Epidemiology of infective endocarditis in Africa: a systematic review and meta-analysis

Jean Jacques Noubiap, Jan René Nkeck, Beckly Shu Kwondom, Ulrich Flore Nyaga

Summary

Background The epidemiology of infective endocarditis in Africa is inadequately characterised. We therefore aimed to comprehensively summarise the available data for the incidence, risk factors, clinical pattern, microbiology, and outcomes of infective endocarditis in Africa.

Methods We did a systematic review and meta-analysis. We searched PubMed, Embase, African Index Medicus, and African Journals Online for all studies reporting primary data for the epidemiology of infective endocarditis in populations within Africa, published from inception to Jan 14, 2021, irrespective of the language. We used the search terms “endocarditis”, “Africa”, and the name of all African countries in the search strategy. We excluded articles that did not include primary data, primary studies with a small sample size (<30 participants), and those that report findings from before 1990. We recorded data for study characteristics, sample size, criteria used to define infective endocarditis, risk factors, potential entry site, clinical patterns, microbiology profile, outcomes including complications such as embolic events, heart failure, acute kidney injury, and death, and predictors of death. We used random-effects meta-analysis method to pool estimates. This study is registered with PROSPERO, CRD42021243842.

Findings We retrieved 2141 records from the database and bibliographic searches, of which a total of 42 studies were included in this systematic review. Rheumatic heart disease was the most common risk factor for infective endocarditis in adults (52.0% [95% CI 42.4–61.5]), whereas congenital heart disease was the most common risk factor for infective endocarditis in children (44.7% [29.5–60.5]). Microbiological testing (mostly blood cultures) was positive in 48.6% (95% CI 42.2–51.1) of patients with infective endocarditis, with *Staphylococcus* species (41.3% [95% CI 36.2–46.5]) and *Streptococcus* species (34.0% [29.0–39.3]) the most commonly identified microorganisms. The pooled rate of surgical treatment of infective endocarditis was 49.1% (95% CI 43.2–55.1). The pooled in-hospital mortality rate was 22.6% (95% CI 19.5–25.9). Other frequent complications included heart failure (47.0% [95% CI 38.2–56.0]), acute kidney injury (22.8% [18.8–27.0]), and embolic events (31.1% [22.2–40.7]).

Interpretation As the most prevalent risk factor in Africa, rheumatic heart disease should be central in interventions to reduce the burden of infective endocarditis on the continent. In tertiary hospitals with good access to cardiac surgery, the outcomes of infective endocarditis seem relatively similar to what has been reported in other parts of the world, especially in high-income countries.

Funding None.

Copyright © 2021 The Author(s). Published by Elsevier Ltd. This is an Open Access article under the CC BY 4.0 license.

Introduction

Infective endocarditis is defined by infection of a native or prosthetic cardiac valve, the endocardial surface, or an indwelling cardiac device. Although infrequent, with an annual incidence of about 2–12 cases per 100 000 people, infective endocarditis is a life-threatening disease with substantial mortality and disability. The mortality associated with infective endocarditis is estimated at about 20% in hospital, increasing up to 30% at 6 months and 40% at 5 years. This mortality varies substantially depending on the causative microorganism, underlying cardiac conditions and comorbidities, and the earliness and appropriateness of treatment, both medical and surgical. Infective endocarditis is commonly associated with severe complications, such as heart failure, embolic events including stroke, and renal failure, which contributes to increased mortality and long-term disability.

The pattern of infective endocarditis varies across regions and socioeconomic status. In high-income countries, the cardiac conditions predisposing to infective endocarditis have shifted from rheumatic heart disease and congenital heart disease to a preponderance of degenerative valve disease, prosthetic valves, and intracardiac devices. The spectrum of causative microorganisms has also changed, now dominated by *Staphylococcus* species compared with *Streptococcus* species a few decades ago. Furthermore, early treatment and widespread availability of cardiac surgery have substantially improved the outcomes of infective endocarditis in high-income countries. In Africa, as in most low-income and middle-income countries, rheumatic heart disease remains a major public health problem, and access to cardiac services is inadequate for a large proportion of the population despite some
Articles

Research in context

Evidence before this study
Infective endocarditis is a life-threatening disease with substantial mortality and disability. The epidemiology of infective endocarditis, which varies across regions and socioeconomic status, is well known in high-income countries. However, it is inadequately characterised in low-income and middle-income countries such as those in Africa. We searched PubMed, Embase, African Index Medicus, and African Journals Online from inception until Jan 14, 2021, without language restriction, with the search terms “endocarditis”, “Africa”, and the name of all African countries to identify studies summarising epidemiological data for infective endocarditis in African populations.

