BURNS 50 (2024) 454–465

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/burns

Risk factors for burn contractures: A cross-sectional study in a lower income country

RuthAnn Fanstone [a,*], *Patricia Price* [a], *Owen Bodger* [b], *Tom Potokar* [a], *Mohammad Rabiul Karim Khan* [c]

[a] *Centre for Global Burn Injury Policy and Research, Swansea University, UK*
[b] *Faculty of Medicine, Health and Life Sciences, Swansea University, UK*
[c] *Sheikh Hasina National Institute of Burn and Plastic Surgery, Bangladesh*

ARTICLE INFO

Article history:
Accepted 9 September 2023

Keywords:
Burn contractures
Risk factors
Cross-sectional study
Low middle-income countries,
Bangladesh

ABSTRACT

Risk factors for burn contractures require further study, especially in low and middle-income countries (LMICs); existing research has been predominantly conducted in high income countries (HICs). This study aimed to identify risk factors for burn contractures of major joints in a low-income setting. Potential risk factors (n = 104) for burn contracture were identified from the literature and a survey of clinicians with extensive experience in low and middle-income countries (LMIC). An observational cross-sectional study of adult burn survivors was undertaken in Bangladesh to evaluate as many of these risk factors as were feasible against contracture presence and severity. Forty-eight potential risk factors were examined in 48 adult patients with 126 major joints at risk (median 3 per participant) at a median of 2.5 years after burn injury. Contractures were present in 77% of participants and 52% of joints overall. Contracture severity was determined by measurement of loss of movement at all joints at risk. Person level risk factors were defined as those that were common to all joints at risk for the participant and only documented once, whilst joint level risk factors were documented for each of the participant's included joints at risk. Person level risk factors which were significantly correlated with loss of range of movement (ROM) included employment status, full thickness burns, refusal of skin graft, discharged against medical advice, low frequency of follow up and lack of awareness of contracture development. Significant joint level risk factors for loss of ROM included anatomical location, non-grafted burns, and lack of pressure therapy. This study has examined the largest number of potential contracture risk factors in an LMIC setting to date. A key finding was that risk factors for contracture in low-income settings may differ substantially from those seen in high income countries, which has implications for effective prevention strategies in these countries. Better whole person and joint outcome measures are required for accurate determination of risk factors for burn contracture. Recommendations for planning and reporting on future contracture risk factor studies are made.

© 2023 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

* Corresponding author.
E-mail address: rfanstone@hotmail.com (R. Fanstone).

https://doi.org/10.1016/j.burns.2023.09.003
0305-4179/© 2023 The Author(s). Published by Elsevier Ltd. This is an open access article under the CC BY license (http://creativecommons.org/licenses/by/4.0/).

1. Introduction

Burn injuries have been described as 'the forgotten global public health crisis' [1] and are a major public health problem [2]. The vast majority of burn injuries occur in low- and middle-income countries (LMICs) [3–5].

Burns to the dermis and wounds with longer healing times commonly result in scarring [6–8]. One of the most physically limiting consequences of scarring is a burn contracture. A burn contracture has been described as "an impairment caused by skin with pathological scar tissue of insufficient extensibility and length, resulting in a loss of motion, or tissue alignment of an associated joint or anatomical structure" [9, p. 544]. Burn contractures are known to radically reduce quality of life [10–17]. Reported contracture prevalence rates are high, ranging from 18% to 85% even in high income countries (HICs) [18–20]. There are few comparable data from LMICs, but the high incidence of burns and lack of specialist burn care is believed to contribute to even higher contracture rates in these settings [5,16]. Despite high prevalence rates, burn contractures are often stated to be preventable, either fully [5,21] or in part [22–24]. Without comprehensive identification of risk factors, it is not possible to determine the preventability of contractures within different settings or to develop appropriate effective prevention strategies to mitigate these risks.

Most published research on risk factors for burn contractures is from HICs and focuses largely on biomedical features such as burn depth, total burn surface area (TBSA%), skin grafting/TBSA grafted, and lack of therapy interventions such as pressure and splinting [18,23–26]. Research on contracture risk factors in LMICs is sparce [27]. Due to significant differences between HICs and LMICs in socioeconomic factors and healthcare access, it cannot be assumed that the key risk factors identified in HICs are the same as those in LMICs.

This study was conducted in Bangladesh, where the healthcare system is typical of that in many LMICs. Unless patients live in an urban setting or have the means to access private care, access to healthcare is through emergency care at the nearest Government clinic or District Hospital. For those of low socioeconomic status, especially in rural settings, even this level of care may not be accessible, and patients rely solely on local traditional healers or family care. Burn treatment received is not standardised in any of these settings and no formal specialist referral system exists. Many components of burn care which are considered standard in HICs, including multidisciplinary burn teams, intensive care, skin grafting, early and regular physiotherapy input and psychosocial support, are often not available in LMICs. Access to appropriate treatment, from acute burn through rehabilitation, is therefore limited and where it does exist, is determined by patients' awareness, social status and ability to pay, rather than their clinical needs. There is also a lack of planned follow-up, attendance being dependent on patients' will and resources. There is little electronic, reliable or comprehensive patient data available in these settings. All of these factors negatively impact accurate identification of burn contracture prevalence and the associated risk factors, which may not be the same as those seen in HICs. Consequently, effective contracture prevention strategies for LMICs may also need to differ from those employed in HICs.

