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ORIGINAL ARTICLE

A systematic review of burn injuries in low- and middle-income countries: Epidemiology in the WHO-defined African Region



Revue systématique des cas de blessures par brûlure dans les pays à revenu faible et intermédiaire: épidémiologie dans la région africaine de l'OMS

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ABSTRACT

Introduction: According to the World Health Organization (WHO), burns result in the loss of approximately 18 million disability adjusted life years (DALYs) and more than 250,000 deaths each year, more than 90% of which are in low- and middle-income countries (LMICs). The epidemiology of these injuries, especially in the WHO-defined African Region, has yet to be adequately defined.

Methods: We performed a systematic review of the literature regarding the epidemiology of thermal, chemical, and electrical burns in the WHO-defined African Region. All articles indexed in PubMed, EMBASE, Web of Science, Global Health, and the Cochrane Library databases as of October 2015 were included.

Results: The search resulted in 12,568 potential abstracts. Through multiple rounds of screening using criteria determined *a priori*, 81 manuscripts with hospital-based epidemiology as well as eleven manuscripts that included population-based epidemiology were identified. Although the studies varied in methodology, several trends were noted: young children appear to be at most risk; most individuals were burned at home; and hot liquids and flame are the most common aetiologies.

Discussion: While more population-based research is essential to identifying specific risk factors for targeted prevention strategies, our review identifies consistent trends for initial efforts at eliminating these often devastating and avoidable injuries.

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ABSTRACT

Introduction: Selon l'Organisation mondiale de la Santé (OMS), les brûlures résultent sur la perte d'environ 18 millions d'années de vie corrigées du facteur d'invalidité (AVCI) et sur plus de 250 000 décès chaque année, plus de 90% se produisant dans les pays à revenu faible et intermédiaire (PRFI). L'épidémiologie de ces blessures, notamment dans la région africaine de l'OMS, reste encore à définir adéquatement.

Méthodes: Nous avons procédé à une revue systématique de la documentation relative à l'épidémiologie des brûlures thermiques, chimiques et électriques dans la région africaine de l'OMS. Tous les articles

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indexés dans les bases de données de PubMed, EMBASE, Web of Science, Global Health et de la Cochrane Library à compter d'octobre 2015 ont été inclus.

Résultats: La recherche a produit 12 568 résumés potentiels. Par le biais de plusieurs séries de tri à l'aide de critères déterminés *a priori*, 81 manuscrits fournissant une épidémiologie dans le cadre hospitalier ainsi que 11 manuscrits incluant une épidémiologie basée sur la population ont été identifiés. Bien que les études variaient dans leur méthodologie, plusieurs tendances ont été observées: les jeunes enfants semblent constituer la population la plus à risque; la plupart des individus étaient brûlés à la maison; et les liquides chauds et les flammes constituent les étiologies les plus courantes.

Discussion: Si des études davantage basées sur la population sont essentielles pour identifier les facteurs de risque spécifiques en vue de stratégies de prévention ciblées, notre revue identifie des tendances constantes pour les efforts initiaux visant à éliminer ces blessures souvent dévastatrices et évitables.

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African relevance

- The WHO-defined African Region carries the greatest burden of disease with regard to burn injuries.
- Little is known about the epidemiology of burn injuries in the African Region.
- To date, no systematic review has been performed on the epidemiology of burns in the African Region.

Introduction

The World Health Organization (WHO) broadly defines a burn as an injury caused by heat (hot objects, gases, or flames), chemicals, electricity and lightning, friction, or radiation [1]. Annually, burns result in more than 7.1 million injuries, the loss of almost 18 million disability adjusted life years (DALYs) and more than 250,000 deaths worldwide. More than 90% of the burden of burn injury is borne by low- and middle-income countries (LMICs). The three WHO regions with the greatest burden of injury are the Eastern Mediterranean Region, the South East Asian Region, and the African Region, with the African Region bearing nearly two-thirds of the total burden [2]. To date, systematic reviews on the epidemiology of burn injuries have been conducted in the first two regions [3,4], but only limited information has been gathered regarding the epidemiology of burn injury in the WHO-defined African Region [5,6].

