SYSTEMATIC REVIEW

Epidemiology, Microbiology, Treatment and Treatment Outcomes of Necrotizing Fasciitis in the East Africa Region: A Systematic Review

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ABSTRACT

Objectives: Necrotizing fasciitis is a rare but deadly infection that has remained a public health challenge despite technology-supported interventions meant to ameliorate the associated conditions. This study identified risk factors, microbial profiles, and essential gaps in healthcare delivery to inform methods for reducing necrotizing fasciitis's high morbidity and mortality rates in the region. Methods: A systematic review of the peer-reviewed literature on necrotizing fasciitis and related necrotizing skin and tissue infections [NSTIs] was conducted on PubMed and Scopus from database induction up to 10th December 2022. The Preferred Reporting Items for Systematic Reviews and Meta-analyses [PRISMA] guidelines were adopted to analyze the epidemiological patterns, microbiological findings, treatment approaches, and outcomes. Data associated with patient demographics, risk factors, microbial isolates, and treatment outcomes were extracted and synthesized. Results: The twenty-nine articles retrieved were screened into nine, which consist of a total of five hundred and five patients based on the selection criteria of the study. More males, 68.1% [344 out of 505], than females, 31.9% [161 out of 505], patients were affected, while the limbs, 47.7% [241 out of 505], were the most affected anatomical site. The co-morbidities included were diabetes mellitus 17.8% [90 out of 505] and trauma 9.3% among others. The most prominent organism was Streptococcus pyogenes, 23.6%. Necrotizing fasciitis infection is prevalent in the East African region with an overall mortality rate of 21%. Conclusion: The high morbidity and mortality rate could be reduced by practicing proper health management of necrotizing fasciitis.

Keywords: Necrotizing fasciitis, flesh-eating bacteria, East Africa, Streptococcus pyogenes, Fournier's gangrene, necrotizing soft skin and tissue infection [NSTI].

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Citing this article
Ibitoye, O.A., Adebayo, I.A., Sankaranpandia, V., Fasogbon, I.V. and Agwu, E. Epidemiology, Microbiology, Treatment and Treatment Outcomes of Necrotizing Fasciitis in the East Africa Region: A Systematic Review. KIU J. Health Sci, 2024: 4[2];

Conflict of Interest: authors are required to disclose any potential conflict of interest

INTRODUCTION

Flesh-eating bacteria infection, also referred to as necrotizing fasciitis [NF], is a rare, acute, severe, rapidly spreading, life-threatening, bacterial, soft tissue infection with characteristic inflammatory and subsequent necrosis of the fascial planes and associated tissues [1]. This soft skin and tissue infection was first recognized and described by Hippocrates in the fifth century BC as a complication associated with erysipelas [2]. Necrotizing fasciitis is etiologically mono-microbial or polymicrobial aerobic and anaerobic infections classified into four distinguished categories, which are class 1 [polymicrobial/synergistic, 70-80%]; class 2 [mono-microbial, 20%]; class 3 [mono-microbial, marine organisms]; and class 4 [fungal] [1]. The major sites of necrotizing fasciitis infection in the body are the extremities; other sites are the abdominal wall and perineum, occurring most especially in patients that have underlying health issues [3]. Some of the risk factors for this disease are chronic liver and renal diseases, intravenous drug use, advanced age, immunosuppression, diabetes mellitus, alcoholism, vascular insufficiency, trauma, contact with marine life, chronic wound infections, and postoperative complications [1]. Though rare in nature, it has a worldwide incidence of about 0.4 per 100,000 individuals. In the US, more than 13,000 cases were recorded in 2007, and an annual incidence of 4.5 per 100,000 individuals [2]. In Africa and Asia, the specific incidence rate was estimated to be more than 1 case per 100,000 population with a mortality rate that ranges from 14% to 42%. In East Africa, necrotizing soft tissue infection [NSTI] has been of tremendous health concern, being a devastating disease associated primarily with the low socio-economic class of society. The disease has been widely associated with poor hygiene and immunodeficiency owing to poor dietary intake and possibly difficulty in accessing health facilities. Thus, making this infection a health menace of global concern. In Uganda, NF incidence has been reported to be 14%, with the limbs as the most commonly affected anatomical site of the infection [4]. Despite aggressive combined treatment, there has been a high morbidity rate, which is due to late diagnosis of the infection and lack of significant cutaneous signs; thus, delayed treatment becomes inevitable. Medical interventions like early diagnosis, aggressive resuscitation of the patient, multiple surgical debridement, and administration of broad-spectrum antibiotics have proven very effective in the management of this infection for better outcomes with a possible concomitant increase in the survivor rate [5]. There is limited research that has been conducted on necrotizing fasciitis in the East Africa region; thus, there is limited information about this infection in the East Africa region. It is against this backdrop that we aim to review the epidemiology, microbiology, treatment, and treatment outcome of necrotizing fasciitis within the East African region in a bid to provide relevant assistance for future research, which would be of tremendous help in the management of this infection ravaging the East African region.

MATERIALS AND METHODS

Literature Search and Identification

The systematic literature review was conducted according to the Preferred Reporting Items for Systematic Reviews and Meta-analyses [PRISMA] Moher et al. [10] reporting guidelines. PubMed and Scopus databases were used to collect publications up to 10 December 2022. The following search terms were applied: "necrotizing fasciitis" AND [East Africa OR Burundi OR Comoros OR Djibouti OR Ethiopia OR Eritrea OR Kenya OR Madagascar OR Malawi OR Mauritius OR Mozambique OR Réunion OR Rwanda OR Seychelles OR Somalia OR Somaliland OR Tanzania OR Uganda OR Zambia OR Zimbabwe].

Eligibility Criteria

For the literature that was downloaded from the two search engines, the search terms were considered in the title, abstract, and body of the study. The journals downloaded were saved in Notepad using different formats [CSV, text file, Excel format] provided by the two different search engines. Subsequently, the inclusion criteria were applied: studies on necrotizing fasciitis or related [Fournier's gangrene] as the main topic and studies available in full text.

Inclusion and Exclusion Criteria

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The inclusion criteria applied include studies that must be necrotizing fasciitis or related, must be in the English language, must be within the East African region, and must be real research and not reviews [narrative, systematic review, or others, not core research]. The exclusion criteria applied include studies that were in other languages apart from the English language, the ones that do not have necrotizing fasciitis or are related to necrotizing fasciitis as their main topic, and studies not within the East African region.

Study Outcomes

The primary study outcomes were [1] the epidemiology and risk factors of patients with necrotizing fasciitis and [2] the site of necrotizing fasciitis involvement listed in the literature. Secondary outcomes included [1] microbiological data, [2] treatment received, and [3] treatment outcomes [mortality, survivor].

Data Extraction

All essential variables from the eligible studies were extracted and analyzed. The extracted variables were title, author, year of publication, place of the study, central topic, number and characteristics of the study subjects, type of study, patient demographics [age and sex], risk factor for necrotizing fasciitis, clinical manifestations, microbiological diagnosis, morbidity record, treatment [antimicrobial, debridement, and others], and mortality outcomes. Two reviewers [O.A.I. and I.V.F.] independently screened the articles for eligibility, and all differences about the articles to be used were reached based on a consensus.