The aim of this exploratory study was to examine a wide range of potential risk factors and their relationship to the presence and severity of major joint contractures in a non-acute adult population of burn survivors in a low-income setting.

2. Method

2.1. Study design

The study was conducted in Dhaka Medical College Hospital (DMCH) and the Sheikh Hasina National Institute for Burn and Plastic Surgery (SHNIBPS) in Dhaka Bangladesh, during a 4-week period in late 2019. These are the leading Government hospitals in Bangladesh for burn care and receive high volumes of in and outpatients from all over the country, at various stages post-burn. A cross-sectional observational design was used to collect data on exposures (risk factors for contracture formation) and outcomes (presence and severity of contractures at major joints at risk of contracture).

Participants were recruited from adult (≥18 years) burn survivors attending outpatient clinics at DMCH/SHNIBPS or who were admitted for surgical release of a contracture during the study period. Only patients with at least one major joint at risk of contracture were included. Although contractures can occur in many anatomical locations, including major and minor joints and some other body areas such as eyes, mouth, nose, breast and perineum, smaller joints are more complex to measure and some facial features are more difficult to quantify. Hands and feet have multiple small joints, each of which would require individual measurement and evaluation if included. As the time available with participants was limited, a pragmatic decision was made to include only major joints (neck, shoulder, elbow, wrist, hip, knee and ankle).

A 'joint at risk' was defined as any observable scarring which met or crossed a joint line, sufficient to put the joint at risk of contracture, as determined by the primary researcher (an experienced physiotherapist). Joints at risk which had been previously reconstructed or had any reduced range of movement (ROM) prior to burn injury were excluded. Patients with acute or unhealed burn wounds, electrical burns and participants and/or relatives who could not adequately provide a full history of the injury were also excluded.

One hundred and four risk factors were selected from those identified from a review of the literature (from both HIC and LMIC sources) [27] supplemented by factors which emerged from a survey of burn clinicians with experience in LMICs [28]. A semi-structured interview guide was created to extract information on these risk factors and was piloted at the study site, following which 48 risk factors were identified for examination in the final study. Risk factors were categorised by type and analysed at whole person level (where exposure to the risk factor is the same for every joint at risk within a participant e.g., age, inhalation injury) and at joint level (different joints may have different exposures to risk

Table 1 – Risk factors examined at whole person and joint level.

Type of risk factor	Whole person risk factors (Risk factor collected once per participant)	Joint risk factors (Risk factor collected for each of the participants included joints at risk)
Demographic and Socioeconomic	Age, gender, location of residence, distance and time (hours) to DMCH/SHNIBPS, education level, employment status, household income, literacy	
Other Patient factors	Co-morbidities, awareness of contracture development	
Burn factors	Time since burn, childhood burn, TBSA, burn depth, infection, first aid, inhalation injury, neuropathy, heterotrophic ossification, infection	Infection, wound healing time
Surgical/Medical Treatment factors	ITU, LOS in ITU, skin graft, type of skin graft, number of skin grafts, graft failure, time to first skin graft, refusal of skin graft, escharotomy, pain control, weight loss	Skin graft
Therapy treatment factors	Physiotherapy, time to first physio, no. of sessions, duration of session, splinted, scar massage, positioned, exercise	Positioning, splinting, pressure garments
Healthcare access	Untreated burn, level of healthcare for initial and definitive care, treatment received at first care, time to first medical care and to definitive care, LOS in hospital, discharge against medical advice, follow-up received, time to first follow-up, frequency of follow up, cost of care	

Key: TBSA (Total Burn Surface Area) ITU (Intensive Treatment Unit), LOS (length of stay)

factors within the participant e.g., whether the joint was grafted or splinted) (Table 1).

2.2. *Data collection*

Every eligible patient attending outpatient clinics or admitted during the study period was assessed and recruited for the study; only one eligible patient declined to participate. English to Bangla (and vice versa) interpretation was required throughout the study. Interpreters (doctors from DMCH Department of Physical Medicine which is not directly connected with the burn service) were given prior training on the study processes by the researcher. Participant information was given verbally, as this was preferred to written information by patients and local staff and was important for non-literate patients. A consent form, written in Bangla, was thoroughly explained by the interpreter, and signed or thumb printed by the participant. Consent included permission for audio recording of the interview, photographs, and measurements of all joints at risk. Interviews and measurement of joints at risk were conducted in a private room in the ward or outpatient department of SHNIBPS, or by the bedspace of an inpatient in DMCH. Relatives who had been present at the time of injury or through the recovery were included. Data available by interview were verified with medical records and clinical assessment whenever possible.

All joints at risk were measured in degrees by the primary researcher (RF) using an 8-inch goniometer. The Norkin and White protocol for goniometry placement and limb positioning was used [29]. Three active movements, followed by 3 passive movements were performed at each joint at risk and all 6 ROM measurements were documented for each joint at risk. Measurements were taken in two planes of movement for all included joints except the neck, in which only flexion/extension was measured. The planes of movement measured were: neck (extension), shoulder (flexion and abduction), elbow, wrist and knee (flexion and extension), hip (extension and abduction) and ankle (dorsiflexion and plantarflexion).