Several global systematic reviews of burn injuries that include the WHO-defined African Region have been completed to date, but they have often identified different epidemiological patterns and contradictory risk factors [7–12]. For example, a review of childhood injuries in low-income countries by Bartlett in 2002 highlights burn injuries as occurring most often at home in children under four years of age, especially during cooler months in countries with seasonal variations. Bartlett also reports scalds of the upper extremities as the most common injuries and emphasizes the dangers of children's access to appliances in the home

[7]. Ahuja and Bhattacharya, however, note that perhaps children, as well as the elderly, are at less risk for burn injuries likely as a result of the joint family unit and the potential for redundant supervision. They highlight women aged 16–35 as being the most susceptible to burn injuries as a result of their use of loose clothing and their predominant roles in cooking for the family. They also emphasize flame as a common cause for injuries [8].

Furthermore, these global reviews as well as other reviews focused on more specific types of burns [13–27], have several limitations. Most are not comprehensive, few are systematic, many include high-income countries (HICs) or highlight other injury mechanisms along with burn injuries, and none have specifically focused on the WHO-defined African Region. Additionally, most include hospital-based (patients presenting to or admitted to clinics or hospitals), and not population-based, data. As Dissanaikie and Rahimi mention, studies heavily based in data acquired from healthcare facilities often grossly underestimate the incidence of burn injuries as injuries that do not meet admission criteria are often not identified. Furthermore, epidemiological data from these studies is often biased as there are many factors in LMICs that determine whether or not individuals can or do seek medical care for serious injuries and medical conditions [11].

However, although limited, these reviews do help to identify epidemiological factors that are potentially important in the study of burn injuries. These factors include age, sex, socioeconomic status (SES), type of fuel and lighting sources used in the home, education, occupation, number of people in the home, potential for supervision (in paediatric burns), seasonal and temporal variation, high risk locations for burn injury (e.g. specific rooms in the home), mechanism of burn injury, extent of burn injury including total body surface area (TBSA) and burn depth, and other potential risk factors (e.g. medical co-morbidities, flammable clothing, cultural practices).

A detailed understanding of epidemiology is essential in order to take steps to prevent injuries. According to Peck et al., epidemiology and surveillance, are the key first steps in injury prevention

[28]. With this goal in mind, in this paper we systematically review the epidemiological studies of burns in the WHO-defined African Region in order to more specifically and comprehensively describe these preventable injuries in the region with the greatest burden of injury.

Methods

We performed a systematic review of the literature indexed in PubMed, EMBASE, Web of Science, Global Health, and the Cochrane

Library databases as of October 2015. Abstracts were limited to human studies in English. The initial search had a broader scope of burn injuries in LMICs and returned 12568 abstracts, 4248 which were duplicates that were excluded prior to review. On primary review of the remaining 8320 abstracts, 6432 were excluded by two reviewers (with conflicts resolved by a third) using the following *a priori* exclusion criteria: non-human study subjects, language other than English, not a full manuscript (e.g. only an abstract, poster presentation, lecture, letter, or short communication), not conducted in a LMIC – as defined by the World Bank clas-