Risk of Bias and Quality Assessment

Validated tools tailored to each study design were used to analyze the risk of bias [RoB] and quality of the included studies. Risk of bias in Non-randomized Studies of Interventions [ROBINS-I] was used for the observational studies included in this review, while Joanna Briggs Institute [JBI] Critical Appraisal Checklists were used to analyze the case reports and case series reports. Methodological rigor across key domains, including selection bias, confounding, exposure, outcome classification, missing data, and reporting bias, was evaluated using these tools. Each domain was rated as low risk, moderate risk, serious risk, or critical risk, with an overall RoB judgment assigned to each study. For case reports and case series, the JBI checklist assessed criteria such as patient demographics, diagnostic methods, treatment details, and outcomes. The RoB and quality assessments were conducted by two independent reviewers [O.A.I. and I.V.F.], and discrepancies were resolved through consensus while Grading of Recommendations, Assessment, Development, and Evaluations [GRADE] framework, which considers RoB, indirectness inconsistency, imprecision, and publication bias, was used to ensure the certainty of proof of key outcomes.

2.7 **Method for Data Analysis**

Systematic synthesis and analysis of the data from included studies were conducted to extract essential variables [e.g., study design, AMR detection methods, outcomes] using a structured template.

3.0 **RESULTS**

Literature Search

Our literature search yielded a total of 29 articles from PubMed and Scopus databases [figure I], of which nine with a total of five hundred and five patients were selected for the review eligible based on the inclusion criteria. A total of 6 duplicates were removed, two articles that were originally written in French were removed, 21 articles were screened based on title and abstract, and thereafter, 12 were excluded. A total of 9 articles with a total of 505 patients that met the eligibility criteria and quality assessment were selected for the review. Nine articles were not related to the subject of interest, we could not recover the full text for 1, and two articles were not within the study area [the East Africa region].

Characteristics of the included studies

This review consists of a total of 9 studies [one in Uganda, one in Reunion Island, one in Rwanda, two in Kenya, and four in Tanzania] on NSTIs [necrotizing fasciitis [n=7] and Fournier's gangrene [n=2]], with a total of 505 patients conducted in the East African

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region. In total, there were 2 case reports, 1 retrospective single-center study, 1 case series report, 1 retrospective hospital-based study, 1 observational cohort, 1 prospective descriptive cross-sectional hospital-based study, 1 descriptive retrospective study, and 1 prospective descriptive case series.

Epidemiology

The overall number of patients in these studies showed that there were more males, 68.1% [344 out of 505], than females, 31.9% [161 out of 505], and the range of the patients' ages was within 5 weeks to 83 years [Table viii]. The clinical presentations include discoloration of the lower jaw 100% [1 out of 1], fever and ulcer, septic shock 95.5% [64 out of 67], hypertension 21% [14 out of 67], pus discharge 87% [153 out of 175], edema 85% [149 out of 175], different disorders of the submandibular region, scrotal disorder 84% [21 out of 25], pain with swelling 100% [42 out of 42], dehydrated 71.4% [30 out of 42] [Table ix]. The major site of infection for necrotizing fasciitis is the limbs [as computed in Table 4] most especially the lower limbs 78% [52 out of 67], 88.06% [59 out 67], 49% [86 out of 175], other sites were trunk 25% [44 out of 175], perineum 20% [35 out of 175], submandibular region 77.78% [7 out of 9], scrotal area 78.6% [66 out of 84] and others [Table ii]. With respect to the risk factors which were also comorbidities for the infection, the report from Uganda revealed: HIV/AIDS 22.9% [8 out of 35], diabetes Mellitus 6% [2 out of 35], and malignancy 3% [1 out of 35]. The study from Reunion Island revealed: diabetes complications at 31.3% [21 out of 67], lesions from superinfections at 16% [11 out of 67], trauma at 12% [8 out of 67], and ischemia at 6% [4 out of 67] patients were affected. In Rwanda, 17% [29 out of 175] had cardiac disease, being the most prominent of all the risk factors for NF, while others were diabetes mellitus 16% [28 out of 175], smoking, and HIV infection 13% [23 out of 175] and 11% [20 out of 175] respectively. Necrotizing fasciitis cases in Kenya reveal their risk factors as HIV 6% [4 out of 67], diabetes mellitus 19% [1 out 67], hypertension 21% [14 out of 67], and prior history of trauma 58% [39 out 67]. In a similar report of cervicofacial NF case series of nine patients [five male and four female], 22.2% [2 out of 9] patients had uncontrolled diabetes, 22.2% [2 out of 9] patients had HIV, while others had varied established infection of odontogenic sources and neck creases as in the case of the baby in figure 2 and 3. There were diverse risk factors responsible for the NSTI [as computed in Table viii]: cervicofacial NF[7,8], Fournier's gangrene [9,10] infections reported in Tanzania, of all these risk factors/co-morbidities diabetes mellitus [10] 20% [5 out of 25] was implicated as the most common comorbidity for NF, hypertension, and diabetes comorbidities were associated with traumatic urethral catheterization [SPC], hemorrhoidectomy, testicular tumor, perineal abscess, HIV, and infected hydrocele as well as hypospadias were other risk factors for NF as in the case of Fournier's gangrene [7].

Microbiology

Current knowledge of the microbial agents associated with NSTIs is related to the earlier reported polymicrobial and monomicrobial aerobic and anaerobic agents. Microorganisms were isolated from a total of 55.6% [5 out of 9] studies, 11.1% [1 out of 9] were negative for the presence of microorganisms, while 33.1% [3 out of 9] studies were not specific about their microbial history [Table vii]. Of all the five microbial-associated NF studies retrieved and reviewed, the antimicrobial susceptibility test conducted revealed both gram-positive and gram-negative microbial agents of NF; there were about 9% polymicrobial, and 91% of the monomicrobial agents were identified from the NF study from Uganda [4]. Chalya et al. [9] reported that 82.6% [38 out of 46] and 17.4% [8 out of 46] of NF samples from patients cultured in Tanzania were positive for polymicrobial and monomicrobial agents, respectively.