Data collected from the interviews, medical notes and clinical assessment were predominately quantitative (binary, categorical and continuous data) and were later entered into a data collection form which was purpose-built using Open Data Kit (ODK) https://opendatakit.org to host the questionnaire and risk factor data. All data were kept securely, and patient information was anonymised.

2.2.1. *Outcome measures*

A clear definition and quantification of severity of contracture was required to examine the effect of risk factor exposure and was developed through a review of the literature [27], a survey of clinicians [28] and evaluation in the pilot study.

Joint measurements were used to determine contracture presence and calculate contracture severity outcomes. If the mean ROM of the three passive movements for any plane of movement was less than the reference normal ROM [30], the joint was defined as contracted. For contracture severity, a categorical measure, based on the Schneider method [24] and described as the Burn Contracture Severity Classification (BCSC) and a continuous measure based on the Godleski method [26] (described as Loss of Movement Score (LMS) were used (Table 2).

These joint level measures were then further adapted to enable analysis at whole person level (a measure of contracture severity across all joints at risk of a participant) as well as at individual joint level (Table 3).

2.3. *Statistical analyses*

Analyses were performed at both patient and joint level. Summary information of categorical data was presented as frequency counts and percentages. Continuous data was

Table 2 – Definition of outcomes: BCSC and LMS.

Contracture outcome measure	Description
Burn Contracture Severity Classification (BCSC)	The plane of movement at the included joint with the greatest loss was taken to represent the severity of contracture at that joint [24] Contractures were classified as none (no loss), mild (up to 1/3 loss), moderate (from 1/3–2/3 loss) and severe (> 2/3 loss) [24]
Loss of Movement Score (LMS)	The actual loss of ROM in degrees was expressed as a proportion of expected full ROM (FROM) [26] The mean loss of ROM in the two planes of movement measured at each joint (other than one plane for the neck) was taken to represent the average loss of ROM at that joint.

reported as either mean and standard deviation or median and interquartile range, as appropriate.

Due to the small sample size and the distribution of the primary outcome variables, the majority of the methods used were non-parametric. Specifically, we used the Chi-Square Test of Association where the dependent variable was categorical and Mann-Whitney Test, or Kruskal-Wallis where it was continuous. Spearman's Correlation or Pearson's were used for continuous risk factors such as age and for the continuous contracture outcome (LMS). One Way Anova and t-Tests were used in specific situations.

Data were analysed using SPSS Version 26 and assumed a 5% level of significance. All p values are reported to 2 decimal points.

2.4. *Ethical approval*

Ethical approval for both the pilot and main studies was granted by Swansea University (230719b) and by the Ethical Committee of DMCH/SHNIBPS.

3. Results

Forty-eight participants with 126 major joints at risk were included in the study; the median number of joints at risk per participant was 3. Overall, 37/48 participants had contractures of at least one major joint at risk; 23% of participants did not develop a contracture at any included joint at risk. At whole person level (using the BCSC*p* classification) 11 participants had no contracture of any joint at risk; in 10 their worst contracture (BCSCp) was mild, in 15 moderate and in 12 severe. Mean LMS*p* across all participants was 24% (0–93.75%).

3.1. *Demographic and socioeconomic factors*

The mean age of participants was 26 years (18–53 years); 23 females and 25 males. The median age at burn was 21 years (range 1–49 years) and median time since burn was 2.5 years (range 7 months – 37.5 years). Participants represented every District in Bangladesh (Fig. 1); 17/48 were from rural areas. Average travel time to DMCH/SHNIBPS for participants was 4 h (single journey).

Thirty-eight participants were literate with the most common level of education achieved being secondary school (18/48). The majority of participants were unemployed (26/48). The mean monthly household (HH) income (cumulative income of all earners within the participants household) was 13, 466 Bangladeshi Taka (BDT)/equivalent £119/month (National average HH income 22,574 BDT/equivalent £175/month) [31].

All the demographic and socioeconomic factors examined were analysed for any association with whole person contracture outcomes. Neither gender nor age at burn had any direct relationship with contracture outcome, but participants with mild contractures were significantly older at the time of burn ($p = 0.01$). There was no relationship between severity of contracture and the time since injury. No other demographic factors showed any significant association with contracture outcomes.

In terms of socioeconomic factors, employment status was a statistically significant risk factor for both BCSCp and LMSp; participants who were employed had one third fewer contractures overall than those who were unemployed and were three times more likely to have no contracture at all ($p = 0.04$ for BCSCp, $p = 0.01$ for LMSp). Participants employed in non-manual work had fewer contractures overall (60% vs 76.5%) and no severe contractures compared with 12% in manual workers and 38.5% in those who were unemployed ($p = 0.03$). Movement loss was also lowest in non-manual workers (median LMSp 6.85% loss) compared to participants who were in manual work (median LMSp 16.36% loss) or unemployed (median LMSp 34.13% loss) ($p = 0.02$).

3.2. *Joints affected*

Of the 126 joints at risk, almost 85% ($n = 107$) of were in the upper body. The low number of lower body joints at risk

Table 3 – Definition of outcomes: BCSCp/j, LMSp/j.