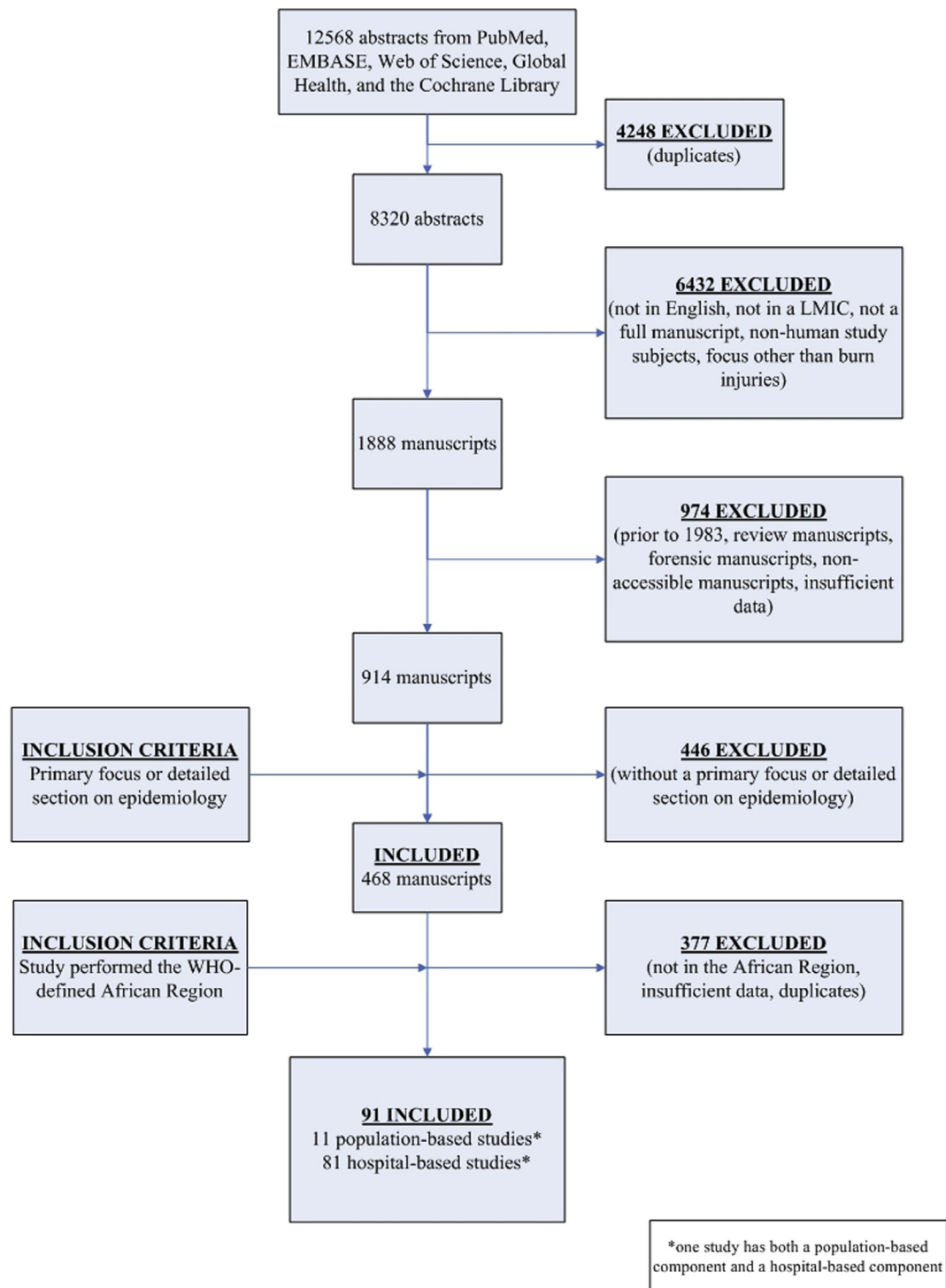


Fig. 1. Flowchart of the systematic review process.

sification of countries as of June 1, 2013 [29], and a manuscript without a focus on thermal, electrical, or chemical burns, or with a focus only on burn injuries involving radiation injuries, sunburns, sulphur mustard/other chemical warfare agents/paraquat, or mass casualty incidents (MCIs). The remaining 1888 manuscripts were screened by two reviewers, using the following *a priori* exclusion criteria: full manuscripts not accessible, manuscripts with epidemiology of only the deceased/forensic manuscripts, manuscripts prior to 1983, other systematic reviews, and finally those without sufficient epidemiological or preventative data (i.e. ten or fewer subjects, limited detailed data). The remaining 914 manuscripts were screened with the following *a priori* inclusion criteria: having a primary focus on or detailed section (must include original data with or without statistical analysis – e.g. percentages, averages) on epidemiology. This resulted in 468 manuscripts. These manuscripts were then separated into regions to determine those conducted in the WHO-defined African Region resulting in 91 manuscripts – ten population-based studies, 80 hospital-based studies, and one manuscript including both a population- and a hospital-based component to the study (Fig. 1).