Added value of this study
To the best of our knowledge, this systematic review and meta-analysis is the first study that comprehensively summarises the available data for the incidence, risk factors, clinical pattern, microbiology, and outcomes of infective endocarditis in Africa. Our study shows that rheumatic heart disease is the most common risk factor for infective endocarditis in adults and congenital heart disease is the most common risk factor for infective endocarditis in children in Africa. Prosthetic valve infective endocarditis is also common, whereas infection of intracardiac devices such as pacemakers is rare. Staphylococci and streptococci species are the most common causative microorganisms. Life-threatening complications such as heart failure and embolic events including stroke occur in a high proportion of patients with infective endocarditis. The proportion of patients receiving surgical treatment for infective endocarditis and the fatality rates are similar to what is reported in high-income countries. This finding can be explained by the fact the data are derived from selected relatively well equipped tertiary hospitals, and that patients with infective endocarditis in Africa are much younger and with less comorbidities compared with patients in high-income countries.

Implications of all the available evidence
Tackling rheumatic heart disease should be pivotal to reducing the burden of infective endocarditis on the African continent, considering that it is the most important risk factor for infective endocarditis. The access to cardiac surgery should be scaled up to improve outcomes of infective endocarditis.

Methods

Search strategy and selection criteria
We did a systematic review and meta-analysis. We searched PubMed, Embase, African Index Medicus, and African Journals Online for all studies reporting primary data for the epidemiology of infective endocarditis in populations in Africa, published from inception to Jan 14, 2021, irrespective of the language. We used the search terms “endocarditis”, “Africa”, and the name of all African countries in the search strategy (appendix p 4). Furthermore, we manually searched the reference list of all relevant articles and reviews to identify additional articles.

We included case-control, cohort, and cross-sectional studies that reported on the incidence, risk factors, clinical pattern, microbiology, and outcomes of infective endocarditis in Africa. We excluded articles that did not include primary data, such as editorials or reviews, as well as primary studies with a small sample size (<30 participants). We also excluded report findings from before 1990 to provide a relatively contemporaneous synthesis. For studies reporting data from the same primary study or registry (ie, duplicates), we included the single most comprehensive report with the largest sample size. Two investigators (JRN and BSK) independently screened records for eligible studies based on titles and abstracts. Full texts of articles deemed potentially eligible were retrieved and screened by two other investigators (JTN and UFN) for final inclusion. Selection discrepancies were resolved through discussion and consensus.

Data analysis
Data were extracted by one investigator (JJN) using a standardised data abstraction form and cross-checked by another investigator (UFN). Data included study characteristics, sample size, criteria used to define infective endocarditis, risk factors, potential entry site, clinical patterns, microbiology profile, outcomes including complications such as embolic events, heart failure, acute kidney injury, and death, and predictors of death. We used an adapted version of the tool developed by Hoy and colleagues to assess the risk of bias in the included studies.

We did meta-analyses to summarise similarly reported data across studies. For prevalence data, a random-effects meta-analysis with the inverse variance model was done using the metaprop function, with the pooled proportions calculated using the arcsine transformation, and the 95% CIs of individual study results calculated using the single approximation interval method. The generic inverse variance method was also used to pool adjusted risk estimates (ie, adjusted odds ratio [aOR]).
and their standard errors with the random-effects meta-analysis model using the metagen function. All estimates were reported with their 95% CIs. Heterogeneity was assessed by the $\chi^2$ test on Cochran's $Q$ statistic, which was quantified by $I^2$ values, assuming $Q$ values of 25% representing low heterogeneity, 50% medium heterogeneity, and 75% high heterogeneity. Subgroup analyses were done according to geographical areas (northern Africa vs sub-Saharan Africa), and to age groups (children vs adults). We assessed small-study effect or publication bias by Egger's linear regression test. Other findings were summarised narratively.

We did statistical analyses using R (version 3.5.0). This study is registered with PROSPERO, CRD42021243842.

Role of the funding source
There was no funding source for this study.

Results
We retrieved 2141 records from the database and bibliographic searches, of which 42 full-text articles were included in this systematic review (appendix p 17). The inclusion period of participants spanned from 1990 to 2019, and articles were published between 1996 and 2020 (appendix p 5). All studies were cross-sectional and hospital-based, and data were collected retrospectively in 37 (88%) of 42 studies. Studies were divided between north Africa (21 [50%] of 42) and sub-Saharan Africa (21 [50%]). 15 (36%) of 42 studies included adults and children, 13 (31%) included only adults, seven (17%) included only children, and seven (17%) included adults but it was unclear whether they also included children or not (appendix p 5). The characteristics of individual studies are presented in the appendix (pp 6–8). 39 (93%) of 42 studies had a moderate risk of bias (appendix pp 5, 9–10).