The overall result of the NF microbial agents isolated from the studies revealed that 23.6% [90 out of 178], which represent *Streptococcus pyogenes*, were the most prominent, followed by 21.3% [38 out of 178], which represent polymicrobial agents, among others [as computed in Table ix]. Vandroux et al. [11] reported *S. pyogenes* 37.3% [25 out of 67] in the cultured samples from NF patients as the most common NF microbial agent, followed by *Staphylococcus aureus* 7.5% [5 out of 67] in Reunion Island. Twelve out of forty-two [28.6%] samples

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cultured were identified as *S. aureus*, which was the predominant microorganism in Tanzania and also present in all the microbial-associated NF studies [Table viii]. The aerobic bacterial culture results that were obtained in 54.8% of the patients from Tanzania showed the presence of polymicrobial 82.6% [38 out of 46] and monomicrobial 17.4% agents. Ampicillin, Augmentin, cotrimoxazole, and other antibiotics showed multidrug resistance to antibiotics tested except for meropenem and imipenem, which the microbes were each totally sensitive to [9]. In another study, specimens of 30 [71.4%] patients showed that *S. aureus* was the commonly isolated microbe, and the antibiotic susceptibility test carried out revealed that they were highly sensitive to ceftriaxone [96.7%], gentamycin [86.7%] and erythromycin [83.3%] and resistant to ampicillin [86.7%] and cloxacillin [90%] [9]. Blood culture sensitivity from an NF cervicofacial sample showed the presence of *S. aureus* which was sensitive to clindamycin, gentamicin, meropenem, and vancomycin and resistant to ceftriaxone and benzathine penicillin. *Escherichia coli*, a gram-negative organism was the most implicated microbial pathogen associated with NF infections in both Uganda and Tanzania [4,9].

TREATMENT

Basically, the treatment for necrotizing fasciitis infection involves the administration of broad-spectrum antibiotics, surgical debridement, and wound management techniques that are done depending on the severity of the infection [11]. The studies showed that patients that were diagnosed with Fournier's gangrene [necrotizing fasciitis of the scrotum and perineum] were resuscitated and aggressively surgically debrided, having been generally anesthetized, thereafter receiving intravenous broad-spectrum antibiotics [ceftriaxone 4 g/day and metronidazole 1.5 g/day or doses administered with respect to the patient's weight] [4]. Ninety-seven percent [34 out of 35] of hemodynamically stable patients underwent debridement of the necrotic tissue; afterwards, 8% [3 out of 35] of patients had a repeated debridement on follow-up [9]. In Reunion Island, a report stated that 30% [20 out of 67] and 15% [10 out of 67] of patients were administered nonsteroidal anti-inflammatory drugs [NSAIDs] and corticosteroid anti-inflammatory treatments, respectively; thereafter, surgical debridement was done for 40 patients, single amputation for 11, and multiple amputations for 4 patients [12]. The first operation was done for all patients [n=175]; 51% [90 out of 175] had debridement, and 30% [52 out of 175] had amputation or disarticulation. skin graft was the second operation conducted for 12, while 5 patients received amputation or disarticulation [Table ix]. In one of the studies from Kenya, all patients received antibiotics within 6 hours of arrival at the health facility; single and combined antibiotic therapy were administered to 15% and 85% of the patients, respectively [1]. In another cervicofacial NF case series that involved four female and five male patients, treatments administered were repeated surgical debridement, a broad-spectrum antibiotic, and fluid therapy were administered to patients that were co-morbid with diabetes mellitus [13]. In a case of necrotizing fasciitis of the jaw of a 5-week-old female patient examined in Tanzania, intensive medical management that involved surgical debridement in an anesthetized state was administered; afterwards, the baby was placed on intravenous antibiotics. In another case of Fournier's gangrene reported in Tanzania, all the patients received combined treatment, which was wound debridement, antibiotics, analgesics, fluid replacement, and daily dressing of their wounds [9]. In addition to all these treatments, 28% [7 out of 25] of patients had a skin graft, one received an orchiectomy, and co-morbid blood, sugar, and hypertensive patients were also treated on an individual protocol basis. In a similar Fournier gangrene case that involved 84 patients, the aforementioned treatments were administered [9]. For patients with co-morbid cardiopulmonary failure due to sepsis, mechanical ventilation, inotropic support, and continuous monitoring activities were ensured. Sequel to the initial surgery, the wound was monitored closely, and adequate nutrition was made available to the patient in order to ensure wound healing. Further debridement was done under local or no anesthesia, after which the wounds were closed as soon as healthy and viable tissue was available. Most of the patients, 65 [77.4%], received secondary wound closure, while the others, 14 [16.7%] and 5 [5.9%], had their wounds closed by skin grafting and flap rotation, respectively [9].

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OUTCOME

The overall outcome after treatment was good; the average mortality was about 21%, with the highest mortality rate recorded in the cervicofacial NF case of 42 patients in Tanzania. The mortality was 42.9%, comprising 14 [77.8%] males and 4 [22.2%] females. These deaths were due to dehydration during admission and short stays at the health facility; also, there was a similar report of nine patients from the same county, in which 33.3% [3 out of the 9] patients died as a result of co-morbidity due to uncontrolled diabetes mellitus and HIV infection despite aggressive treatment. In a similar case, there was a good outcome of NF of the jaw in a 5-week-old female baby. Sequel to the combined treatment of surgical debridement and aggressive antibiotic therapy administration, the wound progressed well. There was residual slough and minimal serosanguinous discharge, which was managed twice daily by dressing the wound with diluted acetic acid [at a concentration of one to nine] [8]. Upon the baby's completion of the medical therapy, the baby was continually breastfed and administered antiretroviral therapy [8]. Consequent upon the healing of the wound, the baby was continually followed up and later discharged, having had healthy granulation. The best outcome of NF [86%] infection after treatment was from Uganda, where the survival rate was 86%, and death stood at 14% [5 out of 35], with ages ranging between 23 and 48 years [mean 35]; one female and four male patients were involved [Table viii]. The death was due to different comorbidities: HIV, diabetes mellitus, and fulminant cause of illness, which led to death three days after NF diagnosis consequent upon herniorrhaphy. All these death cases were associated with septic shock experienced by the patients. Another good outcome of NF was from a retrospective study in Kenya. A seventy-eight percent survivor rate and a death rate of 10% [7 out of 67] patients were recorded, and different co-morbid factors were associated with an unfavorable outcome [Table ix]. A similar outcome was also recorded in Fournier's gangrene hospital-based retrospective study of 25 patients' case report study from Tanzania. Thirty-two percent [8 out of 25] had good outcomes, 24% [6 out of 25] had few complications, and 12% [3 out of 25] died due to severe septicemia. The outcome from Reunion Island revealed a mortality rate that ranged from 5% to 25%, depending on whether anti-inflammatory drugs were administered or not. The outcome of Fournier's gangrene treatment in Rwanda revealed that there were survivors and a mortality rate of 26% [46 out of 84] due to complications from co-morbidities. In a similar study from Tanzania, 28.6% [24 out of 84] patients died due to advanced age [> 60 years] and some other co-morbidities, though treatments were administered, while 71.4% [60 out of 84] patients survived [Table viii].