All screening and data extraction was completed using Microsoft Excel. Ethics approval was not required by the study facility because this study reviewed existing literature.

Results

Population-based studies

The search resulted in eleven population-based studies: two from Ethiopia, five from Ghana, and one each from Kenya, Sierra Leone, South Africa, and Tanzania. These studies are listed in Table 1 [30–40]. A summary of the major findings from these studies is reported in Table 2.

The majority of the studies note that children are most at risk for burn injuries [30–34,37,39,40]. Most studies highlight younger males and older females as most at risk for burn injuries [30–34,37,39], although some showed no clear differences between the sexes [38,40]. Scald and contact injuries appear to be the most common [30–34,38] often as a result of bathing or cooking, however flame injuries as well as electrical and chemical burns are common in some areas [40]. In the studies describing the location of the burn injuries, the extremities – particularly the upper extremities – are the most common locations for suffering burn injuries, especially in scald and contact burns. The lower extremities are more commonly affected in flame injuries [33,34,38,40]. Many studies highlight the home, particularly the kitchen, as the most common location of sustaining burn injuries [30–34].

Table 1
Population-based studies by country, first author, journal, and year.

Country	First Author	Journal	Year
Ethiopia	Nega	Ethiopian Journal of Health Development	2002
Ethiopia	Courtright	Journal of Epidemiology and Community Health	1993
Ghana	Forjuoh	Burns	1995
Ghana	Forjuoh	Journal of Epidemiology and Community Health	1995
Ghana	Forjuoh	Child Abuse and Neglect	1995
Ghana	Forjuoh	Burns	1996
Kenya	Wong	Burns	2014
Sierra Leone	Wong	Burns	2014
South Africa	Barnes	African Safety Promotion	2004
Tanzania	Roman	International Journal of Injury Control and Safety Promotion	2012

Table 2
Summary of findings in the population-based studies by epidemiological factor.

Epidemiological Factor	Critical Finding
Age	Children (up to five years old)
Sex	Male children; female adults
Most Common	Scalds
Type of Injury	
Areas Affected	Extremities
Location of Injury	Home
Socio-economic Factors	No clear trend in place of residence (rural vs. urban), occupation, education or literacy, income, number of children/adults in family/per room, birth order, size of kitchen, housing quality index, hours spent away by the mother
Risk Factors	<ul style="list-style-type: none"> • Impairment, sibling death or injury from burn, storage of flammable substances in the home • No difference in fuel used in the home, type of appliance, duration of burning throughout the day

It is unclear how the number of persons per household and the composition of those persons contribute to risk of burn injury. Some studies suggest that having four or more persons per room along with having five or fewer adults in the household results in increased risk [31,39]. Furthermore, one study suggested that burn injuries are more common in high income households among employed parents [31]. This may be due to less supervision (parents out of the house working) or due to having more appliances in the home. Other studies, however, found no significant differences in risk of burn injuries in relation to hours spent away by the mother or number of children in the house [33,38]. Additionally, although two studies suggest an increased risk among rural households [33,34], other studies found no association between place of residence (rural vs. urban), as well as occupation, income, education or literacy, size of kitchen, or housing quality index [38–40].

In one study, significant risk factors for burn injury include impairment (odds ratio 6.6), burn in a sibling (odds ratio 1.7), sibling death from burn (odds ratio 4.4), and storage of flammable substance in the home (odds ratio 1.5) [34]. Non-significant risk factors include type of appliance/fuel, duration of daily burning (if flame used), and birth order [39,40]. Children playing and adults cooking are the most common scenarios resulting in burn injuries, and at-risk times include just after morning or evening meals [30–34].