Ten hospital-based studies reported on data for the prevalence of infective endocarditis in various groups or settings (table). In three cross-sectional echocardiographic studies from Nigeria, infective endocarditis was found in one (0.8%) of 116 children, eight (4.6%) of 175, and six (5.5%) of 110 with acquired heart disease. In a study from Ethiopia, 23 (21.7%) of 106 children admitted with acute heart failure had infective endocarditis. In the VALVAFRIC study, a multinational hospital-based registry of hospitalised patients (aged >3 years) with rheumatic heart disease from eight sub-Saharan African countries, infective endocarditis was diagnosed in 23 (1.7%) of 1334 participants. A study from Tunisia reported infective endocarditis among 14 (1.4%) of 959 patients with valvular disease. In two studies, infective endocarditis was reported in seven (0.32%) of 2170 admissions for a cardiovascular problem in Ghana and ten (0.54%) of 1846 in Cameroon.

The distribution of known risk factors for infective endocarditis was reported in 23 (55%) of 42 studies, and...
is summarised in figure 1 and the appendix (pp 18–28). In studies including mostly adults, rheumatic heart disease was the most common risk factor for infective endocarditis (52·0% [95% CI 42·4–61·5]), followed by prosthetic valves (20·3% [16·9–24·0]; figure 1; appendix pp 18–19). Congenital heart disease was reported in 7·2% (5·3–9·4) of patients with infective endocarditis (appendix pp 20–21). Previous infective endocarditis was reported in 5·2% (95% CI 3·9–6·7) of patients, whereas 7·9% (4·1–12·9) of patients were intravenous drug users (appendix pp 22–23). The presence of a pacemaker was reported in 1·3% (95% CI 0·5–2·4) of patients (appendix p 24). In children, 44·7% (95% CI 29·5–60·5) of patients with infective endocarditis had congenital heart disease and 26·0% (10·2–45·9) had rheumatic heart disease as underlying cardiac conditions (appendix pp 27–28).

21 (50%) of 42 studies reported on clinical and echocardiographic features of infective endocarditis. These data are summarised in figure 2 and the appendix (pp 29–44). The diagnosis of infective endocarditis was possible in 18·4% (95% CI 9·3–29·9) of patients and definitive in 87·6% (73·1–97·0; appendix pp 29–30). In terms of valve involvement, the mitral valve was involved in 54·7% (95% CI 48·2–61·1) of patients, the aortic valve in 41·8% (33·7–50·1), the tricuspid valve in 7·2% (3·6–11·9), and the pulmonary valve in 2·7% (0·9–5·4; figure 2; appendix pp 31–34). Native valves were involved in 81·1% (95% CI 76·2–85·5) of patients with infective endocarditis and prosthetic valves in 18·2% (13·9–23·0; appendix pp 35–36). Echocardiography revealed vegetations in 89·1% (95% CI 84·2–93·2) of patients, cardiac abscess in 17·7% (14·2–21·6), and pericardial effusions in 29·3% (22·2–36·8; figure 2; appendix pp 37–39). The potential source of infective endocarditis was most commonly dental (28·3% [95% CI 21·8–35·3]) and infrequently cutaneous, pulmonary, or urinary (appendix pp 40–43). No potential source of infection was reported in 45·1% (95% CI 36·5–54·0) of patients (appendix p 44).

18 (43%) of 42 studies, mostly from north Africa, reported data for microbiological findings in patients with infective endocarditis (figure 3; appendix pp 45–55). Microbiological testing included blood cultures in all these studies, serology in nine studies, and tissue culture in seven studies (appendix p 11). A microorganism was detected in 48·6% (95% CI 42·4–51·1) of patients with infective endocarditis (appendix p 45). Staphylococcus species (41·3% [95% CI 36·2–46·5]) and Streptococcus species (34·0% [29·0–39·3]) were the most common microorganisms identified in the positive microbiological analysis (appendix pp 46–47). Patients with microbiology-positive infective endocarditis reported the causative microorganism to be Staphylococcus aureus (28·1% [95% CI 23·3–33·3]), coagulase-negative staphylococcus (13·2% [7·7–19·9]), viridans streptococci (27·5% [19·6–36·3]), and enterococci (9·1% [5·6–13·4]; appendix pp 48–51).
Eikenella corrodens, and Kingella microorganisms represented 3.5% (95% CI 1.8–5.7) and fungi (Candida or Aspergillus species) represented 7.2% (2.8–13.6) of identified microorganisms (appendix pp 52–53).

Twelve (29%) of 42 studies reported data for surgical treatment of infective endocarditis. The rate of surgery uptake in studies from north Africa was 49.7% (95% CI 42.5–56.9), ranging from 30.2% to 64.6%, whereas the rate of surgery uptake in two studies from sub-Saharan Africa was 46.1% (39.0–53.4). The pooled rate of surgical treatment of infective endocarditis was 49.1% (95% CI 43.2–55.1; appendix p 56). In children specifically, two studies from Tunisia and South Africa showed similar rates of surgery in those with infective endocarditis, with a pooled rate of 51.6% (95% CI 42.8–60.4; appendix p 57).