DISCUSSION

In this study, the overall evaluation shows that more males, 68.1% [344 out of 505], than females, 31.9% [161 out of 505], were infected with necrotizing fasciitis, and on a country basis, the analysis for studies that consisted of males and females showed similar trends. This is in agreement with Obimakinde et al. [14], who reported a higher incidence of necrotizing fasciitis in males: 69.2% [9 out of 13] than females: 20.8% [4 out of 13] in southwestern Nigeria among people of advanced age [>60 years], while in the Netherlands [15], it was predominant among advanced-aged men of 70 years at a similar percentage. Horn et al. [16] also reported more males [65%] than females [35%] were infected with necrotizing fasciitis. In disagreement with this, female predominance has been reported, thus the understanding of no gender predilection becomes disapproved [16]. The trend of sex predilection resulting in more men being infected could have been a result of more men being exposed to anthropogenic activities like farming and menial labor jobs, among others [17, 18]. This is in agreement with the report of Ibikunle et al. [20], who reported that the majority of the NF patients were from the low socio-economic populace of rural Northern Nigeria, who are majorly subsistent farmers and cattle rearers. The disease has shown a correlation between low socio-economic status, poor health indices, malnutrition, and poor health awareness. Tantirat et al. [19] also reported that the Northeastern region of Thailand, noted for agricultural activities, was a hotspot for necrotizing fasciitis infection, with its incidence being at its peak during the May to August farming season. Due to the increased incidence of trauma associated with

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agricultural activities, trauma like skin trauma has aided skin infections that eventually lead to NF infections. Furthermore, Kha et al. [18] also reported that these activities were done barefooted; therefore, they become liable to having their limb skins damaged, thus becoming a portal of entry to these NSTIs causative organisms. In this study, most of the patients presented varied clinical features like fever and ulcer, infection of the submandibular region, scrotal disorder, pain accompanied by swelling, and others. Of all the clinical presentations from all the different studies involved, 100% (1 out of 1) lower jaw discoloration, 100% (42 out of 42) pain accompanied with swelling, 95.5% (64 out of 67) septic shock, 87% (153 out of 175) pus discharge, and 85% (149 out of 175) edema had the highest incidence of all the individual studies within the study area (East African region). Biet-Ner et al. [19] had a similar report of back pain and fever. In this study, the lower limbs were the most commonly affected anatomical site for necrotizing fasciitis, while the scrotum was the most commonly affected for Fournier's gangrene patients. Konik & Huang, [23]; Wang & Lim, [22] also reported the lower limbs as the major anatomical location of NF infection; other common anatomical locations of infection within the different studies were the submandibular region 77.78% (7 out of 9) and the scrotal area 78.6% [66 out of 84] in the case of Fournier's gangrene. Diabetes mellitus was the most common risk factor/comorbidity implicated in association with NSTI [necrotizing fasciitis and Fournier's gangrene] in most of the studies examined, which are representations of the different East African countries. Kha et al. [18] also reported diabetes mellitus as the most common comorbidity to necrotizing fasciitis and other NSTIs in New Caledonia. It has also been identified as the most prominent comorbidity for NF infection in different locations of the world: Nigeria [20], Qatar [21], Taiwan [22], the Netherlands [15], and Thailand [18]. Contrary to these findings, Olusanya et al. [26] findings from the case of cervicofacial necrotizing fasciitis in Nigeria show that the majority of their patients had no underlying systemic conditions. This suggested that CNF of odontogenic origin might not necessarily be associated with any compromising systemic condition. The high prevalence of this DM could have been due to dietary intake habits. In many of the rural areas of these East African countries, where they are mainly peasant farmers, daily dietary intake is mainly carbohydrate, and thus, there is an overdose accumulation of sugar, which eventually leads to diabetes mellitus. Jabbour et al. [21] suggested that a high progression of the severity and mortality of NF in relation to diabetes mellitus could partially have resulted from the hyperglycemic factor responsible for the immunocompromised status of the patients. Lecube et al. [27] also stated that the fatality of NF in association with diabetes mellitus comorbidity could have progressed favorably due to decreased phagocytic and bactericidal action in conjunction with neutrophil dysfunction. Other prominent comorbidities associated with NSTIs in the East African region were hypertension, HIV (Uganda), cardiac arrest (Rwanda), prior history of trauma (Kenya), and diabetes complications (Reunion Island). Different microorganisms, polymicrobial and monomicrobial agents of NSTIs, have been reported in previous studies; these microbes act synergistically in eliciting their infective action [23]. This is in agreement with our present study, where the overall microorganisms were both 9% and 82.6% for polymicrobial and 91% and 17.4% for monomicrobial gram-positive and gram-negative agents of necrotizing fasciitis for Uganda and Tanzania, respectively [4, 9].

In Uganda, *S. pyogenes* was the predominant microbe associated with necrotizing fasciitis, while *S. aureus* was reported to be the most common microbe associated with necrotizing fasciitis infection in Reunion Island [12]. Similarly, *S. aureus* was also the predominant microbe associated with NSTIs in Tanzania and also present in other studies from the various countries involved. Other mono- and poly-microbial agents associated with NSTIs were also isolated from the different microbiologically diagnosed samples. This is in agreement with the findings of Gore [28], where the presence of monomicrobial mixed species of Staphylococcus and Streptococcus to mixed anaerobic microbes, Prevotella and Fusobacterium species of necrotizing fasciitis, were reported but in slight disagreement with the findings from Uganda and Reunion Island, where Prevotella and Fusobacterium were not found, while in another Fournier's gangrene study from Tanzania,

