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Global perspectives on risk factors for major joint burn contractures: A literature review

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ABSTRACT

Contractures are a frequent consequence of burn injuries, yet our knowledge of associated risk factors is limited. This paper provides an extensive review of relevant literature from both High-Income Countries (HICs) and Low-Middle Income Countries (LMICs). Ninety-four papers (up to June 2019) and eight subsequent publications (up to March 2022) were included, 76% of which were from HICs. The majority of publications were either descriptive studies (4 from HICs, 9 from LMICs) or papers citing putative risk factors (37 from HICs, 10 from LMICs). Seventeen publications (all from HICs) reported on the effects of individual non-surgical therapeutic interventions, often with conflicting results. Two published systematic reviews emphasised the poor quality of evidence available. Only fifteen studies (3 from LMICs) examined potential contracture risk factors with statistical comparisons of outcomes; significant findings from these included demographic, burn, comorbidities, and treatment risk factors. LMIC papers included socioeconomic and healthcare system factors as potential risks for contracture; these were rarely considered in HIC publications. Methodological issues identified from this review of literature included differences in contracture definitions, populations studied, standards of care, joints included and the timing and nature of contracture assessments.This review is the first to collate existing knowledge on risk factors for burn contractures from both HIC and LMIC settings, revealing a surprising lack of robust evidence for many accepted risk factors. In LMICs, where burns are particularly common, universal health provision is lacking and specialist burn care is both scarce and difficult to access; consequently, socioeconomic factors may have more immediate impact on contracture outcomes than specific burn treatments or therapies. Much more work is indicated to fully understand the relative impacts of risk factors in different settings so that context-appropriate contracture prevention strategies can be developed.

1. Introduction

Burns are a global problem, especially in low or lower-middle income countries (LMICs) [1–4] and burn contractures are a common post-burn morbidity. Contracture prevalence rates of 18–85% have been reported [5–7]; with high rates identified even amongst the leading burn care centres in the world. Consequently, multidisciplinary burn care frequently focuses on preventing or minimising contractures.

Contractures contribute significantly to the life changes experienced by burn survivors and the costs of healthcare systems. Contractures (i.e., scarring that limits range of movement (ROM)) can be painful, limit function, result in

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altered appearance and disability, reduce quality of life, have psychological consequences, cause individuals to withdraw from their usual social interactions, and limit work opportunities [8–16]. Contractures that cannot be sufficiently resolved through conservative treatment methods may benefit from reconstructive surgery.

Commonly cited risk factors for burn contracture formation are depth of burn, large total burn surface area (TBSA%), skin grafting, and lack of therapy interventions such as pressure and splinting [17–21], but current evidence comes mainly from high income countries (HICs). Research into contracture risk factors in LMICs is particularly lacking, despite the particularly high incidence of burns and contractures in these regions.

Published literature frequently states that contractures are preventable [3,22]; sometimes statements of contracture preventability are qualified by the availability of effective burn care [23]. Other authors suggest that contractures are not preventable even with the best care [5,21,24]. It is not possible to clarify the extent to which contractures are preventable or develop comprehensive and effective prevention strategies without detailed knowledge of risk factors.

The aim of this study was to collate existing knowledge of risk factors for major joint burn contractures from published literature from both HIC and LMIC sources, in order to better inform contracture prevention policy development.

2. Method

2.1. Definition of key terms

The language around 'risk' and 'cause' in burn contracture literature is diverse, inconsistent, and often misleading. For this study a broad definition of what constitute a risk factor was used: "*any factor that is considered to increase the probability of an adverse outcome*" [25].

In addition there is no accepted or standardised operationalised definition of a burn contracture [5], therefore papers with any reference to contracture were included even where no definition of the term 'contracture' was given. The presence of contracture release was taken to imply the presence of a contracture.

2.2. Search strategy

The main literature search included peer-reviewed publications available through electronic search tools up to June 2019. Search databases used were Cumulative Index to Nursing and Allied Health Literature, Medical Literature Analysis and Retrieval System Online, PUBMED, Scopus, Web of Science, Safety Lit, Cochrane, PROSPERO, EThOS, EBSCO, ProQuest dissertation and thesis, DART Europe E-theses portal, Open Access Theses and Dissertations (OATD).

Search terms employed for titles and abstracts were: Burn (MH Burn or Burn*) AND Contracture (contracture* or "range of mo*") AND Risk (OR risk*, caus*, profile*, epidemiol*, factor*, influenc*, determin*, contribut*, predispose*, prevent*, outcome*.

Between July 2019 and March 2022 an alert was set up to identify additional relevant publications, focusing on new systematic reviews or those papers that collected primary data in order to ensure the most recent findings were included.

2.3. Inclusion and exclusion criteria

All causes of burns in all age groups were included. No date filter was used. Non-English articles were manually filtered; many abstracts were in English even if the full text was not. This enabled a broader view of the literature; any key articles on the topic, especially if from a LMIC source, could be translated if necessary. Major joints were considered to be the neck, shoulder, elbow, wrist, hip, knee and ankle.

Publications were excluded if they addressed:

- Contractures not caused by burns
- Contractures related to a burn injury but not as a direct result of burn scarring, such as heterotopic ossification, Volkmann's contracture, peripheral nerve damage
- Reports of non-acute surgical management of contractures (burn reconstruction) or any other treatment given to fixed contractures that did not include a description or statistical analysis of any risk factors which may have caused the contracture
- Reports of contractures only of non-major joints (i.e., hands, face, perineum, breasts, toes). Papers including these features/joints along with major joints (neck, shoulder, elbow, wrist, hip, knee and ankle) were included
- Reports on wound contraction or cellular level contraction
- Animal studies

2.4. Search results

Ninety-four publications addressing or mentioning risk factors for burn contractures were identified by the main literature search (up to June 2019, see Fig. 1), with a further 8 papers published up to 2022 (see Table 10). The country sources of publications were classified according to the World Bank Classification of countries at the time of the review in 2019 [26].

No specific quality assessment tools were used to appraise papers, however a single reviewer (RF) individually critiqued each paper in detail with respect to methodology, data analyses and interpretation as part of a PhD thesis.

Risk factors identified from every paper were collated according to the strength of evidence from which they were extracted and subsequently categorised into one of five categories - patient factors (including demographics, socioeconomic factors and co-morbidities), burn factors, medical/surgical treatment factors, therapy factors and health system factors.