Outcome data were reported in 23 (55%) of 42 studies. The pooled in-hospital mortality rate across studies was 22.6% (95% CI 19.5–25.9), which was similar in studies from north Africa (22.5%) and those from sub-Saharan Africa (22.7%; figure 4). Heart failure was the most frequent complication, occurring in 47.0% (95% CI 38.2–56.0) of patients with infective endocarditis (appendix p 58). Acute kidney injury occurred in 22.8% (95% CI 18.8–27.0) of patients with infective endocarditis, and embolic events in 31.1% (22.2–40.7) including ischaemic stroke in 14.2% (8.7–20.9; appendix pp 59–61). Data for other complications are reported in figure 5 and the appendix (pp 62–66).

Three (7%) of 42 studies reported data specifically in children. The mortality rate in the paediatric population was 15.9% (95% CI 10.0–22.8; appendix p 67). Heart failure occurred in 49.0% (95% CI 36.8–61.2) of children with infective endocarditis, embolic complications in 15.6% (9.7–22.5), and stroke in 12.1% (6.9–18.4; appendix pp 68–70).

Predictors of in-hospital mortality in patients with infective endocarditis included congestive heart failure (pooled aOR 6.99 [95% CI 4.19–11.67]), prosthetic valve infective endocarditis (2.51 [1.56–4.03]), and vegetation size of more than 15 mm (5.89 [2.52–13.78]; figure 6). Data for other predictors are summarised in the appendix (pp 12–13).

There was no evidence of publication bias in all analyses, except for analyses of pooled proportions of patients with mitral valve involvement, tricuspid valve involvement, prosthetic valve infective endocarditis, and native valve infective endocarditis (appendix pp 14–16).

Discussion
The epidemiology of infective endocarditis in low-income and middle-income countries has long been considered similar to that of high-income countries in the mid-20th century, during the early antibiotic era. However, this consideration was not based on a thorough analysis of epidemiological information from low-income and middle-income countries. The current systematic review and meta-analysis is the first to comprehensively summarise available data for the epidemiology of infective endocarditis in Africa. All included studies were hospital-based. In the absence of community studies, it is not possible to have an estimation of the incidence of infective endocarditis in the general population in Africa. Analyses of hospital records from few countries showed that infective endocarditis is an infrequent condition,
accounting for less than 0·5% of adult cardiovascular admissions. In a study in Nigeria, it was seen in less than 0·2% of children brought to the paediatric department. However, these rates are probably underestimated, due to referral and case ascertainment biases. Indeed, in resource-limited primary care settings, an uncommon condition such as infective endocarditis is more likely to be misdiagnosed, and suspected cases might not reach tertiary hospitals because of financial limitations.

Structural heart diseases, especially valvular diseases, are well-established risk factors for infective endocarditis. In our study, half of patients with infective endocarditis had rheumatic heart disease. This finding is similar to what has been reported in several low-income and middle-income countries outside Africa, and is due to the endemicity of rheumatic heart disease in these countries. In comparison, rheumatic heart disease is identified in only 3% of patients with infective endocarditis in high-income countries. Only about 8% of patients with infective endocarditis had congenital heart disease in studies including mostly adults. In children specifically, almost half of the patients with...
infective endocarditis had underlying congenital heart disease, whereas about a quarter had rheumatic heart disease. This finding suggests that congenital heart disease is a more common risk factor for infective endocarditis in children, whereas it is less common in adults, possibly because in the absence of surgical treatment, most patients with life-threatening congenital heart disease will die during childhood. We also found that about one in five patients with infective endocarditis had a prosthetic valve, with higher rates in studies from north Africa, reflecting an increased access to cardiac surgery in countries from this region. Moreover, this high rate of prosthetic valve infective endocarditis could also be due to a reporting bias. Indeed, because patients who have a prosthetic valve receive regular medical follow-up, infective endocarditis is more likely to be diagnosed if it occurs, whereas native valve infective endocarditis is more likely to be underdiagnosed. Infection on an implanted pacemaker was rare, in opposition to reports from high-income countries where indwelling cardiac devices have become a common cause of infective endocarditis.1,3 Degenerative valve disease was not common in patients with infective endocarditis in this study, contrasting with findings from high-income countries where it is the major underlying cardiac disease in native valve infective endocarditis.4 This finding is most likely due to the younger age of patients with infective endocarditis in Africa, with a mean age of less than 40 years in most studies included in our study. Intravenous drug use was not uncommon. Although much lower than that of other regions such as North America or Europe,5 five the population prevalence of intravenous drug use in African countries is increasing.6 Indeed, a striking rise in the incidence of infective endocarditis associated with intravenous drug use has been reported in some African settings.49 Our study also reveals that in more than a quarter of patients with infective endocarditis, the potential source is dental. Altogether, these data for risk factors for infective endocarditis suggest that primary health-care interventions for primary and secondary prevention of acute rheumatic fever and rheumatic heart disease, for improved oral hygiene and access to dental care services, and to reduce intravenous drug use, could substantially reduce the burden of infective endocarditis in Africa.

