Congestive heart failure, *CMRI* – Cardiac magnetic resonance imaging, *CoA* – Coarctation of the aorta, *CPB* – Cardiopulmonary bypass, *CVA* – Cerebrovascular accident, *DORV* – Double-outlet right ventricle, *ECG* – Electrocardiogram, *ECMO* – Extracorporeal membrane oxygenation, *HIV* – Human immunodeficiency virus, *ICU* – Intensive care unit, *JET* – Junctional ectopic tachycardia, *LCOS* – Low cardiac output syndrome, *LV* – Left ventricle, *LVEF* – Left ventricular ejection fraction, *mBT shunt* – Modified Blalock–Taussig shunt, *MODS* – Multiple organ dysfunction syndrome, *MRI* – Magnetic resonance imaging, *MVR* – Mitral valve repair, *NGOs* – Non-governmental organizations, *NICU* – Neonatal intensive care unit, *PDA* – Patent ductus arteriosus, *PPM* – Permanent pacemaker, *PR* – Pulmonary regurgitation, *PTFE* – Polytetrafluoroethylene, *PVCs* – Premature ventricular complexes, *RACHS-2* – Risk Adjustment for Congenital Heart Surgery category 2, *RHD* – Rheumatic heart disease, *RV* – Right ventricle, *RV-PA* – Right ventricle–pulmonary artery, *RVOT* – Right ventricular outflow tract, *STAT 2020* – Society of Thoracic Surgeons–European Association for Cardio-Thoracic Surgery mortality categories (2020), *TAP* – Transannular patch, *TAPVR* – Total anomalous pulmonary venous return, *TOF* – Tetralogy of Fallot, *UHI* – Uganda Heart Institute, *VSDs* – Ventricular septal defects.

function in most cohorts. In Cameroon, 95% of patients had normal right ventricular function postoperatively, while mild depression was seen in 5% [19]. South African patients showed better right ventricular outcomes when transannular patches were avoided [18]. Pulmonary regurgitation (PR) was the most common residual lesion. Severe PR was documented in 43.5% of patients in South Africa, 30.7% in Uganda, and 56.1% in Morocco. In these cases, free PR was significantly associated with previous RVOT enlargement or TAP use [13, 18, 21]. Similarly, RV dysfunction post-surgery ranged from 19.4% to 37.5% in Uganda, Nigeria, and Ethiopia [12, 13, 25]. Notably, quality of life measures were sparsely reported. In addition, the incidence of conduction system disturbances varied. Complete heart block requiring a permanent pacemaker was seen in 3.5% of Egyptian VSD repair cases and in 2.1% of Libyan patients [28, 30]. In one Egyptian cohort, 20.5% experienced transient arrhythmias postoperatively, most of which resolved without intervention [28]. Furthermore, a few studies [3, 22, 26, 27, 30] examined PDA ligation alongside TOF surgeries with functional outcomes ranging from complete heart block to CVA and ischemia, among others.

Long-term survival and reinterventions

Long-term follow-up was inconsistent across studies. Only a few centers, primarily in Cameroon and South Africa, reported extended surveillance beyond 12 months. In Cameroon, patients followed for up to six years maintained good right ventricular function, with minimal arrhythmias and no late mortality reported [19]. Encouragingly, reintervention rates were low but not negligible. Early reoperations within 30 days occurred in up to 3.8% of cases in South Africa, primarily for bleeding or residual defects [18]. Residual VSDs requiring reoperation were rare but present in Egyptian and Ethiopian cohorts [25, 28]. Some centers documented single cases of late complications requiring reintervention. In Uganda, one patient underwent reoperation for persistent RVOT obstruction [13]. However, late mortality was infrequently captured due to poor tracking mechanisms. The few centers that followed patients beyond discharge reported stable outcomes. In South Africa, most deaths occurred during hospitalization, and no significant late mortality data were recorded due to limited surveillance infrastructure [29].