3. Results

Papers from 1932 to 2019 were identified from the main review covering both acute and reconstructive burn patients. The majority of studies were hospital-based and addressed

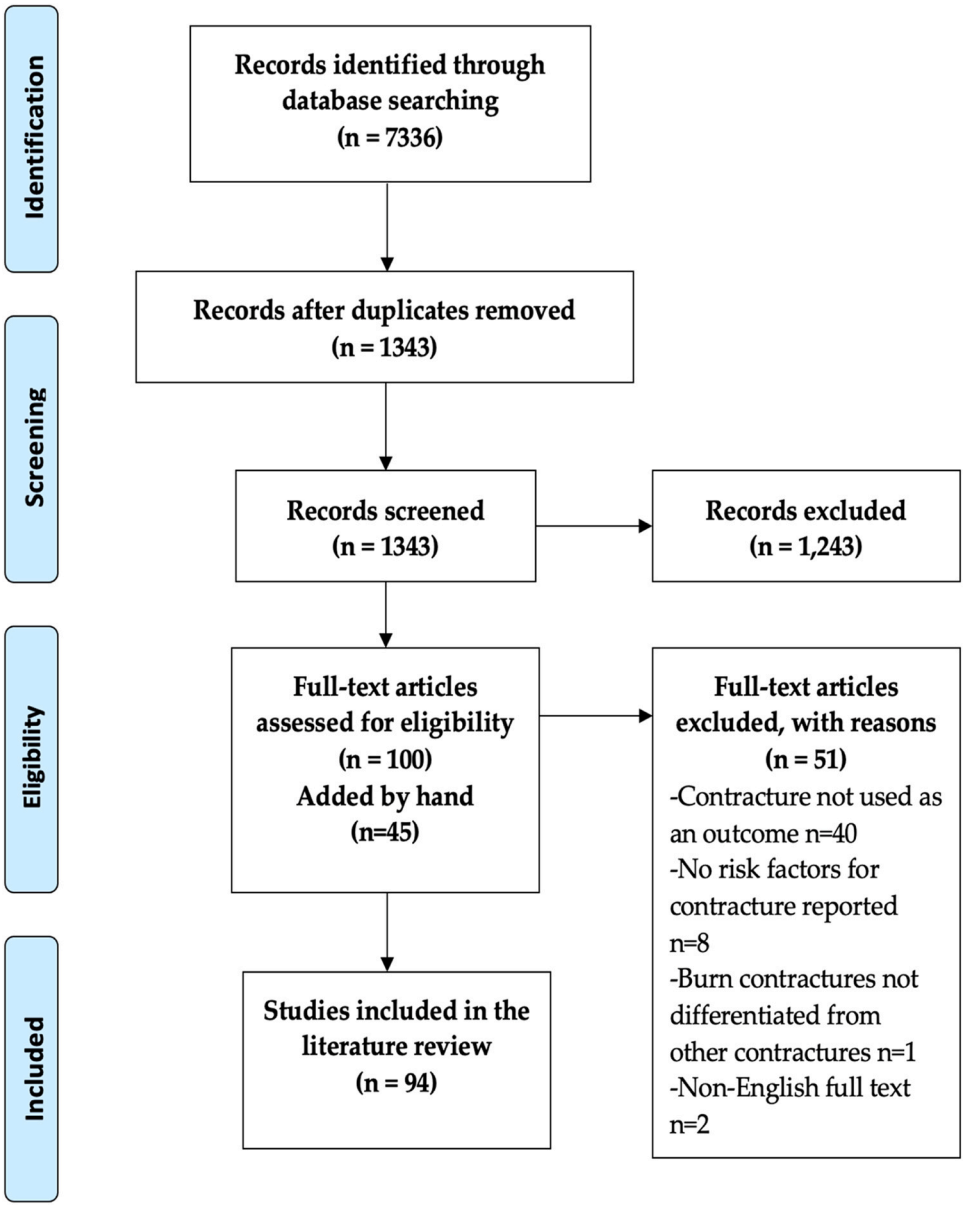

Fig. 1 – PRISMA Chart.

acute burn patients. Only one study (from a LMIC) collected data at community level [27]. Most LMIC studies involved both children and adults, but HIC studies tended to separate children and adults with most including adult patients only.

All papers but one [28] included in this review were authored by burn care clinicians. All papers written from LMIC sources were written by medical doctors. The HIC studies also have a predominance of medical authors but included physiotherapists.

The papers identified used a wide range of methods and were categorised into five groups: systematic reviews, risk factor studies, descriptive papers, therapy intervention studies and papers reporting only putative risk factors (Table 1). 'Risk factor studies' included papers using inferential statistical methods to identify risk factors for contractures. 'Putative' papers were those stating contracture risk factors without reference to supporting data. The distribution of publications according to category and source is shown in Table 1.

Table 1 – Number of publications reviewed by category and origin.

Category	HIC	LMIC	Total
Systematic reviews	2	-	2
Risk factor studies	12	3	15
Descriptive	4	9	13
Interventional	17	-	17
Putative	37	10	47
TOTAL	72	22	94

3.1. Systematic reviews

Two systematic reviews (both from HIC sources) specifically addressed general risk factors for contracture formation [5,28].

Fergusson et al. [28] included all types of contractures, not only burn contractures; only one of the 19 papers they included pertained to burn contractures [29] and was appraised separately in this review. Oosterwijk et al. [5] identified 7 papers; all were from HICs [17,18,21,29–32]. The risk factors identified in these studies are found in Tables 2, 5 and 7. Both systematic reviews concluded no clear standardised definition of contracture, which made identification of prevalence and determinants difficult.

3.2. Risk factor studies

Fifteen papers were identified in this category, only three of which were from LMICs (Tables 2 and 4), including one with shared HIC/LMIC authorship [33]. The 12 HIC/UMIC (Table 2) source articles included two conference abstracts [32,34] and one Letter to the Editor [35] in relation to another publication; this letter also included re-analysis of original data from prior publications.

The conference abstracts and Letter to the Editor are not included in Table 2, but the factors associated with contracture identified in these publications were: Hispanic children, adults of black race, patients with flame burns and those with high TBSA, longer time splinted and longer duration of rehabilitation time. It is likely that the latter two factors reflect a greater severity of burn injury rather than being primary risks for contracture.The statistically significant risk factors for contracture are summarised and categorised in Table 3; this categorisation offers a framework for future studies of contracture risk factors. The three risk factor papers from LMICs did not specifically examine risk factors for contracture, but rather for a range of adverse outcomes including scarring, keloids, contracture, amputation and disfigurement; no statistically significant risk factors for contracture alone could be identified. All were retrospective studies; two included both children and adults [33,40] and one included only children [41]. The significant risk factors for all adverse outcomes are summarised in Table 4.

Although not specific for contracture, the risk factors for adverse outcomes in these LMIC papers introduce a number of health system and socioeconomic factors which are not generally considered in HIC publications, but may be important contributors to contracture formation in LMICs.

3.3. Descriptive studies

Thirteen papers (8 from LMICs) used only descriptive statistics to examine their study populations in relation to a range of outcomes, including contracture (Table 5). While such studies have known limitations, they may give some clues or insight into the nature of potential risks, particularly in LMIC settings where more robust studies may be more difficult to undertake.

3.4. Studies of specific therapy interventions

Seventeen publications (all from HICs) addressed the impact of specific non-surgical therapy intervention(s) on contracture presence and/or severity (Tables 6–8). Case reports or small series with less than five subjects were not included. If an intervention has been demonstrated to reduce the prevalence or severity of contracture after burn, then absence of, delay in, or insufficient duration of that intervention during treatment could be a risk factor for contracture in itself, and was therefore included in the review.

Three publications were systematic reviews but one of these also included contractures due to conditions other than burns (Table 6). Exercise, particularly aerobic exercise with resistance, was found to be associated with a significant reduction in the need for surgical release of post-burn contractures in a meta-analysis [48]. However, the reviewers emphasised the low quality of evidence and a high degree of imprecision overall, particularly in relation to the use of the need for surgical contracture release as an outcome. In general, the quality of evidence found for any of the interventions was considered poor; populations differed significantly with variation and imprecision in methods used.