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E. coli was the most prominent isolated microbe from the Fournier's gangrene [NF of the scrotum and perineal] samples. This is in agreement with Kha et al. [18], who reported the presence of arrays of microorganisms, including *S. aureus* and *S. pyogenes*, *S. pyogenes* being the prominent microbe isolated from cultured NSTI samples in New Caledonia. Similarly, these prominent microbial agents of NF have been reported from different locations: Nigeria [20, 24], the Netherlands [15], India [25], and Australia [26]. In a study conducted in South Korea by Park et al. [31], they reported an array of type I and type II microbial agents of necrotizing fasciitis, among which are *S. pyogenes*, *S. aureus*, and *E. coli*, *E. coli* being the prominent microbial agent of necrotizing fasciitis. The necrotizing fasciitis samples cultured tested positive for the presence of *S. aureus*. When subjected to an antibiotic susceptibility test, *S. aureus* was sensitive to the following antibiotics: gentamycin, erythromycin, ceftriaxone, and cloxacillin [25]. This is in agreement with the findings of Moyo et al. [32], who reported the presence of more monomicrobial than polymicrobial agents that were sensitive to an array of antibiotics. The sensitivity of these microbes isolated from the various NF samples could have been a result of the aggressive antibiotic administration to NF patients during the treatment process. Necrotizing fasciitis is a fatal disease that could be devastating; thus, combined treatment after the diagnosis of this infection is inevitable for reducing the morbidity and mortality rate. Considering the complex intricacies involved in the treatment of NSTIs, synergistic treatment intervention that involves adequate surgical debridement, supportive care management by the health personnel, and immediate antibiotics administration to the patients upon diagnosis has been reported to be crucial in NF health management [27]. Patients with confirmed NSTIs should be treated with antibiotics; the choice of antibiotics to be administered depends on the nature of the microbes implicated as the causative agent of the necrotizing fasciitis, the anatomical location of the infection, and other clinical features that might be presented at diagnosis [27]. In this study, NSTI [necrotizing fasciitis and Fournier's gangrene] patients treated followed the basic procedure as earlier stated, with some having additional wound management regimens depending on the severity of the NSTI infection. Reports from the studies revealed that surgical debridement was done until healthy tissues of the necrotized localized body parts were achieved. Of all the studies, the highest surgical debridement was reported in Tanzania, where 97% (34 out of 35) hemodynamically stable patients were surgically debrided, while 8% (3 out of 35) of these patients received a second phase of debridement [9]. Antibiotics administration in conjunction with surgical debridement was also reported as the most effective approach in the treatment of necrotizing fasciitis patients and other NSTIs-related infections [17, 28]. In the study from Reunion Island, 30% (20 out of 67) and 15% (10 out of 67) of patients received nonsteroidal anti-inflammatory drugs (NSAIDs) and corticosteroid anti-inflammatory treatments, respectively [12]. This report is in agreement with the findings from New Caledonia, in the North Pacific region, where the same chemotherapies were used in the combined treatment process administered to necrotizing fasciitis patients [17]. Other studies from different countries within the East African region also showed similar treatment patterns with slight variations depending on the specificity and severity of the patients to be treated. This is in disagreement with the findings from South Korea, where it was observed that despite combined treatment of aggressive antibiotic administration and early surgical debridement, the mortality rate was high due to some underlying health conditions of the NF patients [29]. In the case of Fournier's gangrene from a study in Tanzania, all patients received analgesics and fluid replacement in addition to the basic NSTIs standardized treatments. 28% (7 out of 25) of the patients had their skin grafted; others received specialized treatments based on the individual's protocol [9]. This is slightly different from the report of Stigt et al. [33], where 58 NF patients in The Netherlands all underwent at least one operation. Thirty-nine (69.2%) of the patients were operated upon in the first twenty-four hours, while sixteen [27.6%] underwent surgery thereafter, twenty-four hours later. Forty-nine patients (84.5%) underwent radial necrotomy, three (5.2%) couldn't be done due to the extent of health damage, while six (10.3%) were amputated. Early surgical treatment has been suggested as an excellent, inevitable regimen in the management of necrotizing fasciitis, without which worse outcomes have been clearly evident when

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surgeries were delayed [26]. A good outcome can only be achieved when good health management practices are observed. The outcome of necrotizing fasciitis and other NSTIs related to a patient's treatment is the premise of the factors associated with the management of the disease. Chen et al. [26] identified these factors as potential predictors of mortality. The factors include age, comorbidities, and laboratory findings upon presentation and time. Of all these factors, Nawijn et al. [35] have described time to treatment as the most important, potentially modifiable predictor for mortality. The outcome of treatment of necrotizing fasciitis and other NSTIs over time has been in response to the time of diagnosis of the infection and the nature of the treatment administered. Early recognition, preferably within 6 hours, and quick treatment that includes adequate surgical debridement and aggressive broad-spectrum antibiotic administration have proven more effective with a better outcome of reduced mortality rate [30, 31].

The overall outcome shows an average mortality rate of 21%, with the highest mortality rate of 42%, which comprises 77.8% (14 out of 42) male and 22.2% [4 out of 42] female patients recorded in the case of cervicofacial NF of 42 patients in Tanzania. This is in slight disagreement with the study conducted in The Netherlands by Stigt et al. [33], who reported a mortality rate of 29%. This could be due to the array of microorganisms implicated as the causative agents of necrotizing fasciitis. This high mortality rate was also due to the presence of comorbidities [HIV and uncontrolled diabetes mellitus], dehydration during admission, and inadequate health management service, which was evident from the report that showed that they spent a short period at the health facility. This discovery of the causes of the high mortality rate is in agreement with the earlier statement of Gelbard et al. [36] and Nawijn et al. [35]. Contrary to the last report, a good outcome was observed in the case of a 5-week-old female cervicofacial jaw NF patient comorbid with HIV contracted as a fetus via the maternal route. Upon administration of the basic combined necrotizing fasciitis prescribed treatment with continual proper wound management regimen being followed by administration of antiretroviral therapy, the baby became healed and the NF site healed up [8]. The best outcome, with a survival rate of 86% and a mortality rate of 14% (5 out of 35) patients with their ages ranging between 23-48 years, was reported from Uganda, and a 77.8% survival rate and a mortality rate of 10% (7 out of 67) in Kenya. The patient's death was a result of septic shock syndrome in conjunction with the different comorbidities they experienced. [4,13]. The outcomes from the various studies reported from the different countries were in line with the previously stated condition that reported these comorbidities to be potential predictors for mortality.

Limitation of the Research

Primarily, the limitation of this systematic review lies in the limited number of the literature available for this analysis, having only nine studies with a population size of 505 patients across the East African region. There might have been an introduction of variability in the quality and comprehensiveness of the data due to the study design, which ranges from case reports to observational cohort studies. There exist significant gaps in microbiological and epidemiological data due to the fact that quite a number of studies lack detailed information on the pathogen profile. This limitation is further aggravated by the underrepresentation of some countries within the East African region. Consequently, the findings about the diversity and complexity of necrotizing fasciitis in this region might not have been fully captured. Furthermore, the dependence on retrospective data introduces the possibility for recall and reporting biases and limits insights into the resistance patterns and pathogen dynamics due to the absence of molecular diagnosis in many of the studies.

CONCLUSION

Necrotizing fasciitis infection is prevalent in the East African region with an overall mortality rate of 21%. This high mortality rate is due to some potential predictors like comorbidities, poor health management, and immunosuppression. Diabetes mellitus is the most common of all the comorbidities, and this potential predictor of mortality could have resulted from poor dietary intake [not being able to maintain a balanced diet] of the populace, considering their low socio-economic status. The high morbidity and mortality rate owing to necrotizing fasciitis was

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due to some potential predictors of mortality, like immunodeficiency, late diagnosis, and poor necrotizing fasciitis health management schemes. Proper management of necrotizing fasciitis, which includes early diagnosis, antibiotic administration [especially within 6 hours of diagnosis], combined treatment of surgical debridement and broad-spectrum antibiotics depending on the microorganism implicated as the causative agent of the NSTI, and proper wound management, is essential in achieving reduced morbidity and mortality rates among the populace of the East African region.

RECOMMENDATION FOR FUTURE RESEARCH

In future studies, collection of standardized, high-quality, and region-specific data that would address identification gaps in the microbiology and the epidemiology of necrotizing fasciitis within the region should be prioritized. Treatment outcome should be enhanced by the provision of a molecular diagnostic approach to elucidate the pathogen resistance profiles, thus revealing its implication on the outcomes of the treatment administered. Furthermore, deeper insights into the drivers of high morbidity and mortality rates could be provided by the integration of socioeconomic and health system factors into research frameworks. Expansion of surveillance to accommodate underrepresented areas and utilization of a broader linguistic inclusion policy would enhance the representativeness and applicability of findings. Finally, improving diagnostics and treatment protocols and supporting the development of tailored interventions aimed at reducing disease burden in resource-limited settings by fostering collaboration between regional and global institutions to facilitate capacity-building initiatives should be encouraged.