Predictors of poor outcomes

Importantly, several predictors of poor outcomes were consistently identified across the reviewed studies. Prolonged cardiopulmonary bypass (CPB) and aortic cross-clamp times were associated with increased operative mortality and longer ICU stays in Ethiopia and South Africa [25, 29]. In addition, delayed diagnosis and intervention, often resulting in advanced disease at the time of surgery, were linked with poorer surgical tolerance and higher complication rates. For instance, in Uganda and Nigeria, patients older than 4 years at surgery experienced more arrhythmias and residual defects [12, 13]. Conversely, low cardiac output syndrome (LCOS) and multi-organ dysfunction syndrome (MODS) were major causes of early postoperative mortality. These were particularly highlighted in Ethiopian and Egyptian cohorts, where patients with small pulmonary valve annuli and prolonged CPB time fared worse [25, 28]. Additionally, preoperative cyanosis, reflected by oxygen saturation below 70%, was associated with increased risk of perioperative mortality and postoperative cardiac dysfunction in Uganda [13]. Furthermore, malnutrition, often reflected by underweight status and WHO z-scores, was noted to impair wound healing and increase infection risk in Tanzania, Ethiopia, and Cameroon [15, 19, 25]. Similarly, genetic syndromes, particularly Down syndrome, were associated with increased complications, such as heart block and pulmonary hypertensive crises. In the Egyptian AVSD cohort, 14.5% of patients with Down syndrome had higher complication rates and prolonged ICU stay [28]. Similarly, a Libyan series observed a 25% mortality in the AV canal repair subgroup, with Down syndrome being a contributing factor [30]. Another critical factor was the lack of specialized postoperative care infrastructure, including the absence of ECMO, limited availability of inotropes, and shortage of pediatric cardiac ICU beds, which was repeatedly cited as a structural predictor of mortality across Uganda, Nigeria, Ethiopia, and Libya [12, 13, 17, 30]. Finally, institutional and systemic factors such as surgical experience, volume of cases, and continuity of care played important roles. Centers with locally trained cardiac surgeons had better survival rates than those reliant solely on visiting international missions. Notably, the transition from foreign to local teams in Cameroon and Libya corresponded with a gradual reduction in operative mortality over time [19, 26].

Quality assessment

The quality assessment was conducted for the 18 included studies. Seven studies were assessed using the Newcastle-Ottawa scale (NOS) for cohort studies. All studies performed well with a score of 6, as scores ranging from 6 to 9 signify a low risk of bias and good quality. They all had no comparator. Nine studies were assessed using the Critical Appraisal Skill Program (CASP) tool for descriptive/cross-sectional studies. All studies were recorded to have a low bias, except for the study by Tandia et al. [21]. The Joanna-Briggs Institute (JBI) quality assessment tool for case series was used to assess 1 study [22]. They had a high rating of 80% and 90%, respectively. One study

Table 2 Quality assessment using Newcastle-ottawa scale (NOS) for cohort studies

Study	Selection (0–4)				Comparability (0–2)		Outcome (0–3)			Total score
	REC	SNEC	AE	DO	SCIF	SCAF	AO	FU	AFU	
Majani et al., 2024 [15]	*		*	*			*	*	*	6
Muringo-Shumba et al., 2024 [18]	*		*	*			*	*	*	6
Tchoumi et al., 2011 [19]	*		*	*			*	*	*	6
Khainza et al., 2024 [13]	*		*	*			*	*	*	6
Azab et al., 2013 [20]	*		*	*			*	*	*	6
Tefera et al., 2019 [25]	*		*	*			*	*	*	6
Ejigu & Amare 2023 [27]	*		*	*			*	*	*	6

REC: representativeness of the exposed cohort; *SNEC*: selection of the non-exposed cohort; *AE*: ascertainment of exposure; *DO*: demonstration that outcome of interest was not present at start of study; *SCIF*: study controls for important factor; *SCAF*: study controls for additional factors; *AO*: assessment of outcome; *FU*: follow-up long enough; *AFU*: adequacy of follow-up