In addition to the systematic reviews, one literature review addressed the benefits of static splinting in preventing burn contractures [51]. The main conclusion of the review was that although splinting is a core treatment in the prevention of burn contractures, no good quality evidence supports static splinting prevents scar contracture and could even worsen contracture formation through upregulation of fibroblasts. The authors noted the wide variation in reported contracture rates, with different rates evident at different times of assessment and emphasised the need for a standardised definition and method of contracture measurement, both are currently lacking in clinical practice.

Two subsequent letters challenged some of the conclusions of that review [35,52], but both confirmed the need for further rigorous investigation of the impact of commonly used splinting. One response [35] presented the results of a re-analysis of data from two articles, both included in this review [29,53] showing the statistically significant impact of splint use in neck contractures and the need for splints to be worn for a minimum of 6 months. The four individual papers on splinting are summarized in Table 7; only one used any objective measure of ROM. Non-adherence was noted to be a problem in two papers [29,54].

Six individual papers examined the effect of multimodal programmes of exercise on contracture development and are summarised in Table 8. All had methodological issues which makes evaluation of their reliability difficult: these included low numbers, lack of baseline or contracture measurements and limited follow-up. Although exercise, particularly aerobic exercise with resistance, was found to be associated with a significant reduction in the need for contracture release in the systematic review by Flores et al. [48], only 2 of the 19 papers reviewed in that analysis included contracture as an outcome.

3.5. Putative risk factors

The literature search identified forty-seven papers (37 from HICs and 10 from LMICs) which included statements on putative contracture risk factors. Most papers which stated risk factors for burn contractures were on topics of general burn care management or burn rehabilitation. Arguably such

Table 2 – Characteristics of full papers from HIC.

Article and source	Study Type	Study Population	Follow-up (FU) Period	Significant Risk Factors for Contracture
Kraemer et al. 1988 (USA)[37]	Retrospective over 5.5years	53 children & adults having reconstruction	Not specified; based on time of contracture release	Being a child, greater burn size & depth, burn location (head/neck/axilla/hand)
Schneider et al. 2006 (USA)[21]	Prospective over 9 yrs	985 adults	Mean 22 days	**Presence:** Length of stay, TBSA grafted, TBSA burned **Severity**: amputation and inhalation injury risk factors for more severe contractures
Gangemi et al. 2008 (Italy)[18]	Prospective over 12.3years	703 adults (2440 burns)	Complete healing and maturation (max 29 m)	* Younger age, female, TBSA (greater), full thickness TBSA (greater), anatomical location of burn (upper limb and neck), performance of surgical procedures and number of procedures, time to wound healing and timing/type of excision/grafting **Outcomes defined in terms of pathological appearance of scar, not simply contracture*
Kidd et al. 2013 (UK)[30]	Retrospective over 3 years	94 children < 16 yrs undergoing surgery	Mean 5.1 years	Young age at injury (< 5 years), higher TBSA, anatomical location (upper limb/head/neck)
Hop et al. 2014 (Netherlands)[38]	Retrospective multicentre, over 4 years	1768 children & adults	10 years	* *Higher TBSA, flame burns, upper limb burns, number of surgeries during acute phase * **Risk factors related to any reconstructive surgery, not just contracture*
Goverman et al. 2017 (USA)[24]	Retrospective, multicentre, over 10 years	1031 children < 18 yrs	Mean 24.3 days	**Presence:** Greater age, ICU stay **Severity:** age, ICU LOS, amputation, black race **Number of contractures:** TBSA burned and grafted
Goverman et al. 2017b (USA)[36]	Retrospective, multicentre, over 10years	1065 adults	Mean 25 days	**Presence and severity**: Male sex, black/Hispanic ethnicity, pre-existing medical problems, TBSA burned, TBSA grafted, presence of neuropathy **Number of contractures:** Male sex, medical problems, flash-burn, neuropathy, TBSA burned and grafted
Godleski et al. 2018 (North America)[19]	Retrospective, multicentre, over 10 years	659 adults with contractures	Mean 31.9d	Increased contracture severity correlates with higher TBSA burned and LOS
Schouten et al. 2019 (Netherlands)[39]	Prospective, multicentre, 12 m	173 adults	ROM:12 m, Total FU: 24 m	Operated burns (deep burns), burns over vs. adjacent to joint, anatomical location of burn and affected joint, TBSA burned, early vs. later stages post burn

Table 3 – Statistically significant risk factors identified from publications upto 2019.

Category of Risk Factor	Significant Risk Factors for Contracture	No of papers reporting factor
Demographic	Male gender	**1** Goverman et al. 2017[36]
	Female gender – risk	**1** Gangemi et al. 2008)[18]
	Female gender – protective	**1** Goverman et al. 2017[36]
	Age at burn – children	**3** Kraemer et al. 1988[37]; Kidd et al. 2013[30]; Goverman et al. 2017[36]
	Age at burn – younger adult	**1** Gangemi et al. 2008[18]
	Older age	**1** Goverman et al. 2017[24]
	Ethnicity – black/Hispanic	**2** Goverman et al. 2017, Goverman et al. 2017[24,36]
Burn Factors	Aetiology – flame/fire	**2** Hop et al. 2014[37]; Goverman et al. 2017b[35]
	TBSA burned	**9** Kraemer et al. 1988[37]; Kidd et al. 2013[29]; Hop et al. 2014[38]; Schneider et al. 2006[21]; Gangemi et al. 2008[18]; Goverman et al. 2017[24,36]; Godleski et al. 2018[19]; Schouten et al. 2019[36]
	Depth of burn	**3** Kraemer et al. 1988[32]; Gangemi et al.2008[18]; Schouten et al. 2019[39]
	Anatomical location of burn	**5** Kraemer et al. 1988[37]; Gangemi et al. 2008[18]; Kidd et al. 2013[30]; Hop et al. 2014[38]; Schouten et al. 2019[39]
	Amputation[a]	**2** Schneider et al. 2006[21]; Goverman et al.[24]
	Inhalation injury[a]	**1** Schneider et al. 2006[21]
Medical Factors	Pre-existing medical problems	**1** Goverman et al. 2017b[36]
	Neuropathy	**1** Goverman et al. 2017b[24]
Treatment Factors	ICU length of stay[a]	**1** Goverman et al. 2017a[24]
	TBSA grafted	**4** Schneider et al. 2006[21], Goverman et al. 2017[24,36]; Schouten et al. 2019[39]
	Type of graft	**1** Gangemi et al. 2008[18]
	Time to wound healing	**1** Gangemi et al. 2008[18]
	Need/no. of surgical procedures	**2** Hop et al. 2014[34]; Gangemi et al. 2008[18]
	Length of stay	**2** Schneider et al. 2006[21]; Godleski et al. 2018[19]

[a] severity of contracture

statements reflect commonly accepted beliefs amongst burn care professionals about the factors that influence burn contracture formation.

From these 47 papers, 32 putative general risk factors (e.g. location of burn/scar) and 83 more specific putative risk factors (e.g. scarring across a joint) were identified. The six most frequently cited risk factors from HIC and LMIC sources are reported here (Table 9).