Identification of the causative microorganisms is crucial for an adapted and effective antimicrobial therapy. Unfortunately, our study shows that in about half of patients with infective endocarditis no microorganism was identified, unlike high-income countries where about only 10% of affected patients show no growth in blood cultures.7 Potential reasons for such a low blood
culture yield in our study include the frequent use of antibiotics before blood collection, limited resources for microbiology investigations, and inadequate blood sampling procedures. It has been shown that three sets of blood cultures taken before patients start antibiotics detect 96–98% of bacteraemia. Because of financial limitations, it is possible that not enough blood cultures are done in these patients in Africa, especially in settings where patients pay out of pocket for health care. These high rates of non-identification of causative microorganisms are probably a contributor to the poor prognosis of patients with infective endocarditis in Africa. Our study shows that the microbiology profile of infective endocarditis in Africa resembles that of high-income countries, with a marked predominance of staphylococci followed by streptococci, unlike previous reports suggesting that streptococci were the most common cause of infective endocarditis in low-income and middle-income countries. Staphylococcal infective endocarditis poses important problems including its severity, with a high incidence of abscess formation, and the propensity of staphylococci to acquire antibiotic resistance, with methicillin-resistant strains becoming a major health concern globally. The high prevalence of streptococcal infective endocarditis in this systematic review, especially due to the oral viridans group (27–55% of cases), is consistent with the fact that a dental source of infection was identified in a substantial proportion of patients (28–33%). These findings highlight the importance of antibiotic prophylaxis in patients with structural heart disease, especially rheumatic heart disease, undergoing dental procedures. Nevertheless, with the causative microorganism detected in only half of patients, our data might not fully reflect the microbiological profile of infective endocarditis in Africa and, therefore, should be interpreted with caution.

The pooled in-hospital mortality rate of infective endocarditis was 22.6%, ranging from 11.2% to 31.2%. This overall estimate is consistent with the in-hospital mortality of about 20% found in high-income countries and low-income and middle-income countries from other regions. This finding is somewhat surprising, considering that the resources for the management of severe conditions such as infective endocarditis are less available in African countries compared with high-income countries. However, one of the explanations is the fact that patients with infective endocarditis in Africa are much younger and with less comorbidities compared with patients in high-income countries. Indeed, older age and comorbidities substantially increase mortality in patients with infective endocarditis. Another striking finding is the high rates of surgical interventions in the studies included in this systematic review. Indeed, we found that half of patients with infective endocarditis received surgery treatment, which is similar to what is reported in high-income countries. This finding might be explained by the fact that all the studies reporting on surgical treatment in patients with infective endocarditis were from tertiary hospitals mostly from upper-to-middle-income countries such as Algeria, Tunisia, or South Africa where cardiac surgery is readily available. Predictors of mortality in the included studies were similar to what has been reported elsewhere, with infective endocarditis on prosthetic valve, infective endocarditis due to S aureus, or infective endocarditis complicated with heart failure being of poorer prognosis. Valve dysfunction leading to heart failure, uncontrolled infection, and prevention of embolism are the three main indications for surgery. The high incidence rates of heart failure (half of patients), embolic event (a third of patients), and perivalvular abscess (a sixth of patients) underscore the frequent need for surgical interventions in patients with infective endocarditis. It is important to highlight that the high rates of surgical treatment for infective endocarditis reported in this systematic review should be interpreted with caution, as they are specific to the tertiary hospitals where studies were done, and contrast with the very limited access to cardiac surgery in African countries. Indeed, a survey of cardiac surgery capacity in Africa conducted in 2013 revealed that there was one cardiac surgeon for 1·1 million people in north Africa and one for 14·3 million people in sub-Saharan Africa. Additionally, there is only one cardiac centre per 33 million people in Africa, compared with one centre for 120 000 in the USA.