Table 3 Quality assessment for the Cross-Sectional studies below using the critical appraisal skill program (CASP) tool

	Author and year of publication								
	Amah et al., 2024 [3]	Tandia et al., 2022 [21]	Edwin et al., 2016 [23]	Agwar & Tekleab 2022 [17]	Aliku et al., 2014 [24]	Madany et al., 2024 [26]	Mohammed et al., 2024 [25]	Bellanti et al., 2023 [30]	Bamigboye-Taiwo et al., 2022 [12]
(Q1) Did the study address a clearly focused issue?	Y	Y	Y	Y	Y	Y	Y	Y	Y
(Q2) Did the authors use an appropriate method to answer their question?	Y	CT	CT	Y	Y	Y	Y	Y	Y
(Q3) Were the subjects recruited in an acceptable way?	Y	Y	Y	Y	Y	Y	Y	Y	Y
(Q4) Were the measures accurately measured to reduce bias?	Y	Y	Y	Y	Y	Y	Y	Y	Y
(Q5) Were the data collected in a way that addressed the research issue?	Y	Y	Y	Y	Y	Y	Y	Y	Y
(Q6) Did the study have enough participants to minimise the play of chance?	Y	CT	Y	Y	Y	Y	Y	Y	Y
(Q7) How are the results presented and what is the main result?	Y	Y	Y	Y	Y	Y	Y	Y	Y
(Q8) Was the data analysis sufficiently rigorous?	Y	Y	Y	Y	Y	Y	Y	Y	Y
(Q9) Is there a clear statement of findings?	Y	Y	Y	Y	Y	Y	Y	Y	Y
(Q10) Can the results be applied to the local population?	Y	CT	Y	Y	Y	Y	Y	CT	CT
(Q11) How valuable is the research?	Y	N	Y	Y	CT	Y	CT	Y	Y

Y= YES, N= NO, CT= Cannot tell

was assessed via the JBI tool for analytical cross-sectional studies [29]. It had an average rating of 50%, indicating some concerns with the quality of the study. **See** Tables 2, 3, 4 and 5.

Discussion

Several studies examined the surgical and interventional outcomes of congenital heart disease among African pediatric populations. These studies revealed wide systemic inequities in terms of the availability of surgical services and outcome measures such as mortality and complications [31]. Mortality rate was low across structured programs and charity-led organizations but was relatively higher with delayed or unavailable care [23, 32]. Children who had corrective surgery overseas in the Gambia reported a 100% survival rate [31]. Additionally, according to Edwin et al. [23], Ghana also reported a hospital mortality rate of only 4% for the repair of conotruncal defects. Furthermore, a single charity-center method was used to achieve a 2% mortality rate in a two-year pediatric surgical program in Guyana (an LMIC model applicable to Africa) [33]. On the one hand, indirect mortality, or loss to follow-up, was high in many African countries because less than 1% of anticipated CHD patients obtain prompt surgery, particularly in the absence of organized programs [32].

Africa has reported many successful surgical outcomes for many pediatric congenital heart diseases despite severe resource constraints. This was achieved through partnership, charity, and NGO models as well as cost-effective models in resource-poor settings [16, 23, 33, 34]. For instance, the 30-day death rate for the Namibian Children's Heart Project, which sends patients to South Africa, was just 3.2% despite the lengthy journey times

Table 4 Quality assessment using Joanna-Briggs Institute (JBI) tool for case series

	Mve Mondo et al., 2024 [22]
Q1. Were there clear criteria for inclusion in the case series?	*U*
Q2. Was the condition measured in a standard, reliable way for all participants included in the case series?	*Y*
Q3. Were valid methods used for identification of the condition for all participants included in the case series?	*Y*
Q4. Did the case series have consecutive inclusion of participants?	*Y*
Q5. Did the case series have complete inclusion of participants?	*Y*
Q6. Was there clear reporting of the demographics of the participants in the study?	*Y*
Q7. Was there clear reporting of clinical information of the participants?	*N*
Q8. Were the outcomes or follow up results of cases clearly reported?	*Y*
Q9. Was there clear reporting of the presenting site(s)/clinic(s) demographic information?	*Y*
Q 10. Was statistical analysis appropriate?	*Y*
	80%