Only two of the top six risk factors were the same in both LMIC and HIC papers (lack of splinting and positioning); the evidence for either of these is questionable, as described above. LMIC sources include reference to ineffective treatment and health system issues such as lack of healthcare facilities and lack of physiotherapy; none of these were mentioned in HIC publications, probably reflecting differences in burn care provision between these types of environment.

3.6. *More recent publications*

The updated review included relevant papers published between July 2019 and March 2022 (n = 10) (Table 10). Six of these specifically addressed risks or predictive factors for contracture [3,62–66].

These studies largely confirmed risk factors already reported in the literature, but two of the publications (both from HIC/UMIC) also contributed three new statistically significant risk factors not previously identified, namely longer bed rest and greater weight gain [64] and being a blue-collar (manual) worker [65].

All recent papers from LMICs [3,62,68] commented on the lack of knowledge about contracture formation in such settings. One of these papers, a systematic review that included 14 papers from LMICs [62], stated “there is a severe lack of information on what happens between the early phase (of a burn injury) and the late complication stage (contractures)…. this disconnect makes any correlations between early burn care and late sequelae very difficult” [62, p. 1002].

3.7. *Summary of knowledge on contracture risk factors*

The literature search identified a total of 64 potential risk factors for contracture. The five most frequently reported risk factors, both overall and when putative sources are excluded, are shown in Table 11. A list of all the risk factors identified in the literature is available in the supplementary material.

4. Discussion

This literature review is a comprehensive collation of potential contracture risk factors, covering many types of literature, study designs and populations. The potential risk factors identified span many different categories, including demographic, socioeconomic, medical, burn, treatment and health system categories.

The review has identified few evidence-based and many putative risk factors for burn contractures. Few robust, well-controlled, prospective studies are available on risk factors for contracture development. Without robust supporting data it can be difficult to reach agreement on the necessary treatment or

Table 4 – Risk factors for adverse outcomes identified by 3 LMIC publications.

Source and type of study	Sample population	Time since burn	Adverse outcomes studied	Risk factors for adverse outcomes
Forjuoh et al. 1996[41] **(Ghana)** Retrospective, multisite cluster sampling	630 burns in 113 children ≤5 years	Not stated	Any impairment, including scarring, keloids, contracture and amputation	Age at burn TBSA (no data presented), burn to head/neck and trunk/back, depth–of burn - deeper, longer number of days for healing, infection of burn wound (no definition or data presented), contact with health facility (no contact), level of facility visited (lower level), number of days of limitation, lack of maternal education, lack of first aid
Fatusi et al. 2006[33] **(Nigeria)** Retrospective, single site	139 adult & paediatric patients	Not stated: at hospital discharge	Outcomes in patients with or without facial burns	No difference in rates of wound infection, contracture, inhalation injury or death between those with/without facial injury
Agbenorku 2013[40] **(Ghana)** Single centre, predominantly descriptive	70 adults & children, selected patients with disability	1–105 weeks	Disability: scar +/- contracture +/- disfigurement	Age < 10 years3rd degree burn depth, burn location (axilla or head/neck)Social mockery, impact on carers finances and time, lack of supportive nuclear family

policy changes to reduce the incidence and severity of burn contractures. Schouten et al. [39] stated, "as burn scar contractures are a common sequalae of burns it would be expected that their prevalence and development had been extensively studied. However, the opposite is true." (p. 784).

The evidence base for contracture risk factors in LMICs is particularly sparse. Nevertheless, LMIC publications report some potential risk factors for contracture which are different from those reported in HIC papers. Risk factors from HICs are largely burn- or treatment-related, whereas LMIC authors emphasise non-medical factors, especially poor income, access to care, education, and unemployment i.e., the social determinants of health [69]. Although some areas overlap (e.g., young age, TBSA, depth of burn, anatomical location of burn and duration to wound healing), socioeconomic factors are rarely mentioned as potential risks for contracture in HIC papers.

In LMICs, even if specialist burn care is available, socioeconomic factors may limit access for many patients, resulting in poor outcomes. As the literature is predominately from HIC sources it is possible that some of the most important risk factors in LMICs are overlooked and/or not identified due to differences in access to and availability of care and the influence of socioeconomic factors. In this challenging environment, it is difficult to navigate and clarify our understanding of risk factors for burn contractures, especially in LMICs.

4.1. *Key issues identified from current literature*

A number of factors undermine confidence in the reported findings of current literature and limit direct comparisons of studies, (Fig. 2).

i) Standard of Care:
The general standard of burn care will affect the power of any intervention to ameliorate contracture development. Furthermore, different risk factors may be present or controlled for to varying degrees with different standards of care. For example, only two of the LMIC studies included physiotherapy treatment as a variable [3,46], whereas it is often considered in detail by HIC studies [7]. This does not imply that therapy is considered unimportant in LMICs (it is one of the most frequently reported putative factors from LMIC sources), but rather because it is not routinely available.

ii) Health and social care system
The ease of access to general and specialist healthcare care is likely to affect the relative importance of several identified risk factors. In HIC settings where healthcare is either free, provided by insurance or affordable by the majority, family socioeconomic status may be less relevant to outcome and the presence or absence of other risk factors such as access to skin grafting, specialist burn care or pressure garments. In LMIC settings, payments required for treatment may significantly constrain the ability of patients to access appropriate care at the optimal time.
The organisation of the health system and resource level is also likely to affect available data. Several studies from HIC settings used multi-centre databases for data collection; no

Table 5 – Potential risk factors for contracture reported in descriptive papers.

Possible Risk Factors	Source	
Patient Factors	**HIC**	**LMIC**
Female gender	Pegg et al. 1978[31]	
Lack of education	Richard et al. 2017[42]	
Associated co-morbidity	Richard et al. 2017[42]	
Psycho-social problems	Richard et al. 2017[42]	
Burn Factors		
Deep burn	Dobbs & Curreri, 1972[17]	Armani et al. 2010[43]
Flame burn		Muguti & Fleming, 1992[44]; Armani et al. 2010[43]; Saaiq et al. 2012[14]
Larger TBSA	Dobbs & Curreri, 1972[17]; Richard et al. 2017[42]	
Treatment Factors		
Incomplete initial burn care		Muguti & Mhaka, 1994[45]; Saaiq et al. 2012[14]; Kim et al. 2012[46]
Treatment in rural healthcare		Muguti & Mhaka, 1994[45]
Delayed referral to specialist care		Muguti & Fleming, 1992[44] Muguti & & Mhaka, 1994[45]
Lack of skin grafting		Muguti & Mhaka, 1994[45], Saaiq et al. 2012[14]; Kim et al. 2012[46]
Larger skin grafted area	Richard et al. 2017[42]	
Complicated hospital course	Richard et al. 2017[42]	
Inadequate hospital stay	Richard et al. 2017[42]	
Lack of physiotherapy		Saaiq et al., 2012[14]; Kim et al., 2012[46]
Lack of splinting		Saaiq et al. 2012[14]; Kim et al. 2012[46]
Delayed physiotherapy	Dobbs & Curreri, 1972[17]	Muguti & Mhaka, 1994[45]; Ringo et al. 2014[47]
Lack of daily rehabilitation time	Richard et al. 2017[42]	
Low ratio of rehabilitation to hospital days	Richard et al. 2017[42]	
Low pain tolerance	Richard et al. 2017[42]	
Low compliance with rehabilitation	Richard et al. 2017[42]	

Table 6 – Summary of systematic reviews of non-surgical therapies for contractures.