Two sub-populations are also highlighted in additional studies – those with intentional burn injuries and children with a history of more than one burn injury. In the former population, the majority of victims are 24–35 months old, male, and living in rural areas.

Table 3
Summary of findings in the hospital-based studies by epidemiological factor.

Epidemiological Factor	Critical Finding
Age	Children (up to 15 years of age)
Sex	Trend toward male children, female adults
Most Common	Scald (children), flame (adults)
Type of Injury	
Areas Affected	Upper extremities, trunk
Extent of Injury	Most <20%; partial thickness
Location of Injury	Home (kitchen)
Socio-economic Factors	<ul style="list-style-type: none"> • Among those admitted, the adults are unemployed, the families are of low SES • Those admitted are often from crowded households with limited number of rooms
Other Common Themes	<ul style="list-style-type: none"> • Intentional injuries are among those admitted • Epilepsy is a common contributing factor • Chemical and electrical burns are among those admitted • Many injuries occur during the cool/dry/windy seasons

Table 4
Summary of findings by studies on special cases of burn injury.

Type of Injury	Critical Findings
Stove Burns	<ul style="list-style-type: none"> • Women 20–29 years of age are most at risk • Most are of low SES • Injuries most often occur during cooking or refilling
Bed Net Burns	<ul style="list-style-type: none"> • Most individuals are one year of age or less • Most are male • Most suffer >20% TBSA
Intentional and Unintentional Chemical Burns	<ul style="list-style-type: none"> • Chemical assaults are often suffered by males and are a result of acids thrown at the face, head, and neck • Chemical ingestions are most often acids if accidental and alkalis if intentional • Of cases of ingestions, most individuals are of low SES
Intentional Burns	<ul style="list-style-type: none"> • Many are suffered by females 20–30 years of age using flame in a suicide attempt • Assaults of men by their partners are also described, often by hot liquids • Many are a result of relationship difficulties • Most are > 60% TBSA
Electrical Burns	<ul style="list-style-type: none"> • Most of those injured are male • Most are between 20–40 years of age • The extremities are most commonly affected
Occupational Burns	<ul style="list-style-type: none"> • Most are males • Most suffer approximately 20% TBSA • Most injuries are flame burns

SES, socio-economic status; TBSA, total body surface area.

The majority involve 1–2% TBSA and the trunk/back rather than the extremities. Intentional injuries more often occur outside the home and are more likely to be caused by flame [35]. In the latter group, there is no difference in demographics between repeat victims and those with history of a single burn injury with the following exceptions: those injured more than once more often suffer scald and flame burns and there are more double parent households and more households with televisions among those with more than one injury, and, among children with a single injury, there are more households with stored flammable substances and more mothers away more than eight hours [36].

Hospital-based studies

The majority of the studies (81) found in this review are based on epidemiological data on patients presenting to or admitted to health care facilities (Tables 3 and 4) [42–107]. While comparisons are limited by differences in admission criteria and in descriptions of burn injuries and of paediatric populations, these data provide information about which patients with burn injuries present for medical care.

Studies show that children up to the age of 15 years are most at risk, with those less than five at highest risk [31,42–99]. Male children and female adults (usually between 20 and 30 years of age) are at risk in studies of children and of all age groups [31,42–53, 55–59,60–62,64–71,73–75,77–80,81–87,89–92,96,98]. Among studies with adults only, men are found to be more at risk especially between 20 and 30 years of age [100,102,103,105,106]. Scald injuries (usually in children) and flame injuries (usually in adults) are the most common types of injuries [41–99,101–107]. The most common areas affected are the extremities followed by the trunk [41,52–61,67–73,75–99,102–106]. Most injuries are partial thickness with \leq 20% total body surface area (TBSA). Burn severity in terms of TBSA tend to increase with age [42–46,62–67]. Most burn injuries are sustained in the home, particularly the kitchen [42–46,67,72,87–98].