Y = Yes, N = No, U = Unclear, N/A = Not applicable

Table 5 Joanna-Briggs Institute (JBI) quality assessment tool for analytical Cross-sectional study

	Sarma et al., 2025 [29]
Q1. Were the criteria for inclusion in the sample clearly defined?	*Y*
Q2. Were the study subjects and the setting described in detail?	*Y*
Q3. Was the exposure measured in a valid and reliable way?	*U*
Q4. Were objective, standard criteria used for measurement of the condition?	*Y*
Q5. Were confounding factors identified?	*U*
Q6. Were strategies to deal with confounding factors stated?	*U*
Q7. Were the outcomes measured in a valid and reliable way?	*Y*
Q8. Was appropriate statistical analysis used?	*Y*
	50%

Y = Yes, N = No, U = Unclear, N/A = Not applicable

and delayed presentation of complicated cases. The death rate was low, despite complications occurring in more than 50% of patients [16]. Additionally, the examples of Ghana and Guyana show how competent teams may produce outstanding results even in environments with limited resources if they have access to organised assistance, training, and follow-up capabilities [23, 33]. Furthermore, at about $270 per QALY gained, surgery for common CHDs was incredibly cost-effective in Rwanda, which encouraged policy investment even in health systems with limited resources [16].

The management of pediatric CHD patients in Africa employed several intervention strategies, though limited by a lack of local registry, they include local surgery, abroad referrals, and palliative as well as corrective surgeries [23, 31, 32] and [34]. Nations such as Ghana and Namibia use cross-border cooperation with South Africa or conduct local procedures. On the other hand, Gambia has no organised domestic programs and depends solely on foreign surgery [31, 34]. Due to financial constraints and late presentation in Africa, palliative treatments are still very popular. However, Ghana has achieved a high rate of corrective surgery with minimal mortality [23], but the lack of local registries has affected planning. Hence, the AfroCaTS program seeks to close the data gap by creating a register that spans the whole continent, but outside of large centres, adoption is still low [32].

Disparities in access to care remain a central challenge undermining the improvement of congenital heart disease (CHD) surgical outcomes across Africa. These disparities are driven by geographic, socioeconomic, and systemic inequalities that limit the ability of many children to obtain timely and appropriate care.

According to Hoosen et al. [35], pediatric cardiac surgeons, anesthetists, and perfusionists are either extremely few or nonexistent in the majority of sub-Saharan African nations. For instance, South Africa still has severe shortages despite having considerable resources, which causes lengthy waiting lists and delayed treatments. Additionally, dedicated pediatric cardiac surgery theatres and critical care units (ICUs) are lacking in many institutions in Africa. Surgical capability is limited by a lack of basic supplies (such as oxygen and blood products) and restricted access to diagnostic instruments like echocardiography [35]. Continuity of care is limited in sub-Saharan Africa because the few functioning cardiac facilities rely mostly on sporadic assistance from foreign missions [32]. Many children in Africa receive their diagnoses after heart failure has already developed. Poor screening procedures and a shortage of qualified primary care doctors are the major causes of this [31]. Furthermore, delays are made worse by transportation and geographic obstacles; many patients must travel hundreds of kilometres for therapy. According to Shidhika et al. [34], more than 78% of patients in Namibia had to travel more than 400 km merely to get to the referral hospital.