Outcome	Person (p)	Joint (j)
BCSC	**BCSCp:** Each participant categorised by their worst contracture	**BCSCj:** BCSC category for an individual joint
LMS	**LMSp:** Total of proportional losses of ROM at all joints at risk divided by number of joints at risk	**LMSj:** Degrees of movement loss expressed as a proportion of FROM for each individual joint

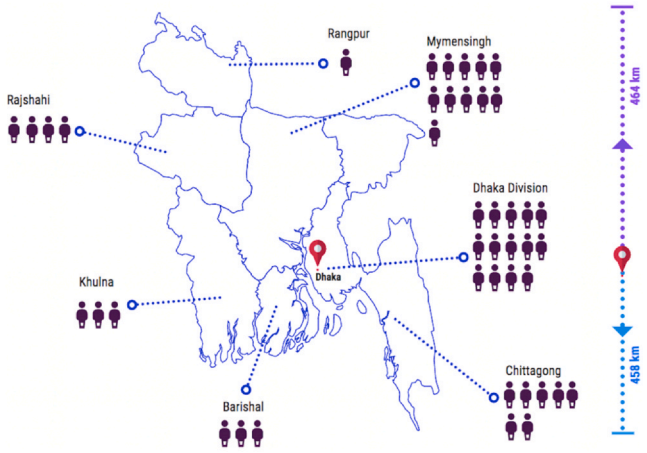

Fig. 1 – : Map of the Regions in Bangladesh showing origin of participants.

means that robust comparisons between lower limb joints was not possible but all upper body joints were well represented in the study population; the most common joint at risk was the wrist (n = 33) (Table 4).

The observed contracture rate was very similar between upper (52%) and lower body (51%), although the neck and shoulder had much higher rates than the other joints (83% and 80% respectively). By comparison, elbow, wrist and knee reported the lowest contracture rates with only around a third affected.

The elbow, wrist and knee had higher proportions of joints which did not contract, as reflected by both BCSCj and mean LMSj. The ankle had the highest proportion of severe contractures for any joint by BCSCj and demonstrated the highest joint LMSj. The neck and shoulder had the highest movement loss determined by LMSj and the greatest proportion of severe or moderate contractures by BCSCj. The elbow and knee consistently demonstrated least severe losses of movement; all knee contractures were mild (Table 4).

Statistical analyses showed that anatomical location of the joints at risk had a significant impact on contracture presence as assessed by BCSCj; the neck and shoulder were more likely to contract than other joints and wrists were less likely to contract ($p < 0.01$).

3.3. *Burn injury factors*

Flame burns were the most frequent aetiology (36/48, 75%); other causes were scalds (n = 7), contact burns (n-4) and chemical burns (n = 1). Average TBSA was 25% (6–60%); participants with mild contractures had the highest median TBSA (31.50%), the median TBSA for participants categorised as no or moderate contractures was 25% and for the severe group 16.59%. Data were limited for depth of burn, but 13/20 had a full thickness injury.

Eleven participants had an inhalation injury. Only 4 participants had any co-morbidities. The frequency of infection of the acute burn was difficult to discern due to a lack of microbiological reports, but 13 participants reported having had an infection; overall, 38/94 (40%) burn wounds over joints had been infected. The available medical notes did not document wound healing times; 27 participants reported healing times between 4 and 52 weeks, with an average reported healing time of 16 weeks.

Of the ten potential burn/non-burn injury factors examined (cause, TBSA, depth, inhalation injury, co-morbidities, healing time, infection, amputation, neuropathy, heterotopic ossification) only burn depth was statistically significantly related to contracture outcome. Participants with full thickness burns had significantly more severe

Table 4 – Joints at risk, category of contracture severity (BCSCj) and mean loss of movement (LMSj%) at each joint location.

Joint (N)	None (%)	Mild (%)	Moderate (%)	Severe (%)	Mean LMSj %	Contracture Rate (%)
Upper Body						
Neck (18)	3 (17%)	5 (28%)	8 (44%)	2 (11%)	36	83%
Shoulder (30)	6 (20%)	6 (20%)	12 (40%)	6 (20%)	35	80%
Elbow (26)	18 (69%)	5 (19%)	1 (4%)	2 (8%)	12	31%
Wrist (33)	24 (73%)	5 (15%)	2 (6%)	2 (6%)	11	27%
SUBTOTAL (107)	**51 (48%)**	**21 (20%)**	**23 (21%)**	**12 (11%)**	**22**	**52%**
Lower Body						
Hip (2)	1 (50%)	0	0	1 (50%)	50	50%
Knee (11)	8 (73%)	3 (27%)	0	0	9	27%
Ankle (6)	2 (33%)	1 (17%)	0	3 (50%)	50	67%
SUBTOTAL (19)	**11 (58%)**	**4 (21%)**	**0**	**4 (21%)**	**26**	**42%**
TOTAL (126)	**62 (49%)**	**25 (20%)**	**23 (18%)**	**16 (13%)**	**23**	**51%**

contractures as assessed by BCSCp than other burn depths (p = 0.02).