Several studies note specific socio-economic factors common to admitted patients. Limited education, unemployment, having more

than six persons in the home and/or single room house, being from a rural area, and/or having a 'low income' are common among admitted patients [67,71,74–99].

Chemical and electrical burns as well as intentional burns do occur and are among those admitted [41–44,52–66,69–70,75–98, 100,102–106,107]. Many burn injuries occur during the cool/dry/windy months [52–66,68,75–86,100]. Epilepsy is a common contributing factor to burn injuries [47,50,62–66,68,74,100,107].

Special cases

There are several studies involving specific burn types. They involve chemical and electrical burns, ingestions, intentional burns, burns from bed nets, burns from stove explosions, and occupational injuries and span six countries: Ghana, Kenya, Nigeria, South Africa, Uganda, and Zimbabwe (Table 4).

Ombati et al. describe risk factors for kerosene stove explosion burns in Kenya. They report women of low SES between the ages of 20 and 39 as those most commonly injured by stove explosions with the majority being injured during cooking or refilling of the stoves [108].

Kalanzi et al. report on burn injuries from bed nets presenting to Mulago National Referral Hospital in Uganda. A bed net burn is one that occurs as a result of when a net that is hung to protect an individual from mosquitoes when he or she is sleeping catches fire as a result of coming into contact with hot objects or flames that are kept in and around the sleeping area for warmth and/or light. Bed net burns are particularly serious as the individual is most often asleep under the net at the time of the injury. Most of those admitted to the hospital with these injuries are one year old or less, are male, and suffer >20% TBSA [109].

Several studies report intentional chemical injuries. The majority of the incidents are a result of domestic disputes, robbery, or assault involving injuries to the head and neck, particularly the eyes, with the majority of those assaulted being male and 30–40 years of age [110–112]. Thomas et al. and Adedeji et al. describe injuries caused by chemical ingestions. The majority of those admitted are men with a mean age of 23 years. Many are of low SES. Some note accidental ingestions – mostly of acids; most however are intentional ingestions of alkalis in suicide attempts [113,114].

Datubo-Brown describes the characteristics of intentional burns that present to Port Harcourt Teaching Hospital in Nigeria. The majority of those affected are male and are a result of attempts to treat another ailment. The rest are inflicted as punishment or in the course of attempted robbery. The most common aetiology is flame, followed by chemicals and hot liquids [115].

In a study by Godwin and Hudson, men assaulted by their partners are described. The mean age is 37 years. Injuries result from hot water, stove or fish oil, and paraffin and flame in decreasing frequency. The average TBSA is 30% with the head and neck and upper extremities most commonly injured [116].

Mzewewa et al. describe patients admitted for intentional injuries sustained as a result of suicide attempts. The majority of the patients are female and are 22–30 years of age who use paraffin for self-harm, with attempts mostly occurring in the evenings and resulting in an average of 60% TBSA. The most common cause for these actions are relationship difficulties [117].

Two studies report that among electrical injuries, the majority of patients affected are male between 20 and 40 years of age with injuries that occur from high voltages to the upper extremities while at work [118,119].

Finally, Muguti and Doolabh describe occupational burn injuries sustained by males in Zimbabwe. Of these workers, the majority are skilled workers 30–40 years of age. The mean TBSA is 21% with injuries to the face, hands, and feet in decreasing frequency. The

majority are flame burns, followed by scalds, electrical burns, and chemical burns in decreasing frequency [120].

Discussion

Burn injuries are common throughout the world, with the WHO-defined African Region bearing the majority of the burden of the global morbidity and mortality. Unfortunately, little is known about the epidemiology of these injuries in this region. The purpose of this systematic review was to highlight trends from epidemiological studies for the purpose of stimulating further population-based surveillance and of informing preventative efforts. While each country and region are unique, several consistent findings from the eleven population-based studies and the 81 hospital-based studies, representing 13 of the 47 countries in the WHO-defined African Region, are reported in this review.