In many African countries, national health expenditures frequently provide less attention to CHD than to infectious disorders like HIV, TB, and malaria. The majority of procedures are either supported by foreign donors or paid for out of pocket. The lack of sustainable public financing sources deters service expansion even more [23]. However, congenital heart disease (CHD) and other surgical diseases make up approximately 30% of the world's illness burden, which is five times the combined

impact of HIV/AIDS, TB, and malaria [36]. Despite this, global health agendas continue to place a low priority on surgical care. Years of life lost (YLLs) and years lived with disability (YLDs) result in avoidable deaths, permanent disabilities, and substantial economic losses in sub-Saharan Africa due to inadequate access to safe and reasonably priced surgery [6, 8]. This hidden burden is best shown by congenital heart disease (CHD), where children with medically curable abnormalities frequently die or experience long-term damage as a result of delayed intervention. In addition to lowering mortality, strengthening the surgical and anesthetic systems would have significant positive social and economic effects, supporting the goals of sustainable development and universal health coverage [36].

Additionally, new cost-effectiveness assessments provide positive information on the cost of CHD surgery in Africa. According to a Rwandan study, local pediatric heart surgery programs that are backed by regional collaborations and government funding may deliver greater long-term benefits and survival rates than models that mostly rely on outside doctors [16, 17]. Similarly, a global analysis by Cardarelli et al. [37] demonstrated that humanitarian pediatric cardiac surgery programs in lower- and middle-income countries (LMICs) are highly cost-effective, with an average cost of approximately US$171 per DALY averted in 2015, a figure comparable to or better than other widely implemented global health interventions such as antiretroviral therapy or childhood vaccination [37]. This demonstrates that, even in environments with limited resources, funding cardiac surgery for congenital heart disease has a significant positive impact on public health, especially when program design incorporates sustainability and local capacity.

There is a lack of registration for the entire continent to track results or direct policy. Although the AfroCaTS is promising in solving this problem, its adoption has not been widespread [32]. Hence, it is challenging to prove illness burden, evaluate cost-effectiveness, and persuade governments to spend without adequate data.

Survival from CHD among the pediatric population is comparable to international standards when African children receive prompt surgery; nevertheless, access, local capability, data, and quality monitoring systems are crucially lacking in Africa relative to high-income areas [32].

Perioperative mortality for common pediatric CHD procedures in North America and Europe is often less than 1% for uncomplicated abnormalities like ASD or VSD closure and less than 3% for the majority of lesions [38]. Over 90% of children with treated congenital heart defects survive for a long time, and many of them grow up to have fulfilling lives [39]. In Africa, death rates might be comparable to High-Income Countries (HIC) levels when surgery is made available through charity missions or referrals abroad. For example, Ghana reported a 4% perioperative death rate for repairs of conotruncal defects [23]; The Gambia's overseas operations had a 0% perioperative mortality rate [31]. The problem is access: in sub-Saharan Africa, only 0.5–3% of children who require CHD surgery get treatment, while in HICs, coverage is almost universal [32].

Even with complicated problems, early management is ensured in HICs through multidisciplinary teams, specialised pediatric intensive care units, routine newborn screening, and improved diagnostics [39]. Similarly, despite late referrals and lengthy travel, only nations with formal partnerships, such as Namibia and South Africa, show comparable effectiveness in Africa, with a 30-day surgical death rate of 3.2% [34]. The problem is that, in contrast to North America or Europe, where local systems drive delivery and research, success stories rely more on outside financing (NGOs, charitable missions) than on strong local systems.

Recommendations

The following suggestions are put forth to enhance surgical outcomes for infants with congenital heart disease throughout Africa in light of the evaluated evidence:

Training through regional fellowships and collaborations with reputable institutions should be increased for pediatric cardiac surgeons, anaesthetists, perfusionists, and specialised nurses [35]. To lessen the need for outside charitable missions, in-country training initiatives and retention incentives should be provided for the surgeons and cardiologists. Additionally, investments in specialised child cardiac surgery theatres and critical care units should be made so as to provide safe perioperative treatment and a steady supply of the necessary tools, medications, and supplies for complicated pediatric operations [35]. Early diagnosis and recognition of heart failure symptoms is essential for optimal outcomes; hence, there is a need to adopt a national CHD screening program that includes educating primary care physicians on how to recognize these signs and symptoms early. Finally, to track surgery volumes, outcomes, and quality indicators, the AfroCaTS databases' complete roll-out should be supported by the government and integrated with the hospital's current information systems [32].