Additionally, wound healing times (median time to heal 19 weeks) and infection (40% of joints were infected) were analysed at joint level; these risk factors did not have a statistically significant effect on contracture incidence or severity.

3.4. *Treatment risk factors*

Thirty-five participants had received some first aid care for their burn, but in only 22 was the care deemed appropriate by current standards. Inappropriate first aid given included application of egg, leaves, ayurvedic ointments and toothpaste. Of the 41 participants who received any subsequent medical care for their acute burn, only 3 had an escharotomy.

Thirteen participants were admitted to an ICU (Intensive Care Unit) for between 4 and 90 days (median length of stay (LOS) 30 days). Participants who had an ICU stay had less movement loss than those who did not (median 14% compared to 30% LSMp), however, this difference was not statistically significant.

Twenty participants had at least one skin graft. Fifty of the 126 joints at risk were grafted. Median time to graft was 7 weeks (range 1.5–52 weeks). Within the Government healthcare system in Bangladesh, all participants who were grafted had attended DMCH/SHNIBPS. Of the 26 participants offered a skin graft, 6 refused the procedure. At person level, there was no statistically significant difference in outcome between participants who had/had not had skin grafting but skin graft refusal resulted in greater loss of ROM overall (LMSp, $p < 0.01$).

Participants had also received positioning and exercise advice from non-physiotherapists, usually from medical staff. Medical staff prescribed all pressure garments and splints which were supplied by technicians (non-therapists). Overall, 27 participants received advice about exercise, 19 on positioning, 22 were advised on scar massage and 17 participants received pressure garments for 46 joints.

At whole person level, only pressure therapy was statistically significantly associated with a better outcome; participants who received a pressure garment had a lower loss of movement (LMSp) (14% compared to 32%) than those who did not ($p < 0.01$). At joint level, grafting, positioning, splinting, and pressure therapy were examined; 21/126 joints (in 14 participants) were splinted, and 28/115 joints were positioned. Only grafting and pressure therapy were significantly associated with better outcomes. Grafting did not affect the incidence of contracture, but severe contractures developed in only 3/26 grafted joints compared to 12/37 non-grafted joints (BCSCj, p = 0.03). Pressure therapy reduced the likelihood of a joint contracture ($p < 0.01$); 33% of joints receiving pressure developed a contracture compared to 61% of joints which did not receive pressure (relative risk of contracture without pressure = 1.84). An attempt was made to determine the effectiveness of the pressure treatment given, based on the time of its initiation, duration of therapy, review and/or adjustment of garments and participant tolerance; on this basis, in only 6/47 joints receiving pressure was the treatment deemed to have been effective.

Occupational therapy was not available to any participants, and only 19/48 were seen by a physiotherapist, 32% of whom were seen only once. Average time from admission to first treatment by a physiotherapist was 49 days (2–195 days). Only one participant had seen a professional counsellor at any time.

3.5. *Healthcare access factors*

Most participants (37/48) received their care in the Bangladesh Government healthcare system; 2 who were working in the Middle East at the time of injury were treated there and 2 participants were treated privately in Bangladesh. Seven participants had received no medical treatment for their acute burn; of those who did attend for care, all but one presented within the first 24 h of injury.

The most frequently accessed first healthcare contact was a District Hospital (12/48). For 18 participants, the first stop was also the location of their definitive care. A minority of participants (11/48) received specialist burn care throughout their acute stay; only 8 participants had all their acute care treatment at DMCH/SHNIBPS. Median length of hospital stay was 7.5 weeks (1–25 weeks). Eleven of 42 participants who were admitted to hospital self-discharged without medical consent.

Only 26 participants (42%) had any follow-up after discharge. Mean time from discharge to first follow up was 2 weeks (range 7–84 days) and the median number of follow up visits was 5 (1–120 visits).

Participants who self-discharged against medical advice had statistically significant more severe contractures and more movement loss than participants admitted who did not self-discharge; BCSCp, ($p = < 0.01$) and LMSp ($p < 0.01$). Low frequency of follow-up was the other statistically significant healthcare access risk factor associated with poorer outcomes for both BCSCp and LMSp ($p < 0.04$ and $p < 0.01$ respectively), (Table 5).

3.6. *Participant awareness*

Overall, participants showed a very low level of awareness about the potential contracture consequences of their burns, whether because of lack of information or inability to retain or understand the information. Only 12 (25%) participants had heard the equivalent word for 'contracture' at any time during their care. At the time of acute burn care, 20/48 participants had not known that a burn could result in a contracture. Participant awareness of the possibility of contracture was associated with less loss of movement overall (LMSp, $p < 0.03$) but did not affect contracture presence or severity as assessed by BCSCp, (Table 5).

3.7. *Summary of statistically significant contracture risk factors*

Of the 48 risk factors examined in this study, only 10 resulted in statistically significant associations with any contracture outcomes.

At whole person level, 8 risk factors were significantly linked to contracture severity as assessed by at least one

Table 5 – Statistically significant risk and protective person factors for burn contracture.