Systematic review	Intervention (s) studied	Papers included	Review conclusions
Harvey et al. 2017[49]	Stretching therapy for up to 7 months (by sustained passive stretch, positioning, splinting or cast)	49 RCTs (only 2 on burns patients) including 2135 adults with contractures due to various neurological or non-neurological conditions (only 76 burn contractures)	Short term (<7 months) stretching had no impact on contractures
Zhang et al. 2017[50]	Mechanical stretching, massage and splint	9 studies (5 randomised controlled trials) including 375 children/adults with post-burn hypertrophic scars	Significant benefit from stretch in 3/5 papers using contracture as outcome but evidence inconclusive due to confounding factors and varying regimens of stretching
Flores et al. 2018[48]	Exercise modalities (including aerobic +/- resistance, vibration, isokinetic, coordination and strength, range of motion, and video game–assisted exercises)	19 papers (only 2 used contracture as outcome) including 669 children/ adults after burn injury	Exercise regimens improve some physical, physiological and psychological outcomes after burns, but quality of evidence poor and imprecision very serious

LMIC studies report results from regional or national databases and no LMIC studies were found which utilise data from more than one centre. Most LMIC studies collect data directly from patients/carers by interview, which has limitations.

iii) Profile of the study population

The characteristics of the study population may also impact final contracture rates, as many patient factors such as age will affect predisposition to contracture, as will burn injury factors such as TBSA and depth of burn. These factors may be very different in different studies and therefore may significantly alter the risk profile of the group under investigation, thus reducing generalisability of the findings and risks identified.

iv) Variables/risk factors examined

Different studies examine different risk factors. Risk factors are often not clearly defined, or are not standardised across studies, making comparisons of findings difficult.

Table 7 – Papers examining effect of splinting on contractures.

Source	Intervention	Outcomes documented	Assessment methods	Significant findings
Bunchman et al. 1975[53]	Neck collar (splint) for minimum 6 months	• incidence and severity of contracture • need for contracture release	Visual clinical assessment	Reduced incidence and severity of neck contracture with neck splint
Huang et al. 1978[28]	Effect of splint and pressure on contractures in various joints	• Severity of contracture • Surgical interventions • Duration of using splint/pressure	Medical records, visual clinical assessment	• Incidence of contracture and surgical release significantly reduced in splint/pressure patients, provided splints worn for at least 6 m and ideally > 12 m. • 12.5% non-compliance in wearing splint
Richard et al. 2000[55]	Multimodal physiotherapy vs splinting or cast	Contracture resolution time	Visual clinical assessment	• Some contractures corrected by non-surgical Rx alone. • Splinting/casts result in faster resolution of contracture than multimodal Rx
Kolmus et al. 2012[54]	Axillary splinting for 12 weeks	Measured axillary ROM (flexion and abduction) using Plurimeter-V Inclinometer on admission, and at 6 and 12 weeks	Measured ROM Splint adherence	• No significant benefit from intervention with respect to ROM at any stage of assessment • Very poor compliance with splint use for various reasons

Table 8 – Exercise intervention studies.

Source	Study and **Population**	Intervention Studied	Outcomes/endpoints Documented	Intervention Assessment	Significant Findings
Celis et al. 2003 (USA)[56]	Prospective randomised study; 53 children age 7–19 y with severe burns > 40% TBSA	12-week resistance & endurance exercise programme	Need for surgical intervention to correct contracture	6 monthly clinical assessments and goniometry	Significantly fewer contractures undergoing surgery in intervention group after 12 months
Okhovatian & Zoubine, 2007 (Iran)[57]	Prospective, matched, RCT; 30 burn admissions	Intensive rehabilitation including stretch and exercise	LOS and incidence of contractures, and thrombosis at acute discharge	Clinical records: contracture defined as loss of ROM measured by goniometer	Incidence of contracture significantly reduced in intervention group at discharge
Neugebauer et al. 2008 (USA)[58]	Non-randomised, descriptive cohort; 24 children aged 2–6 y	12-week music and exercise programme	AROM and PROM of elbows and knees at 3,6,9,12,18,24months	Goniometer measurements	Significantly better ROM in some movements of certain joints in intervention group
Paratz et al. 2012 (USA)[59]	Prospective, descriptive quasi-experimental, non-randomised controlled study; 26 adults > 20% TBSA	Supervised aerobic and resisted exercise program after final grafting	Fitness, muscle strength, upper limb function, health quality of life, need for contracture release before and at intervals	Various measures of fitness, function and quality of life at 6 weeks and 3 months. No ROM data.	Intervention group underwent fewer contracture releases despite greater burn depth and severity
Karimi et al. 2012 (Iran)[60]	Prospective case-control study; 64 adults and children with hypertrophic burn scars following grafts	Effect of intensive physiotherapy and exercise vs standard Rx of pressure garment and silicone	Scar appearance and joint ROM after 20months	Scar appearance and joint ROM every 4–6 weeks for 20months	Reduced severity of loss of ROM and improved scar appearance in physiotherapy/exercise group cf PGT/silicone
Deng et al. 2016 (China)[61]	Retrospective cohort study; 73 adult ICU patients with > 50% burns	Active mobility training vs passive regimen	LOS in BICU and hospital, duration of bedrest, rehab time in BICU, ROM of affected joints and ADL at discharge from ICU	Goniometer joint measurements + Bartel Index assessment of activities of daily living	Some movements improved in intervention group

Table 9 – Top 6 most frequently cited putative risk factors for contracture.

HIC sources	No of papers	LMIC sources	No of papers
Lack of splinting	34	Lack of splinting	13
Location or position of scar	14	Healing by secondary intention/lack of graft	8
Depth of burn	12	Ineffective treatment	7
Lack of positioning	11	Lack of healthcare facilities	3
High TBSA	9	Lack of positioning	3
Younger age	6	Lack of physiotherapy	3

Table 10 – Additional relevant publications from July 2019- March 2022.

Article	Origin	Type of Study	Sample	Main Focus of Study
Meng et al. (2019)[62]	Canada (HIC)	Systematic review	14 papers included	A systematic review of factors affecting contractures in children in LMICs
Tan et al. (2019)[63]	China (UMIC)	Descriptive retrospective	108 adults treated in ICU for > 50% burns	Factors affecting incidence and severity of contracture at 1 month in patients with burns > 50% TBSA
Puri et al. (2019)[3]	India (LMIC)	Retrospective observational	486 patients undergoing contracture reconstruction	Presumed causes of contracture and preventive action needed at clinical and health system level
Lensing et al. (2020)[64]	North America (HIC)	Descriptive observational	300 patients on ACT database (9 centres)	Factors affecting limitation of ROM in affected joints at hospital discharge
Zhu et al. (2020)[65]	China (UMIC)	Retrospective cross-sectional observational	220,642 pts on national database	Prevalence and predictors of readmission for contracture over 5 years
Yelvington et al. (2021)[66]	North America (HIC)	Retrospective observational	225 children with 1597 contractures	Severity of contracture at hospital discharge
Schouten et al. (2021)[67]	Holland (HIC)	Prospective	117 patients, 353 operated joints	Changes in limitation of joint ROM over 12 months during healing of burns after acute surgical Rx
Botman et al. (2021)[68]	Tanzania (LMIC)	Descriptive observational	67 (31 acute burns and 36 with contracture)	Factors contributing to delayed arrival of acute burn patients at tertiary centre and reasons why patients from hospital catchment still developing into severe contractures

Table 11 – Top five contracture risk factors reported in the literature.