As for all meta-analyses, our study has some limitations. Primary studies included in this systematic review were from a small number of countries, making the reported estimates not absolutely representative of the epidemiology of infective endocarditis on the whole African continent. Furthermore, as discussed previously, because these studies were conducted in tertiary hospitals, their findings cannot be generalised to lower-level health-care facilities. We did not find any population-based study of infective endocarditis in Africa. Because of a substantial referral bias observed on the profile of infective endocarditis, hospital-based studies are not ideal to investigate the epidemiology of infective endocarditis. The retrospective nature of most studies also impairs the accuracy of the estimates provided. There was substantial heterogeneity in most analyses. This heterogeneity can partly be explained by differences in populations’ characteristics, study designs, case ascertainment, and human and infrastructural resources across studies. An evaluation of source of heterogeneity was hampered by the small number of studies in each analysis. This study shows that rheumatic heart disease is the most common risk factor for infective endocarditis in adults and that congenital heart disease is the most common risk factor for infective endocarditis in children within Africa. Prosthetic valve infective endocarditis is also common, whereas infection of indwelling cardiac
devices such as pacemakers seem infrequent possibly because of limited access to these devices. As the most prevalent risk factor for infective endocarditis in Africa, rheumatic heart disease should be central in interventions to reduce the burden of infective endocarditis on the African continent. Staphylococci and streptococci species are the most common causative microorganisms in African populations, similar to what is reported in high-income countries and low-income and middle-income countries from other regions. High rates of complications were reported, which are indications for surgery, such as heart failure, embolic events, and perivalvular abscess. The proportion of patients receiving surgical treatment for infective endocarditis and the fatality rates are similar to what is reported in high-income countries. Although our study is a unique effort to summarise available data for the epidemiology of infective endocarditis in African countries, the estimates presented have limited generalisability as they were derived from selected well equipped tertiary hospitals. High-quality population-based studies are needed to better capture the epidemiology of infective endocarditis in populations in Africa.

Contributors
JJN conceived the study and designed the protocol. JIN and JRN did the literature search. JIN, JRN, and BSK did the study selection. JJN and UFN extracted the relevant information. JIN and JRN accessed and verified the data. JIN synthesised the data. JIN wrote the first draft of the paper. All authors critically revised successive drafts of the paper. All authors had full access to all the data in the study, read, and approved the final manuscript, and had final responsibility for the decision to submit for publication. JIN supervised the overall work and is the guarantor of the review.

Declaration of interests
JIN is supported by a Postgraduate Scholarship from the University of Adelaide. All other authors declare no competing interests.

Data sharing
All data generated or analysed during this study are included in this published Article and the appendix.

Acknowledgments
There was no funding source for this study.