The findings presented here are similar to those in previous reviews, however, unlike previous studies suggest, there does not seem to be any clear association between certain socio-economic factors such as place of residence, occupation, income, education/literacy, number of children, number of adults, size of kitchen, types of fuels/appliances in the home [5–12]. This is likely a result of a broader scope of this systematic review as well as the heterogeneous definitions of socioeconomic factors used in the various studies. Finally, it is important to note that electrical and chemical burns, including ingestions, while rare, do occur; intentional burns (either homicidal or suicidal) are a substantial problem in certain areas; and co-morbidities such as epilepsy are likely contributors to burn injuries. These special topics have not always been highlighted in previous reviews.

In hospital-based studies, we see many of the same trends as in the population-based studies, however, there are more findings that are consistent with previous reviews in LMICs as well as in reviews of injuries in HICs, for example, most studies note a male predominance among those admitted [6,121]. As mentioned, low SES and unemployment are also often reported among families of patients admitted as has also been highlighted in previous studies [5–12]. Children who are admitted have most commonly suffered a scald; adults most commonly suffered flame burns; most reviews note this, however there is not always the same distribution by age group [5–12]. The TBSA of those admitted is often 20% or less (often higher in developed countries), perhaps because more severe injuries are more likely to be fatal in LMICs [121]. Special cases of burn injury, such as those caused by epilepsy, intentional burn injuries (including therapeutic burns and assaults), chemical and electrical burns, and injuries occurring at work (especially among men) are often among those admitted as well. The identification of these special burns is not only important for training health care providers in these unique situations (the majority of which are not as common elsewhere with the exception of work- or industry-related burns which are much more common in HICs), but it is also imperative in directing specific and efficient preventative efforts [121–123].

It is important to remember, however, that these conclusions are made on the basis of both population-based and hospital-based studies with variable methodology and inclusion criteria and are therefore more qualitative than quantitative. There are subtle characteristics of those affected by burn injury as well as risk factors for burn injury that vary among countries and even among communities within countries that are not yet characterized in the literature, and thus, by this review. Further limitations of this review include the exclusion of studies not reported in English; the majority of the literature highlighted here is often more than 10–15 years old; the varied definitions of age groups, of burn injuries, and of admission criteria to hospitals and burn

units; and the heterogeneity of data in the included studies precludes meta-analysis. Overall, however, this review represents a large sample that is unique among literature reviews on burn injuries, and it provides an extensive overview of the epidemiology in a region that has not been previously well-highlighted.

In areas with limited resources, it is important for each community to identify the population at risk for burn injury and the most unique factors that may contribute to it. As a result, specific, and therefore more effective, preventative programs may be put into effect. It is imperative that future studies, particularly population-based studies in the WHO-defined African Region with consistent definitions of epidemiological factors continue to more comprehensively describe the epidemiology of and to more completely capture the incidence of burn injuries in this heavily burdened area.

Burn injuries are common throughout the world, with the WHO-defined African Region bearing a large burden of injury. Although specific trends have been noted in this review, primary studies are few and are limited by varying definitions of age groups, burn injuries, and hospital or burn unit admission criteria. While the data are limited and would benefit from more study, the consistent epidemiologic trends noted here can inform education and prevention strategies to hopefully begin to reduce the incidence, morbidity, and mortality from burn injuries in the WHO-defined African Region.

Conflicts of interest

Gabrielle Jacquet is an associate editor for the African Journal of Emergency Medicine. Dr Jacquet was not involved in the editing or peer review process for this paper. The authors declare no other conflict of interest.

Authors' contributions

MR, JS, CE, SS, PV, KB, LC and GJ screened the papers. MR, JS, SS, LC extracted the data. MR analyzed the data. MR wrote the paper. All authors revised the manuscript and approved the final version of the manuscript.

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