All Sources	Frequency	Ranking	Sources excluding putative reports	Frequency
Lack of Splinting	53	1	High TBSA	11
Location of Burn/Scar	24	2	Location of Burn/Scar	9
Lack of exercise	23	3	Lack of Exercise	6
High TBSA	20	4	Deep Burns	6
Deep burns	18	5	Age at time of burn	5
			Lack of Splinting	5
			Lack of /Delayed physiotherapy	5
			Cause of burn	5

Note to Editor/Reviewer the full list of identified risk factors is available on request

The duration of studies vary, this impacts on which risk factors can be examined (such as rehabilitation follow-up interventions). It could be argued that some risk factors are more appropriately examined at person level (e.g. age, income, inhalation injury) and others at joint level (e.g. skin grafting, splinting); the importance of this has not yet been clearly articulated in the literature.

v) Methods of definition, timing, and measurement of contracture and joints at risk

Perhaps the most significant variation amongst existing studies is inconsistent definition and variable measurement of contractures. As stated by Fergusson et al. [28] "Standard definitions are necessary to reduce misclassification bias and for comparing measures across populations" (p.28)". In many studies which used contracture as an outcome, no information was given about how contracture presence or severity was determined. Only five risk factor studies considered the quantification of the contracture [17,19,21,24,36]. Severity of the outcome may facilite understanding of the potency of various risk factors. No accepted classification of contracture severity remains [67].

Similarly, only three risk factor studies [17,39,70] reported the definition of a joint at risk, even though variation in its definition could itself lead to widely differing contracture rates and affect the identification and effect of risk factors.

Timing of assessment also varies widely, from the time of acute hospital discharge (which is early in the contracture maturation timeline [67,70]) to many years later. Measuring the outcome at different points, particularly in contracture formation which is a progressive outcome until a point post scar maturation (longer for children who still grow), means

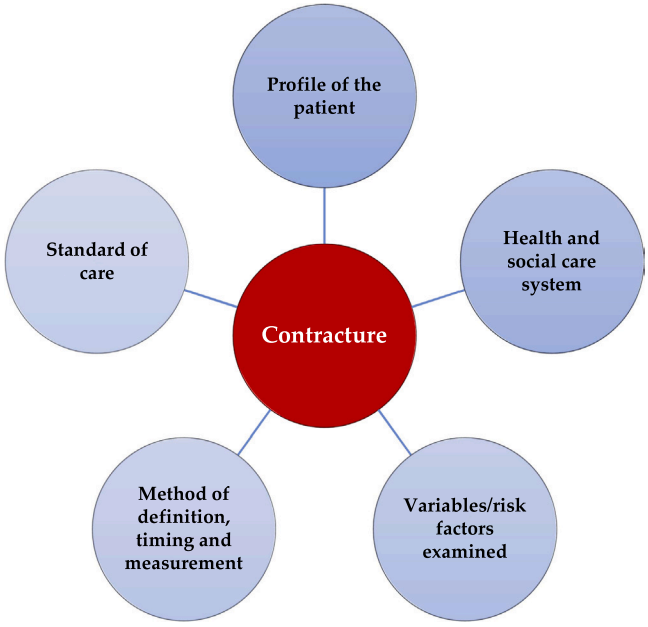

Fig. 2 – Key areas of variation in published papers on contracture formation.

prevalence and risk factors may not be accurately identified and are not comparable across studies.

All HIC papers published before July 2019 assessed contractures at individual joint level, but all LMIC factors considered risk factors at whole person level (i.e., whether the patient had any contracture or not). In some studies, the location of the contracture is not stated, particularly in LMIC papers. It is apparent that some anatomical locations may be at more risk of contracture than others; despite this studies do not seem to stratify the analyses of risk factors by joint location. Inclusion of patients with multiple joint involvement may confound analyses of risk factors further because of hierarchical errors.

Many unanswered questions remain, due to a lack of adequately controlled prospective studies and an absence of studies examining the relative potency of risk factors, how they interact, and which have the greatest impact on severity of contracture. Further work is indicated to differentiate between direct or proximal risks such as depth of wound and peripheral (indirect) risk factors such as income levels, particularly in LMICs.

5. Limitations

A limitation of this review was that studies were not included in the review if they only focussed on single non-major joints e.g. hands, perineum. It is possible that published studies of non-major joints could have yielded further information on potential risk factors for contractures in general. As publications in all languages were not included, potential sources from non-English speaking LMICs were not identified. Additionally, it is recognised that World Bank source country classifications could have changed between the date of publication and the time of this review, due to the long period covered; in fact only 2 publications from one country source changed categories during this period (Iran moved from classification as LMIC to UMIC in 2019).

Despite these limitations, this review includes a broader range and greater numbers of articles than any other investigation of risk factors for burn contracture to date and has produced a large number of factors for evaluation. Papers were critiqued in detail, but no formal quality assessment tools were used to determine the internal validity of the various types of studies and no inter-rater evaluation of identified risk factors was possible.

6. Conclusion

This literature review has consolidated and categorised currently cited contracture risk factors from all sources, differentiated between HIC and LMIC publications and demonstrated how little we actually know, especially about risk factors pertinent to low-income environments.

We found methodological inconsistencies in many studies (both from HICs and LMICs) including varying definitions of contracture and joints at risk, differing times and methods of measurement (of outcomes and of risk factors), mixed populations of participants, joints and burns, and non-standardised care, all of which make identifying genuine risk factors in HICs and LMICs very difficult.

Despite these issues it appears that some risk factors in LMICs may be different from, or of lesser importance than those which operate in HICs. As most of the literature on burn contractures is from HICs, existing knowledge may present only part of the overall framework of contracture risk.

In view of the limited evidence on risk factors, the global Burns community needs to reflect on the preventability of contractures. Prevention of burn contractures is likely to be environment-dependent; prevention strategies will likely have to differ in different situations, because the predominant risk factors are different. Without robust identification of local risk factors preventative efforts will be ineffective and inefficient.

Contractures cause huge misery, particularly in LMICs, and reduce both personal and national productivity; it is therefore imperative to identify the real risk factors for contractures so that effective policies for their mitigation and modification can be created. More research is urgently needed to improve methodology and fully understand the risk factors for burn contractures in LMIC settings.

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Declaration of Interest

There are no conflicts of interest for any of the authors.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.burns.2023.09.014.