Risk Factor	BCSCp	LMSp
Person factors		
Older age at time of burn (protective factor)	0.01	NS*
Unemployment	0.04	0.01
Non manual labour (protective factor)	0.03	0.02
Full thickness burn	0.02	NS
Refusal of skin graft	NS	< 0.01
Discharged against medical advice	< 0.01	< 0.01
Low frequency of follow up	0.04	0.01
Issued a pressure garment(s)	NS	0.01
Participant awareness of risk of burn contracture formation	NS	0.03
Joint factors	**BCSCj**	**LMSj**
Joint location (neck and shoulder at greatest risk, wrist at least risk)	< 0.01	NS
Skin grafting	0.03	NS
Pressure therapy	< 0.01	NS

* NS = not statistically significant

outcome measure (either BCSCp or LMSp). Only three risk factors (employment, discharge against medical advice and low frequency of follow-up) were statistically significant for both outcome measures at whole person level.

At joint level, three risk factors were statistically significant, all for the BCSCj outcome: grafting decreased the severity of contracture ($p < 0.03$) and pressure garment therapy reduced the likelihood of a joint contracture ($p < 0.01$). Some joint locations (neck and shoulder) were more likely to contract, and wrists were less likely to contract ($p < 0.01$).

A summary of the statistically significant risk and protective factors identified is shown in Table 5.

4. Discussion

This study explores a greater number and range of risk factors than previous LMIC papers, drawn from a comprehensive list of potential risk factors collated from both HIC and LMIC settings [27,28]. This is also the first LMIC study to examine risk factors at both joint and person levels with clear definitions for joints at risk and for contracture presence and severity. As far as can be ascertained, this is also the first study in which a risk-adjusted mean loss of joint movement score (LMSp) has been created to provide a continuous whole-person variable, incorporating ROM losses at all affected joints, against which whole person risk factors can be evaluated.

4.1. *Risk factors*

Fig. 2 provides a summary of the statistically significant risk factors for contracture which have been reported previously from HIC and LMIC settings [27] and those identified in this study. Only age, burn depth and location are reported from all three sources to be significant risk factors.

4.2. *Person factors*

Person factors include risks which affect all joints at risk in an individual, including demographic and socioeconomic factors as well as comorbidities and patients' understanding of their injury and possible outcomes.

The finding that participants who were older at the time of burn had statistically more mild contractures than those in other severity categories is consistent with the literature. Age at burn is a commonly cited statistically significant factor;

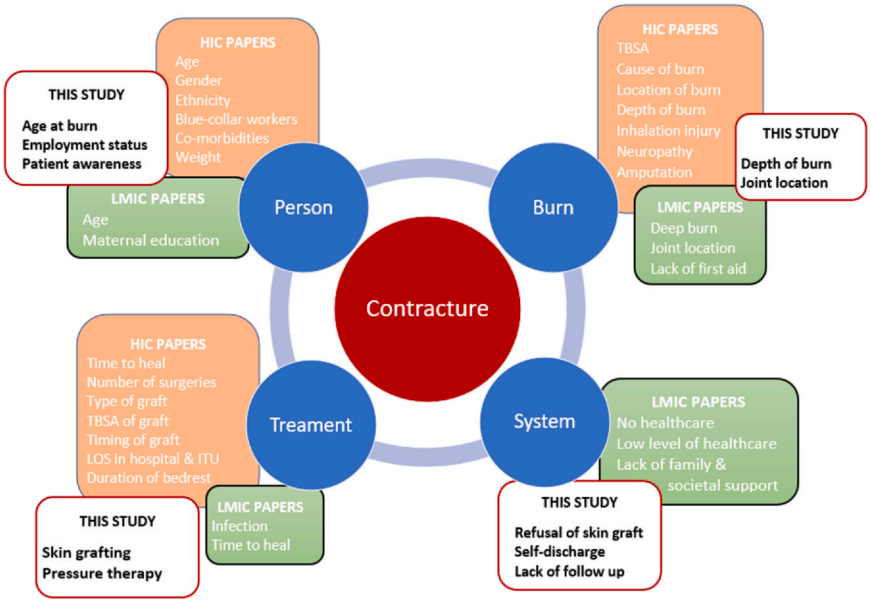

Fig. 2 – : Statistically significant risk factors for contracture which have been identified in HIC and LMIC studies.

the risk was predominantly highest for younger ages [25,32–35], although older age has also been reported [30,36].

Employment was the only socioeconomic risk factor which was statistically significantly associated with severity of contracture. Zhu et al. [37] found that blue-collar (manual) workers had a higher risk of readmission for contracture after burns. Employment status has not been reported as a risk factor for burn contracture in any HIC studies. We also cannot determine whether employment status is a cause or effect of contracture, since contracture may limit the ability to return to work [38,39]. Employment status may also be an indicator of socioeconomic status and household income, which in turn may affect access to healthcare, especially in LMICs.

Participant awareness of the possiblility of contracture formation has not been investigated previously as a risk factor; we found patient awareness of contracture risk to be an protective factor. It may be that this knowledge heightened participants desire to do everything to avoid contracture, including adhering to recommended treatments, exercises, and follow-up. This underlines the importance of increasing awareness of burn sequelae in all stakeholders, especially patients, their families and hospital staff [5].