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Table I: Search Strategies

Database and search date	Search Strategy
PubMed 10/12/22	["necrotizing fasciitis"[Title/Abstract]] AND ["east africa"[Title/Abstract] OR Burundi[Title/Abstract] OR Comoros[Title/Abstract] OR Djibouti[Title/Abstract] OR Ethiopia[Title/Abstract] OR Eritrea[Title/Abstract] OR Kenya[Title/Abstract] OR Madagascar[Title/Abstract] OR Malawi[Title/Abstract] OR Mauritius[Title/Abstract] OR Mozambique[Title/Abstract] OR Re´union[Title/Abstract] OR Rwanda[Title/Abstract] ORSeychelles[Title/Abstract] OR Somalia[Title/Abstract] OR Somaliland[Title/Abstract] OR Tanzania[Title/Abstract] OR Uganda[Title/Abstract] OR Zambia[Title/Abstract] OR Zimbabwe[Title/Abstract]]
Scopus 10/12/22	TITLE-ABS-KEY ["necrotizing fasciitis" AND [“east africa” OR burundi OR comoros OR djibouti OR ethiopia OR eritrea OR kenya OR madagascar OR malawi OR mauritius OR mozambique OR réunion OR rwanda OR seychelles OR somalia OR somaliland OR tanzania OR uganda OR zambia OR zimbabwe]] AND [EXCLUDE [DOCTYPE , "no"]]

Table II: Risk of Bias Assessment for Observational Studies [ROBINS-I]

Study	Confounding Bias	Selection Bias	Exposure Classification Bias	Missing Data Bias	Outcome Measurement Bias	Reporting Bias	Overall Judgment
Mpirimbanyi et al. [2018]	Moderate	Low	Low	Moderate	Moderate	Low	Moderate
Vandroux et al. [2021]	Serious	Moderate	Low	Low	Moderate	Low	Serious
Chalya et al. [2015]	Moderate	Low	Low	Moderate	Moderate	Low	Moderate
Magala et al. [2014]	Moderate	Low	Low	Moderate	Moderate	Low	Moderate
Mtenga et al. [2019]	Moderate	Low	Low	Moderate	Moderate	Low	Moderate
Mabula et al. [2019]	Moderate	Low	Low	Low	Moderate	Low	Moderate
Lodhia et al. [2021]	Moderate	Low	Low	Low	Low	Low	Low
Koech and Chindia [2009]	Moderate	Moderate	Low	Moderate	Moderate	Low	Moderate
Lunar et al. [2020]	Moderate	Low	Low	Moderate	Moderate	Low	Moderate

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Table III: JBI Critical Appraisal for Case Reports

Domain	Lodhia [2021]	Koech and Chindia [2009]	comments
1. Were patient demographics clearly described?	Yes	Yes	Both studies clearly outlined patient demographics, including age, sex, and risk factors.
2. Was the patient's history clearly described?	Yes	Yes	Comprehensive history was provided, including prior medical conditions and presenting symptoms.
3. Was the patient's clinical condition on presentation clearly described?	Yes	Yes	Detailed clinical conditions were provided [e.g., jaw discoloration in Lodhia, submandibular infection in Koech].
4. Were diagnostic tests or assessment methods clearly described?	Yes	Yes	Diagnostic methods, including clinical examination and microbial culture, were well-documented.
5. Was the intervention or treatment procedure clearly described?	Yes	Yes	Both reports described treatment interventions, such as surgical debridement and antibiotics.
6. Was the post-intervention clinical condition clearly described?	Yes	No	Lodhia described the patient's recovery, while Koech provided limited follow-up details.
7. Were adverse events [harms] or unanticipated events identified and described?	Yes	No	Adverse events like co-morbid complications were discussed in Lodhia but not in Koech.
8. Does the case report provide takeaway lessons?	Yes	Yes	Both reports provided insights into diagnostic and treatment approaches for necrotizing fasciitis.

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Table IV: JBI Critical Appraisal for Case Reports

Domain	Magala [2014]	Mabula [2019]	Chalya [2015]	Mtenga [2019]	Comments
Were the criteria for inclusion in the sample clearly defined?	Yes	Yes	Yes	Yes	Clear inclusion criteria were reported in all case series.
Were the study subjects and their conditions clearly described?	Yes	Yes	Yes	Yes	Detailed descriptions of patient demographics, clinical conditions, and comorbidities.
Was the condition measured in a standard, reliable way for all participants included in the case series?	Yes	Yes	Yes	Yes	Diagnostic methods, including microbial culture and clinical exams, were consistent.
Were valid methods used for identification of the condition for all participants included in the case series?	Yes	Yes	Yes	Yes	All studies utilized standard diagnostic methods for necrotizing fasciitis.
Did the case series have consecutive inclusion of participants?	Yes	No	Yes	Yes	Mabula [2019] selectively included patients with Fournier's gangrene, which may bias results.
Were complete outcome data available for all participants?	Yes	Yes	Yes	No	Missing outcome data in Mtenga [2019].
Was there clear reporting of the demographics of the participants?	Yes	Yes	Yes	Yes	All studies provided detailed demographic data, including age, sex, and comorbidities.
Was there clear reporting of clinical information of the participants?	Yes	Yes	Yes	Yes	Comprehensive clinical information was provided for all patients.
Were the outcomes or follow-up results of cases clearly reported?	Yes	Yes	Yes	No	Outcomes were well-documented in all but Mtenga [2019].
Was the case series described with sufficient detail to allow replication?	Yes	Yes	Yes	Yes	Adequate detail was provided across all studies.

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Overall Quality Judgment for Case Series:
Magala [2014]: High quality. Comprehensive reporting on all domains.

Mabula [2019]: Moderate quality. Selective inclusion and limited generalizability.

Chalya [2015]: High quality. Clear and detailed reporting.

Mtenga [2019]: Moderate quality. Missing outcome data limit's reliability.