REFERENCES

[1] Falder S. Burns care overseas—the forgotten health crisis. Br Med J Blogs 2014.
[2] Peck MD. Epidemiology of burns throughout the world. Part I: distribution and risk factors. Burns 2011;37(7):1087–100.
[3] Puri V, Shrotriya R, Bachhav M. The scourge of burn contractures: Who will bell the cat? Burns 2019;45(4):791–7.
[4] World Health Organisation. (2008). A WHO plan for burn prevention and care. ⟨https://apps.who.int/iris/handle/10665/97852⟩.
[5] Oosterwijk AM, Mouton LJ, Schouten H, Disseldorp LM, van der Schans CP, Nieuwenhuis MK. Prevalence of scar contractures after burn: a systematic review. Burns 2017;43(1):41–9. https://doi.org/10.1016/j.burns.2016.08.002
[6] Yelvington ML, Parry I. Integration of cutaneous functional units principles in burn rehabilitation: a diffusion of innovations assessment. J Burn Care Res 2023.
[7] Richard R, Santos-Lozada AR, Dewey WS, Chung KK. Profile of patients without burn scar contracture development. J Burn Care Res 2017;38(1):e62–9. https://doi.org/10.1097/bcr.0000000000000418
[8] Ahuja RB, Mulay AM, Ahuja A. Assessment of quality of life (QoL) of burn patients in India using BSHS-RBA scale. Burns 2016;42(3):639–47. https://doi.org/10.1016/j.burns.2015.11.011
[9] Cabulon EA, Cardoso JR, Maciel SM, Martins JT, Robazzi ML, Cardelli AA. Quality of life of individuals treated in an outpatient burn treatment centre: application of the BSHS-R. Burns 2015;41(3):528–35.
[10] Gauffin E, Öster C, Gerdin B, Ekselius L. Prevalence and prediction of prolonged pruritus after severe burns. J Burn Care Res 2015;36(3):405–13.
[11] Hendriks TCC, Botman M, Binnerts JJ, Mtui GS, Nuwass EQ, Niemeijer AS, et al. The development of burn scar contractures and impact on joint function, disability and quality of life in low- and middle-income countries: a prospective cohort study with one-year follow-up. Burns 2021.
[12] Iyer C, Soletti AB. Lived experiences of adult burn survivors with post-burn contractures. Soc Work Public Health 2022;37(3):209–23.
[13] Lawrence JW, Mason ST, Schomer K, Klein MB. Epidemiology and impact of scarring after burn injury: a systematic review of the literature. J Burn Care Res 2012;33(1):136–46.
[14] Saaiq M., Zaib S., Ahmad S. The menace of post-burn contractures: a developing country's perspective. Annals of burns and fire disasters. 2012;25(3):152–158.
[15] Serghiou MA, Niszczak J, Parry I, Li-Tsang CWP, Van den Kerckhove E, Smailes S, et al. One world one burn rehabilitation standard. Burns 2016;42(5):1047–58.
[16] Peck MD. Epidemiology of burns throughout the world. Part I: distribution and risk factors. Burns 2011;37(7):1087–100.
[17] Dobbs ER, Curreri PW. Burns - analysis of results of physical therapy in 681 patients. 242-& J Trauma 1972;12(3). https://doi.org/10.1097/00005373-197203000-00008
[18] Gangemi EN, Gregori D, Berchialla P, Zingarelli E, Cairo M, Bollero D, et al. Epidemiology and risk factors for pathologic scarring after burn wounds. Arch Facial Plast Surg 2008;10(2):93–102.
[19] Godleski M, Lee AF, Goverman J, Herndon DN, Suman OE, Kowalske KJ, et al. Quantifying contracture severity at hospital discharge in adults: a burn model system national database study. J Burn Care Res 2018;39(4):604–11.
[20] Oosterwijk AM, Disseldorp LM, van der Schans CP, Mouton LJ, Nieuwenhuis MK. Joint flexibility problems and the impact of its operationalisation. Burns 2019;45(8):1819–26.
[21] Schneider JC, Holavanahalli R, Heim P, Goldstein R, Kowalske K. Contractures in burn injury: defining the problem. J Burn Care Res 2006;27(4):508–14.
[22] Ibrahim A, Ijekeye F, Asuku M. Inventory of potential reconstructive needs in patients with post-burn contractures. Niger J Plast Surg 2014;10(2):1–5.
[23] Hudson DA, Renshaw A. An algorithm for the release of burn contractures of the extremities. Burns 2006;32(6):663–8.
[24] Goverman J, Mathews K, Goldstein R, Holavanahalli R, Kowalske K, Esselman P, et al. Adult contractures in burn injury: a burn model system national database study. J Burn Care Res 2017;38(1):e328–36.
[25] Shenderovich Y, Eisner M, Mikton C, Gardner F, Liu J, Murray J. Methods for conducting systematic reviews of risk factors in low- and middle-income countries. BMC Med Res Methodol 2016;16:32.
[26] Netherland ands for the World Bank. (July 20th, 2019). New country classifications by income level: 2019–2020. ⟨https://nl4worldbank.org/2019/07/19/new-country-classifications-by-income-level-2019–2020/⟩.
[27] Forjuoh SN, Guyer B, Ireys HT. Burn-related physical impairments and disabilities in Ghanaian children: prevalence and risk factors. Am J Public Health 1996;86(1):81–3.
[28] Fergusson D, Hutton B, Drodge A. The epidemiology of major joint contractures: a systematic review of the literature. Clin Orthop Relat Res 2007;456:22–9.
[29] Huang TT, Blackwell SJ, Lewis SR. 10 years of experience in managing patients with burn contractures of axilla, elbow, wrist, and knee joints. Plast Reconstr Surg 1978;61(1):70–6.
[30] Kidd LR, Nguyen DQ, Lyons SC, Dickson WA. Following up the follow up–long-term complications in paediatric burns. Burns 2013;39(1):55–60.
[31] Pegg SP, Gregory JJ, Hogan PG, Mottarelly IW, Walker LF. Epidemiological pattern of adult burn injuries. Burns 1979;5(4):326–34.
[32] Kowalske K, Holavanahalli R, Serghio M, Esselman P, Ware L, Delateur B, Helm P. Contractures following burn injury in children and adults - a multicenter report. J Burn Care Rehabil 2003;24:S85.
[33] Fatusi OA, Fatusi AO, Abanji JK, Alatise OI. Management outcome and associated factors in burn injuries with and without facial involvement in a Nigerian population. J Burn Care Res 2006;27(6):869–76.
[34] Richard RL, Jones BS, Dewey WR, Anyan IH, Faraklas RN. Published abstract proceedings of the American Burn Association 47th annual meeting. Small and large burns alike benefit from lengthier rehabilitation time. J Burn Care Res 2005;36(Suppl 1):S1–65.
[35] Richard R, Dewey S, Parry I, Jones J. Letter to the editor. Burns 2013;39(3):539–41.
[36] Goverman J, Mathews K, Goldstein R, Holavanahalli R, Kowalske K, Esselman P, et al. Pediatric contractures in burn injury: a burn model system national database study. J Burn Care Res 2017;38(1):e192–9.
[37] Kraemer MD, Jones T, Deitch EA. Burn contractures: incidence, predisposing factors, and results of surgical therapy. J Burn Care Rehabil 1988;9(3):261–5.
[38] Hop MJ, Langenberg LC, Hiddingh J, Stekelenburg CM, van der Wal MB, Hoogewerf CJ, et al. Reconstructive surgery after burns: a 10-year follow-up study. Burns 2014;40(8):1544–51.
[39] Schouten HJ, Nieuwenhuis MK, van Baar ME, van der Schans CP, Niemeijer AS, van Zuijlen PPM. The prevalence and