References
1 Cahill TJ, Prendergast BD. Infective endocarditis. Lancet 2016; 387: 882–93.
2 Bin Abdulhak AA, Eldourdi LM, Erwin PJ, et al. Global and regional burden of infective endocarditis, 1990–2010: a systematic review of the literature. Glob Heart 2014; 9: 131–43.
3 Njuguna B, Gardner A, Karwa B, Delahunty F. Infective endocarditis in low- and middle-income countries. Cardiol Clin 2017; 35: 153–63.
4 Noubiap JJ, Agbor VN, Bigna J-J, Kaze AD, Nyaga UF, Mayosi BM. Prevalence and progression of rheumatic heart disease: a global systematic review and meta-analysis of population-based echocardiographic studies. Sci Rep 2019; 9: 17022.
5 Agbor VN, Essouma M, Ntsui NAB, Nyaga UF, Mayosi BM. Heart failure in sub-Saharan Africa: a contemporaneous systematic review and meta-analysis. Int J Cardiol 2018; 257: 207–15.
6 Zühlke L, Mirabel M, Marijon E. Congenital heart disease and rheumatic heart disease in Africa: recent advances and current priorities. Heart 2019; 113: 1554–61.
7 Yankah C, Fynn-Thompson F, Antunes M, et al. Cardiac surgery capacity in sub-Saharan Africa: quo vadis? Thorac Cardiovasc Surg 2014; 62: 391–401.
8 Hoy D, Brooks P, Woolf A, et al. Assessing risk of bias in prevalence studies: modification of an existing tool and evidence of interrater agreement. J Clin Epidemiol 2012; 65: 934–39.
9 Harrer M, Cuijpers P, Furukawa TA, Ebert DD. Doing meta-analysis with R: a hands-on guide, 1st edn. London: CRC Press, 2021.
10 Higgins JP, Thompson SG. Quantifying heterogeneity in a meta-analysis. Stat Med 2002; 21: 1539–58.
11 Wilson SE, Chengyue UC, Queennette D. Childhood acquired heart disease in Nigeria: an echocardiographic study from three centres. Afr Health Sci 2014; 14: 609–16.
12 Bode-Thomas M, Igo OJ, Yilgwan C. Children acquired heart diseases in Jos, north central Nigeria. Niger Med J 2013; 54: 51–58.
13 Sani UM, Ahmed H, Jiya NM. Pattern of acquired heart diseases among children seen in Sokoto, north-western Nigeria. Niger J Clin Pract 2015; 18: 718–25.
14 Gbememarian S, Moses T. Pediatric heart failure, lagging, and sagging of care in low income settings: a hospital based review of cases in Ethiopia. Cardiol Res Pract 2016; 2016: 7147234.
15 Kungue S, Ba SA, Balde D, et al. The VAAPFIRC study: a registry of rheumatic heart disease in western and central Africa. Arch Cardiovasc Dis 2016; 109: 321–29.
16 Trifi K, Jidi J, Abid D, et al. Characteristics, aetiological spectrum and management of valvular heart disease in a Tunisian cardiovascular centre. Arch Cardiovasc Dis 2017; 110: 439–46.
17 Appiah LT, Sarfo FS, Ayegman C, et al. Current trends in admissions and outcomes of cardiac diseases in Ghana. Clin Cardiol 2018; 41: 781–88.
18 Boonbhi J, Menanga A, Hamadou B, Yomia AM, Kinge S. Infective endocarditis at the Yaounde General Hospital: clinical aspects and outcome (case series). J Cardiovasc Med Cardiol 2017; 4: 58–61.
19 Freers J, Mayanja-Kizza H, Ziegler JL, Rutakingirwa M. Echocardiographic diagnosis of heart disease in Uganda. Trop Doct 1996; 26: 125–28.
20 Kolo PM, Onosoto ABO, Adeoye PO, et al. Echocardiography at the University of Ilorin teaching hospital Nigeria: a three years audit. Res J Med Sci 2009; 3: 141–45.
21 De Villiers MC, Viljoen CA, Manning K, et al. The changing landscape of infective endocarditis in South Africa. S Afr Med J 2019; 109: 592–96.
22 Rizk HH, Elamragy AA, Yousef GS, et al. Clinical features and outcomes of infective endocarditis in Egypt: an 11-year experience at a tertiary care facility. Egypt Heart J 2019; 71: 17.
23 Mahmoud K, Hamroun T, Kandil H, Mashaal M. Prevalence and predictors of aortic root abscess among patients with left-sided infective endocarditis: a cross sectional comparative study. Egypt Heart J 2020; 72: 62.
24 Athoussa M, Atmam N, Mounir R, et al. Early results for active infective endocarditis. Pan Afr Med J 2017; 28: 245.
25 Benatta NF, Batouche DD, Benouaz S, Djazouli MA. Infectious endocarditis: experience of a cardiology department at Ouan university hospital. Ann Cardiol Angiol 2019; 68: 94–97 (in French).
26 Lakhdar R, Chourabi C, Drissa M, Drissa H. Trends in the profile of infective endocarditis at a university hospital in Tunis. Med Sante Trop 2013; 23: 445–49.
27 Ba DM, Mboup MC, Zeba N, et al. Infective endocarditis in Principal Hospital of Dakar: a retrospective study of 42 cases over 30 years. Pan Afr Med J 2017; 28: 460.
28 Letaief A, Boughazla E, Kaabia N, et al. Epidemiology of infective endocarditis in Tunisia: a 10-year multicenter retrospective study. Int J Infect Dis 2007; 11: 430–33.
29 El-Kholy AA, El-Rachidi NG, El-Enany MG, Abdulrahman EM, Mohamed RM, Rizk HH. Impact of serology and molecular methods on improving the microbiologic diagnosis of infective endocarditis in Egypt. Infection 2015; 43: 523–29.
30 Rekiki S, Trabelsi I, Maaloul I, et al. Short- and long-term outcomes of surgery for active infective endocarditis: a Tunisian experience. Interact Cardiovasc Thorac Surg 2009; 9: 241–45.
31 Trabelsi I, Rekiki S, Znazen A, et al. Native valve infective endocarditis in a tertiary care center in a developing country (Tunisia). Am J Cardiol 2008; 102: 1247–51.
32 Koegelenberg CFN, Dourell AF, Orth H, Reuter H. Infective endocarditis in the Western Cape province of South Africa: a three-year prospective study. QJM 2003; 96: 217–25.
33 Harraz S, Doghmi N, Fellat B, Zarzur J, Cherti M. Infective endocarditis in Morocco through the experience of a hospital department. Ann Cardiol Angiol 2019; 68: 87–93 (in French).
Articles