4.3. *Burn factors*

Higher TBSA is the most frequently reported statistically significant risk factor for burn contractures in HIC publications [24–26,30,33,34,40,41]. In this study, there was no statistically significant relationship between TBSA and contracture, but a trend was observed for participants with *lower* TBSA to have more severe contractures and greater movement loss. This is contrary to what might be expected, perhaps due to lack of acute burn documentation and the retrospective estimation of TBSA. It is also important to recognise that LMIC patients with large TBSA (certainly those >40%) are much less likely to survive than in HIC populations, and therefore fewer will present with contractures. It is also possible that in LMICs, those with smaller TBSA may think the burn is less serious and because of the direct and indirect expenses of seeking care, choose not to access specialist care, resulting in subsequent severe contractures.

In our study, only the depth of burn had a statistically significant impact on contracture severity at whole person level. Although this observation was expected, it needs to be treated with caution because documentary evidence of burn depth was not consistently available from the medical notes.

The anatomical location of a burned joint influences the risk of contracture [25,32–35,40–42], as was confirmed in our study. The potentially confounding effect of joint location on contracture outcome has not been recognised in previous studies of contracture risk factors and requires analyses of risk factors at individual anatomical joints; unfortunately, small numbers in the present study precluded such detailed analysis.

4.4. *Treatment factors*

In HIC studies, burn and treatment risk factors predominate and are the focus of clinical efforts to reduce or prevent contractures [27]. The common burn and treatment risk factors were examined in this study (Table 1), but only a few were statistically significantly related to contracture outcome. There was very little difference in contracture severity at person level between those who had skin grafts and those who did not, which was unexpected. At joint level (perhaps a more appropriate unit of analysis for examining grafting as a risk factor), grafting did statistically significantly reduce the severity of contracture. Although commonly reported as a risk factor in HICs [24,25,30,34,41,43], skin grafting is likely only an indicator of severe injury. In contrast, LMIC literature often reports *lack* of skin grafting to be a risk factor for burn contractures, resulting from the low availability of grafting in low-resource environments [44] and the consequent delayed wound healing and increased scar formation. In our study, the beneficial effect of skin grafting at joint level may also be an indicator of overall specialist care rather than solely a direct result of grafting.

Refusal of skin graft was a significant risk for contracture in our study, which has not been previously reported; obviously, refusal of a graft represents incomplete treatment and indicates the presence of deep burns. Participants who refused grafts cited costs, fear and the need to care for young children at home as reasons. In HIC healthcare settings, such concerns would likely have been countered through professional counselling and support.

Physiotherapy is normally considered essential for contracture prevention [5,9,13,16,17,19,20,23,30,36,45] but was not related to outcome in our study, perhaps because it was instituted very late, if at all. Pressure therapy was the only rehabilitative input which had a statistically significant impact on contracture frequency, and resulted in reduced overall movement loss at person level (LMSp). Since pressure garments are expensive, require follow-up and are only provided from specialist centres, receipt of pressure therapy implies a likelihood of additional beneficial factors such as higher socioeconomic status, ability to return for review and overall specialist care. The fact that the majority of pressure garments dispensed in this study were deemed to have been ineffective supports the hypothesis that any positive effects observed could be a result of the combined effects of specialist care and other advantageous participant factors.

Several previously reported treatment risk factors were not found to be significant in our study. In HIC papers, ICU admission is reported to be a significant risk for burn contractures [30], presumably due to prolonged immobility and severity of injury. In many LMICs availability of ICU is limited and patients requiring ICU often do not survive. In our study, participants treated within the Government healthcare system only received ICU if they were treated at DMCH/SHNIBPS, indicating that they also received specialist acute burn care, which perhaps explains why ICU admission appeared to be a protective factor for contracture.

4.5. *System factors*

Without exception, 'health system' factors are highlighted as risks for contracture only by LMIC authors and are not considered in HIC literature, perhaps because appropriate and timely healthcare access is expected in HICs. Discharge

against medical advice was a significant contracture risk in our study; it implies incomplete treatment and could be considered a treatment factor. However, in a health system where the costs incurred by patients are related to LOS and must be augmented by out-of-pocket fees [46], early discharge against medical advice is often due to inability to pay, rather than any opposition to the suggested care. All participants who self-discharged against medical advice reported lack of funds as their main reason.

In our study, another significant health system risk factor for increased contracture severity was a low number of follow-up visits; this has not previously been reported as a statistically significant risk factor. In HIC settings, follow-up is normally available and planned for as long as required and may have a protective effect on contracture severity through the advice and treatment delivered at consultations. In many LMICs, including Bangladesh, follow-up visits are entirely initiated by patients; with all the attendant costs involved, follow-up may not be possible for many. In HICs, some loss of patient follow-up is also expected [47–49], but the numbers 'lost to follow-up' are much lower in health systems where follow-up is actively offered, missing patients are recalled, and cost and other barriers to attendance may be less of an issue.

4.6. *Connected and modifiable risk factors*

The information gained through exploration of potential risk factors in this study population highlights the different standards of care available to our study population compared with HIC norms. Examples include the low numbers of participants who had access to skin grafting or physiotherapy despite having at least one joint at risk of contracture; other LMIC studies report similar observations [5,16,50]. According to HIC standards, physiotherapy should be initiated on the first day of admission [45] and would be available to all patients. Such differences in standards of care mean that the risk factors for contracture currently dominating burns populations in LMICs are likely to be very different from those identified in HICs and should be investigated separately.