Table V: Anatomical site of NSTIs in the studies

Site of infection	N	Percentage
Lower Jaw	1	0.2%
Limbs	241	47.7%
Peri-anal	4	0.8%
Perineum	38	7.5%
Inguinal	2	0.4%
Perineal	14	2.8%
Cervicofacial region	42	8.3%
Trunk	41	8.1%
Head and neck	1	0.2%
Scrotal region	66	13.1%
Penis	2	0.4%
Buttock	1	0.2%
Scrotum and perineum	33	6.5%
Scalp	7	1.4%
Scalp face	2	0.4%
Lumbo-sacral	1	0.2%
Submandibular region	7	1.4%
Lower anterior abdominal wall	1	0.2%
Other	1	0.2%
Total	505	100%

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Table VI: **Overall risk factors for Necrotizing fasciitis**

Risk factors	N=505	Percentage
Diabetes	90	17.8%
Hypertension	24	4.8%
HIV	39	7.7%
Trauma	47	9.3%
cardiac disease	29	5.7%
Anemia	7	1.4%
prior medical comorbidity	32	6.3%
superinfection of a lesion	11	2.2%
acute ischemia	4	0.8%
Smoking	32	6.3%
Malnutrition	5	1.0%
Malignancy	1	0.2%
Complication due to penile amputation	2	0.4%
Urinary bladder	1	0.2%
Peri-anal abscess	11	2.2%
Post-inguinoscrotal herniorrhaphy	8	1.6%
Scrotal trauma	8	1.6%
Thrombosed hemorrhoids	7	1.4%
Post-hydrocelectomy	5	1.0%
Urethral stricture cane perineum	2	0.4%
Benign prostatic hyperplasia	2	0.4%
others	14	2.8%
Total	381	

Table VII: Overall Microbial agents of Necrotizing fasciitis

Microorganisms	N= 178	Percentage
Staphylococcus aureus	18	10.1%
Streptococcus pyogenes	42	23.6%
Streptococcus Spp	3	1.7%
Klebsiella pneumoniae	11	6.2%
P. aeruginosa	5	2.8%
Negative Gramm bacteria	15	8.4%
H. influenza type b	2	1.1%
Escherichia coli	15	8.4%
ß-hemolytic Streptococcus	6	3.4%
Acinetobacter Spp	4	2.2%
Proteus vulgaris	2	1.1%
Monomicrobial agent	8	4.5%
Polybacterial agents	38	21.3%
Other rare species	4	2.2%
Anerobic Bacteria	1	0.6%
Other positive Gramm cocci	4	2.2%

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Table VIII: General characteristics of the studies

AUTHOR	YEAR	COUNTRY	TYPE OF STUDY	SEX		AGE	SITE OF INFECTION	STUDY PERIOD	SAMPLE SIZE N=505
				Female	Male				
Lodhia [8]	2021	Tanzania	Case Report	1	-	5 weeks	Right lower Jaw [100%]	_	1[0.20%]
Vandroux [11]	2021	Reunion Island	Retrospective single center study	19 [28.4%]	48[71.6%]	45-64 years [48.4± 21.1]	lower limbs [52 cases, 78%], the upper limbs [four cases, 6%], and all four limbs [one case, 1.49%] perineal area [10 cases, 15%].	5 years and 11 months	67[13.27%]
Lunar [1]	2020	Kenya	Original Research work	32 [48%]	35 [52%]	Mean age = 49.2 years	Lower limbs 59[88.06%], upper limbs 3[4.48%], trunk1[1.49%], and head and neck 1[1.49%], Perineum 3[4.48%],	11months and 30 days	67[13.27%]
Mpirimbanyi [2]	2018	Rwanda	Prospective, Observational cohort study	N=83 [47.4%]	92[52.6%]	12-92 years Mean age= 43.8 years	Lower extremity 86[49], Trunk 40[22], Upper extremity 13[7], Perineum 35[20], Other 1[1%]	10 months	175[34.65%]
Koech and Chindia [13]	2009	Kenya	Case Report	4[44.4%]	5[55.6%]	3 months to 60 years	Scalp face 2 [22.22%], Submandibular region 7 [77.78%]	4 years and 7 months	9[1.78%]
Mabula [10]	2019	Tanzania	Retrospective hospital-based study	-	25[100%]	60% [50+] Mean=57.4 years	Scrotum and perineum, Fournier's gangrene	10 years and 11 months	25[4.95%]
Mtenga [7]	2019	Tanzania	Prospective descriptive Cross-sectional hospital-based study	11 [26.2%]	31[73.8%]	15 to 83 years Mean = 43.95±16.16	cervicofacial NF	11months	42[8.32%]
Chalya [9]	2015	Tanzania	Descriptive retrospective study	2[2.4%]	82[97.6%]	15 to 76 years Mean = 34 years	Scrotal 66 [78.6] Peri-anal 4 [4.8%], Perineal 4 [4.8%] Thigh 3 [3.6%] Penis 2 [2.4%] Inguinal 2 [2.4%] Lumbo-sacral 1 [1.2%] Buttock 1 [1.2%]	7 years 5 months	84[16.63%]
Magala [4]	2014	Uganda	Prospective descriptive Case-series study	9 [26%]	26 [74%]	20-40 years	Upper limbs 3/35[8.57%], Lower Limbs 17/35, the scrotum and perineum [23%], Scalp [20%]	4 months	35[6.93%]
Total				161 [31.9%]	344 [68.1%]				

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Table IX: Overall clinical features of the patients

Author	Country	Epidemiology [Clinical presentations]	Risk factor	Sex		Microorganisms present	Treatment	Outcomes	Sample size [n]
				Female	Male				
Lodhia [8]	Tanzania	Ulcer, discoloration of the jaw skin, swelling of the right lower jaw	HIV [100%]	1	-	*Staphylococcus aureus*	Cotrimoxazole, intravenous meropenem, metronidazole, furosemide, captopril, oral miconazole and antiretroviral therapy combination of abacavir, lamivudine and lopinavir/ritonavir.	Survived 100%	1
Vandroux [11]	Reunion Island	Septic shock 64[95.5%]	Diabetic complications 21 [31.3%], trauma 8 [12%], prior medical comorbidity 32[48%], superinfection of a lesion 11[16%], acute ischemia 4 [6%].	Female	Male	*Staphylococcus aureus* 5 [7.5%] *Streptococcus pyogenes* 25 [37.3%] Streptococcus spp 3 [4.5%], Negative-Gram bacteria 15 [22.4%] Others positive-Gram cocci 4 [6%] Anaerobic bacteria 1 [1.5%], total number with organisms N=52	iid therapy 47 [94%] 15 [88%] repinephrine 45 [90%] 17 [100%] inephrin 6 [12%] 6 [35.3%] chanical ventilation [n] 42 [84%] 17 [100%] T [n] 24 [48%] 9 [52.9%] bridement 31 [62%] 9 [52.9%] iputation 10 [20%] 1 [5.9%] Multiple amputations 4 [8%]	Death 17[25.4%] Survival 50 [74.6%]	67
Lunar [8]	Kenya	Comorbidities	Hypertension in 14 [21%], Diabetes mellitus 13 [19%], and HIV 4[6%], Trauma 39[58%].	Female	Male	Not clearly state	metronidazole 46%, piperacillin/sulbactam 27%, clindamycin 53%, ceftriaxone 44%, cefazolin 24%, and cloxacillin 2%. Combined antibiotics 85% and single antibiotics 15% of patients	Death 7 [10%] Survived 60[90%]	67