34 Tribak M, Konaté M, Elhassani A, et al. Aortic infective endocarditis: value of surgery. About 48 cases. Ann Cardiol Angiol 2016; 65: 15–20 (in French).
35 Ikama MS, Nkalla-Lambi M, Kimbally-Kaky G, Loumouamou ML, Nkoua JL. Profile of infective endocarditis at Brazzaville University Hospital. Med Sante Trop 2013; 23: 89–92 (in French).
36 Sadaka SM, El-Ghazzawy IF, Hassounen MM, et al. Molecular and serological techniques for the diagnosis of culture negative infective endocarditis in Alexandria Main University Hospital. Egypt Heart J 2013; 65: 145–52.
37 Ndiaye MB, Dao M, Kane A, et al. Infective endocarditis in cardiac setting in Dakar: descriptive study about 39 cases. Pan Afr Med J 2018; 7: 12 (in French).
38 Tarimz A, Jerbi S, Fradi MS, et al. Early surgery in patients with native valve endocarditis. Ann Cardiol Angiol 2010; 59: 8–13 (in French).
39 Bendriss L, Bekkali Y, Mrani S, et al. Early surgery in infective endocarditis. Retrospective study apropos of 30 cases. Ann Cardiol Angiol 2007; 56: 111–16 (in French).
40 Willoughby ML, Basera W, Perkins SR, et al. Infective endocarditis in infants and children in the Western Cape, South Africa: a retrospective analysis. Cardiothorac J 2019; 29: 1282–86.
41 Moges T, Gedlu E, Isakaakid P, et al. Infective endocarditis in Ethiopian children: a hospital based review of cases in Addis Ababa. Pan Afr Med J 2015; 20: 75.
42 Joruaa W, Ben Ali I, Abd D, et al. Clinical features and prognosis of infective endocarditis in children: insights from a Tunisian multicentre registry. Arch Cardiovasc Dis 2017; 110: 670–81 (in French).
43 Koshy JJ, Engell M, Human P, Carrara H, Brink J, Zilla P. Long term outcome and EuroSCORE II validation in native valve surgery for active infective endocarditis in a South African cohort. SA Heart J 2018; 15: 116–26.
44 Nagy M, Alkady H, Abal Senna W, Abbelday S, Predictors of surgical outcome in isolated prosthetic mitral valve endocarditis. Asian Cardiovasc Thorac Ann 2018; 26: 517–23.
45 Mzoughi K, Zairi I, Ben Hamsida S, et al. Trends in infective endocarditis. Tunis Med 2017; 95: 290–96.
46 Benzazrouel D, Ouanan F, Boumzbeba D, El Hattaoui M. Periarteric abscess and infective endocarditis: beware of this dangerous duo. Ann Cardiol Angiol 2012; 61: 374–80 (in French).
47 Pessinaba S, Kane A, Ndiaye MB, et al. Vascular complications of infective endocarditis. Med Mal Infect 2012; 42: 213–17.
48 Yaméogo NV, Seghida A, Kagambéga LJ, et al. Neurological complications of infective endocarditis in Burkina Faso. Clinical features, management and evolutionary profile. Ann Cardiol Angiol 2015; 64: 81–86.
49 Meel R, Essop MR. Striking increase in the incidence of infective endocarditis associated with recreational drug abuse in urban South Africa. S Afr Med J 2018; 108: 585–89.
50 Drissa M, Amani F, Drissa H. Staphylococcus aureus infective endocarditis at a tertiary Tunisian hospital. A changing profile? Egypt Heart J 2018; 70: 635–68.
51 Singer M, Alkady H, Mohsen T, Rouzhy A, Akh AK, Masnail M. Predictors of surgical outcome in isolated tricuspid valve endocarditis: single center experience of 60 patients. Thorac Cardiovasc Surg 2017; 65: 634–38.
52 Nel SH, Naidoo DP. An echocardiographic study of infective endocarditis, with special reference to patients with HIV. Cardiovasc J Afr 2014; 25: 50–57.
53 Yew HS, Murdoch DR. Global trends in infective endocarditis epidemiology. Curr Infect Dis Rep 2012; 14: 567–72.
54 Murdoch DR, Corey GR, Hoen B, et al. Clinical presentation, etiology, and outcome of infective endocarditis in the 21st century: the International Collaboration on Endocarditis-Prospective Cohort Study. Arch Intern Med 2009; 169: 463–73.
55 Degenhardt L, Peacock A, Colledge S, et al. Global prevalence of injecting drug use and sociodemographic characteristics and prevalence of HIV, HBV, and HCV in people who inject drugs: a multistage systematic review. Lancet Glob Health 2017; 5: e1192–202.
56 Reid SR. Injection drug use, unsafe medical injections, and HIV in Africa: a systematic review. Harm Reduct J 2009; 6: 24.
57 Lee A, Mirrett S, Roller LB, Weinstein MP. Detection of bloodstream infections in adults: how many blood cultures are needed? J Clin Microbiol 2007; 45: 3546–48.
58 Shahi ASY, Mallister DA, Gallacher P, et al. Incidence, microbiology, and outcomes in patients hospitalized with infective endocarditis. Circulation 2020; 141: 2067–77.
59 Habib G, Erba PA, Jung B, et al. Clinical presentation, aetiology and outcome of infective endocarditis. Results of the ESG–EORP EURO–ENDO (European infective endocarditis) registry: a prospective cohort study. Eur Heart J 2019; 40: 3222–32.
60 Prendergast BD, Tornos P. Surgery for infective endocarditis: who and when? Circulation 2010; 121: 1141–52.
61 Zilla P, Bolman RM, Yacoub MH, et al. The Cape Town declaration on access to cardiac surgery in the developing world. Cardiovasc J Afr 2018; 29: 256–69.
62 Bailar JC 3rd. The promise and problems of meta-analysis. N Engl J Med 1997; 337: 559–61.