Pediatric cardiac surgery in LMICs is not only life-saving but also economically sound, with cost-effectiveness ratios that support inclusion in national health budgets and universal health coverage frameworks, according to data from Rwanda and international humanitarian surgical programs [16, 40].

Overall, both local capacity building and international cooperation are needed to address the disparities in access to pediatric cardiac surgery in sub-Saharan Africa. According to Kumar, Zheleva, and Hasan [40], the

current dilemma of uneven access presents a rare opportunity to rethink pediatric cardiac care globally through workforce training, investments in regional centers of excellence, and sustainable financial models [40]. To ensure long-term effects, their paradigm places a strong emphasis on transitioning from short-term humanitarian interventions to the systemic integration of cardiac care into national health systems. African countries may be able to transition from reliance to self-sufficiency in the treatment of congenital and acquired cardiac disorders by implementing such measures.

The viewpoints presented by [40] support the idea that the international community should see the disparity in pediatric cardiac care not only as a moral dilemma but also as a strategic opportunity where investment produces both financial and humanitarian benefits through enhanced surgical ecosystems and population health.

Limitations

This study presented a comprehensive overview of the surgical outcomes of pediatrics in sub-Saharan Africa; however, it has some limitations that should be acknowledged.

First, comprehensive, multicenter research on the surgical outcomes of pediatric congenital heart disease is scarce in Africa. The findings' generalizability is limited since a large portion of the information is derived from retrospective studies, cross-sectional studies, and single-center case series [32]. Better-resourced facilities, missions funded by charities, or patients referred overseas are mostly represented in the statistics. In contrast to the actual scenario in isolated or underdeveloped areas, where access is almost nonexistent and mortality may be greater, this probably overestimates success rates [31]. Also, direct comparisons are difficult since different studies have different designs, outcome measures, and reporting requirements. Inconsistent outcome statistics result from some reporting only perioperative mortality, while others also include cost-effectiveness or long-term follow-up [23]. Furthermore, loss to follow-up is frequent in the included studies, particularly in instances involving surgery performed abroad, which might limit information on late complications, quality of life, or long-term survival [34].

Conclusion

There are wide systemic inequities in terms of the availability of surgical services and outcome measures such as mortality and complications. Outcomes such as mortality rate and functional recovery were favorable across structured programs, charity-led organizations, and centers with locally trained teams, but poorer with delayed or unavailable care. Complications such as arrhythmias, pulmonary regurgitation, and infections were the major complications leading to poor patient outcomes. To break the major barriers to optimal patient outcomes, such as late diagnosis, limited surgical capacity, inadequate infrastructure, and lack of follow-up registries, there is a need to invest adequately in pediatric cardiac programs to ensure the availability of highly-skilled local cardiologists and adequate infrastructure.

Abbreviations

AV	Atrioventricular
RV	Right Ventricle
RVOT	Right Ventricular Outflow Tract
VSD	Ventricular Septal Defect
PDA	Patent Ductus Arteriosus
ASD	Atrial Septal Defect
LPA	Left Pulmonary Artery
TOF	Tetralogy of Fallot
HIV	High–Income Countries
LMICs	Lower–and middle–income countries

Authors' contributions

CSA conceptualized the study. OMC and OA conducted the literature search and prepared Tables 1 and 2, respectively. IJO, CEA and AIE provided critical revisions. NCB and AA were involved in writing the initial draft. All authors reviewed and approved the final manuscript.

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No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent tot participate

Not applicable.

Consent for publication

Not applicable.

Competing interests

The authors declare no competing interests.

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