development of burn scar contractures: a prospective multicenter cohort study. Burns 2019;45(4):783–90.
[40] Agbenorku P. Burns functional disabilities among burn survivors: a study in Komfo Anokye Teaching Hospital, Ghana. Int J Burns Trauma 2013;3(2):78–86.
[41] Forjuoh SN, Guyer B, Ireys HT. Burn-related physical impairments and disabilities in Ghanaian children: prevalence and risk factors. Am J Public Health 1996;86(1):81–3.
[42] Richard R, Santos-Lozada AR, Dewey WS, Chung KK. Profile of patients without burn scar contracture development. J Burn Care Res 2017;38(1):e62–9.
[43] Aramani SC, Gouda HS, Gurudut KS, Yadwad BS. Correlation of pattern of burns with morbidity and mortality-one-year cross-sectional study. Med-Leg Update 2010;10(2):102–6.
[44] Muguti GI, Fleming AN. Contractures after burns: some observations from a 3-year review in Zimbabwe. J R Coll Surg Edinb 1992;37(3):187–90.
[45] Muguti G, Mhaka R. Some pitfalls in burns management: Illustrative case reports with a discussion on ways to improve the outcome of treatment. Cent Afr J Med 1994;40(6):158–60.
[46] Kim FS, Tran HH, Sinha I, Patel A, Nelson RA, Pandya AN, Keswani S, Watkins JF. Experience with corrective surgery for postburn contractures in Mumbai, India. J Burn Care Res. 2012;33(3):e120–6.
[47] Ringo Y, Chilonga K. Burns at KCMC: epidemiology, presentation, management and treatment outcome. Burns 2014;40(5):1024–9.
[48] Flores O, Tyack Z, Stockton K, Ware R, Paratz JD. Exercise training for improving outcomes post-burns: a systematic review and meta-analysis. Clin Rehabil 2018;32(6):734–46.
[49] Harvey, L.A., Katalinic, O.M., Herbert, R.D., Moseley, A.M., Lannin, N.A., & Schurr, K. Stretch for the treatment and prevention of contractures. 2017; Cochrane Database of Systematic Reviews(1).
[50] Zhang YT, Li-Tsang CWP, Au RKC. A Systematic Review on the Effect of Mechanical Stretch on Hypertrophic Scars after Burn Injuries. Hong Kong J Occup Ther 2017;29(1):1–9.
[51] Schouten HJ, Nieuwenhuis MK, van Zuijlen PP. A review on static splinting therapy to prevent burn scar contracture: do clinical and experimental data warrant its clinical application? Burns 2012;38(1):19–25.
[52] Parashar A, Atla K, Sharma RK. Static splinting in burns. Burns 2013;39(1):190–1.
[53] Bunchman IiHH, Huang TT, Larson DL, Lewis SR. Prevention and management of contractures in patients with burns of the neck. Am J Surg 1975;130(6):700–3.
[54] Kolmus AM, Holland AE, Byrne MJ, Cleland HJ. The effects of splinting on shoulder function in adult burns. Burns 2012;38(5):638–44.
[55] Richard R, Miller S, Staley M, Johnson RM. Multimodal versus progressive treatment techniques to correct burn scar contractures. J Burn Care Rehabil 2000;21(6):506–12.
[56] Celis MM, Suman OE, Huang TT, Yen P, Herndon DN. Effect of a supervised exercise and physiotherapy program on surgical interventions in children with thermal injury. J Burn Care Rehabil 2003;24(1):57–61. discussion 56.
[57] Okhovatian F, Zoubine N. A comparison between two burn rehabilitation protocols. Burn: J Int Soc Burn Inj 2007;33:429–34.
[58] Neugebauer CT, Serghiou M, Herndon DN, Suman OE. Effects of a 12-week rehabilitation program with music & exercise groups on range of motion in young children with severe burns. J Burn Care Res 2008;29(6):939–48.
[59] Paratz JD, Stockton K, Plaza A, Muller M, Boots RJ. Intensive exercise after thermal injury improves physical, functional, and psychological outcomes. J Trauma Acute Care Surg 2012;73(1):186–94.
[60] Karimi H, Mobayen M, Alijanpour A. Management of hypertrophic burn scar: a comparison between the efficacy of exercise-physiotherapy and pressure garment-silicone on hypertrophic scar. Asian J Sports Med 2013;4(1):70–5.
[61] Deng H, Chen J, Li F, Li-Tsang CWP, Liu Q, Ma X, et al. Effects of mobility training on severe burn patients in the BICU: a retrospective cohort study. Burns 2016;42(7):1404–12.
[62] Meng F, Zuo KJ, Amar-Zifkin A, Baird R, Cugno S, Poenaru D. Pediatric burn contractures in low- and lower middle-income countries: a systematic review of causes and factors affecting outcome. Burns 2020;46(5):993–1004.
[63] Tan JL, Chen J, Zhou JY, Song HP, Deng H, Ao M, et al. Joint contractures in severe burn patients with early rehabilitation intervention in one of the largest burn intensive care unit in China: a descriptive analysis. Burns Trauma 2019;7.
[64] Lensing J, Wibbenmeyer L, Liao J, Parry I, Kowalske K, Reg R, et al. Demographic and burn injury-specific variables associated with limited joint mobility at discharge in a multicenter study. J Burn Care Res 2020;41(2):363–70.
[65] Zhu Z, Kong W, Wang H, Xiao Y, Shi Y, Gan L, et al. Prevalence and predictors of scar contracture-associated re-hospitalisation among burn inpatients in China. Sci Rep 2021;11(1):14973.
[66] Yelvington M, Godleski M, Lee AF, Goverman J, Parry I, Herndon DN, et al. Contracture severity at hospital discharge in children: a burn model system database study. J Burn Care Res 2021;42(3):425–33.
[67] Schouten HJ, Nieuwenhuis MK, van Baar ME, van der Schans CP, Niemeijer AS, van Zuijlen PPM. The degree of joint range of motion limitations after burn injuries during recovery. Burns 2022;48(2):309–18.
[68] Botman M, Hendriks TCC, de Haas LEM, Mtui GS, Binnerts J, Nuwass EQ, et al. Access to burn care in low- and middle-income countries: an assessment of timeliness, surgical capacity, and affordability in a regional referral hospital in Tanzania. J Burn Care Res 2022;43(3):657–64.
[69] Commission on Social Determinants of Health. Closing the gap in a generation: health equity through action on the social determinants of health: final report of the commission on social determinants of health. World Health Organization; 2008.
[70] Richard RL, Jones BS, Dewey WR, Anyan IH, Faraklas RN. Published abstract proceedings of the American Burn Association 47th annual meeting. Small and large burns alike benefit from lengthier rehabilitation time. J Burn Care Res 2015;36(Suppl 1):S1–65.