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Mpirimbanyi [2]	Rwanda	pus discharge 153 [87%], edema 149, [85%], pain 119 [68%], and skin necrosis 118, [67%].	cardiac disease 29 [17%], diabetes mellitus 28, [16%], smoking 23 [13%], and HIV infection 20 [11%]	83 [47.4%]	92[52.6 %]	Not stated	N = 175 Amputation or disarticulation, Surgical debridement [n = 90 [51%], Second phase operation 24 skin graft [n = 12, 50%] and amputation or disarticulation 5 [21%]. total, 57 [33%], amputation or disarticulation	Septic shock 50, [29%], postoperative complications 89 patients [51%]. pneumonia 29[17%], total mortality 46 [26%]. 89 patients [51%] postoperative infection	175
Koech and Chindia [13]	Kenya	Submandibular infections, Submandibular cellulitis, scalp face and the neck	HIV, 2[22.2%], Uncontrolled diabetes 2[22.2%], others 5[55.6%]	4	5	Negative	Surgical debridement, Aggressive repeated therapy, broad spectrum antibiotics, fluid therapy, management of diabetes	Death 2 [22.2%], Survived 7[77.8%]	9
Mabula [10]	Tanzania	Scrotal disorders 84% 28% combined scrotal abscess, fever	Hypertension 41%, Diabetes Mellitus [20%], others [39%]	-	25	Not stated	Combined treatment, wound debridement, antibiotics, fluid replacement, analgesics and daily wound dressing. 16 [64%] Blood transfusion, 7[28%] skin grafting, 1[4%] Orchiectomy,	Death 3[12%], survived 8[32%] survived [with complications] 6[24%]	25
Mtenga [7]	Tanzania	Pain with swelling 100%, breathing difficulty 19 [45.2%], Clinical dehydration 30 [71.4%], systemic	Malnutrition 5 [100%], Anemia 7 [100%] Diabetes Mellitus 5 [100%] HIV + ve 4 [100%]	11[26.2%]	31[73.8 %]	*Staphylococcus aureus* 12 [28.6%], *S. pyogenes* 9 [21.4%], *Pseudomonas aeruginosa* 3 [7.1%], *Klebsiella pneumoniae* 4 [9.5%], *E. coli* 2 [4.8%],	combined treatment [wound debridement and antibiotics administration]	Survival Male 14 [45.2%], 17 [54.8%] Died: Female 4 [36.4%], survived: 7 [63.6%]	42

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		condition 18[42.9%] Swallowing problem 16[38.1%]				*H. influenza* type b 2 [4.8%] No growth 10 [23.8%]			
Chalya [9]	Tanzania	62 [73.8 %] ulcers, 12 [14.3 %], gangrene 10[11.9 %] and scrotal gangrene	Peri-anal abscess 11 [13.1%], Diabetes mellitus 14 [16.7%] HIV/AIDS 9 [9.5%] Post-inguinoscrotal herniorrhaphy 8 [8.3%] Scrotal trauma 8 [8.3%], Urethral stricture cane perineum 2 [2.4%], Thrombosed hemorrhoids 7 [8.3%] Post-hydrocelectomy 5 [6.0%], Penile amputation 2 [2.4%] Benign prostatic hyperplasia 2 [2.4%], Urinary bladder injury 1 [1.2%]	1	41	*Staphylococcus aureus* 8 [17.4%], *Escherichia coli* 13 [28.3%] *Klebsiella pneumonia* 7 [15.2%] *Pseudomonas aeruginosa* 2 [4.3%], *Proteus vulgaris* 2 [4.3%] ß-hemolytic streptococcus 6 [13.0%], Polybacterial 38[82.6%], *Acinetobacter spp* 4 [8.7%], *Proteus vulgaris* 2 [4.3%] Other rare spp 4 [8.7%] Monomicrobial 8 [17.4%] agents	Aggressive fluid resuscitation, Broad-spectrum antimicrobial administration, [cephalosporin, aminoglycoside], administration, metronidazole, hemodynamic support., debridement	Death 24 [28.6 %] Survived 60 [71.4%]	84
Magala [4]	Uganda		Diabetes Meletus 2 out of 35[6%] HIV/AID 8 out of 35[22.86%], malignancy 1 out of 35 [3%]	1	3	Positive organisms: *Enterococcus faecalis,* C*orynebacteria* species *Staphylococcus aureus*, and *Escherichia coli, Klebsiella pneumonia*, *Proteus mirabilis*, *Acinetoobacter baumanii Providentia stuarti*, *Pseudomonas aeruginosa*, *Mycobacterium* species,	Repeated debridement, antibiotics	Death 14[40%] Survived 21[60%]	35

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Providentia rettgeri, and *Klebsiella oxotyica*,

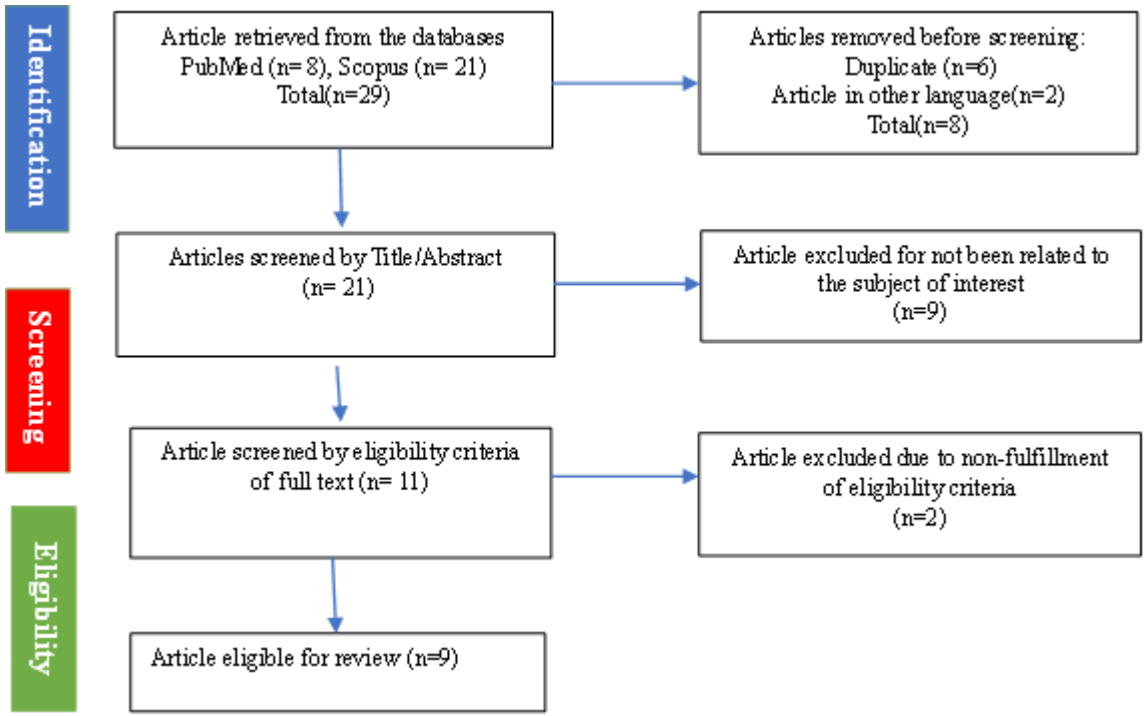

Figure I: Preferred reporting item for Systematic Review and Meta-Analysis [PRISMA] study selection flow chart

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