It is evident that risk factors for contractures in LMICs, are multiple, inter-connected, and heavily influenced by the social determinants of health [51]. Individual stories from our study participants exemplified such interplay between factors; lack of skin grafting was determined to varying degrees by participant reluctance and/or low socioeconomic status rather than by the availability of grafting. Even with early skin grafting, some outcomes were poor due to other factors such as inadequate pain control inhibiting movement, needs of other family members, early discharge against medical advice, lack of further surgery due to limited funds, and lack of physiotherapy. The interplay between different risk factors and their relative impacts on outcomes are not yet well understood and require further investigation.

Forjuoh et al. [32] introduced the concept of '*manipulatable*' or modifiable risk factors for burn contracture. Of the ten statistically significant risk factors identified in this study, only two are not potentially modifiable, namely depth and location of burn. Arguably, with improved primary burn prevention and first aid, even these two factors could be modified.

4.7. *Outcome measures*

Identification of joints at risk is a key component of reporting outcomes. Unlike many published studies, we have defined our criteria for a joint at risk, but the definition used was still subjective. Different definitions of joints at risk can over or under-report contracture prevalence and have a considerable impact on the findings of risk factor studies. Other definitions of a joint at risk are available [23,41,52] and the concept of cutaneous functional units (CFUs) [53–55] may offer an important contribution to understanding what puts a joint at risk. It is critical that all future risk factor studies clearly define the methods used to identify a joint at risk (Table 6).

Appropriate selection of outcome measures is also critical in risk factor studies; simply using "contracture" as an outcome without specifying any definition or severity will considerably affect findings. Determination of contracture severity also requires an appropriate reference ROM for the population being studied [56,57] The reference range of 'normal' ROM presented in the burn literature, is derived from predominantly Caucasian and western populations and may be inappropriate for LMIC studies. Furthermore, the widely utilised Schneider contracture

Table 6 – Recommendations for planning and reporting on contracture risk factor studies.

Risk Factor Data	Outcome Data
Outline the environment in which the study takes place and the standard care provided	State locations of joints included in the study, where possible evaluate different anatomical joints separately
State rationale for selection of the variables/risk factors being examined	Exclude previously reconstructed joints or present data separately
Provide definitions of risk factors and details of operationalisation	Provide definition used to determine a joint at risk
Describe characteristics of study population	Provide definition of contracture
Document time(s) when potential risk factors occurred (e.g., skin grafting, physiotherapy) and if possible other indicators of treatment effectiveness	Document time(s) at which contracture outcomes are measured
Provide sufficient information on methods of data analysis	Provide method of assessment of contracture presence and severity
Report whether the risk factor is explored at joint or/and person level	Provide contracture measurement protocols (including movements, number of measurements, whether active or passive and normal reference ranges used)
	Provide the unit(s) of analysis (i.e., person and/or joint)

categorisation [24,30,43,58] on which BCSC*p/j* is based, requires a difference of just one degree of movement between cut-off levels for each category, which could easily be a measurement error. Such mis-categorisations may over- or underestimate contracture severity and alter the results of risk factor analyses. While our whole person outcomes (BCSCp and LMSp) are still imperfect measures, LMSp does allow for the fact that all joints at risk are exposed to the same whole person risk factors.

Although goniometry has been the most established and commonly accepted objective measure of contracture within clinical practice [55], there have been recent calls to move away from goniometry in its current form. Parry et al. (2019) propose a cutaneokinematic rather than an arthrokinematic approach to measurement of movement loss in burns patients. This approach to measurement should be considered for future studies, but will likely be more challenging to implement in low-income settings.

Even more important for future risk factor studies is the evident difference in contracture risk between different anatomical joints, the implications of which do not appear to have been incorporated in the design or analyses of previous studies. The effect of joint location and type on contracture risk - and thus on other potential risk factors for contracture - should be controlled for in future studies by analysing different anatomical joints separately.

4.8. *Future directions*

Ideally, risk factors for contracture should be identified from prospective long-term follow-up studies of acute burn patients, from whom comprehensive data on all potential risk factors are collected, documented, and analysed at defined points during the natural history of contracture development, using standardised methods for contracture measurement. However, such long-term projects require considerable personnel, time and funding resources, which are rarely available in low-income settings.

In future studies the inclusion of the following data in the planning and reporting of contracture risk factors is recommended (Table 6).

5. Limitations

The fieldwork underpinning this research was conducted under challenging conditions, including incomplete medical documentation, the need for interpreters, reliance on participant recall and the absence of any formal follow-up system.

While every effort was made to recruit participants, the lack of formal follow up systems meant that attendance was dependent on the patients' will and resources. A consequence of this self-selection in sampling was that the extent to which the findings of this study can be extrapolated to the wider population is not clear and it is not possible to estimate any meaningful denominators (e.g., total numbers of participants with at-risk joints without contractures).

Despite the diverse range of risk factors considered, many other potentially relevant factors could not be investigated, such as pain control. Some key groups (paediatric participants and electrical burns) with potentially different risk profiles were excluded. Only major joints and limited planes of movement were included, and it was not possible to standardise the time of joint measurement post-burn.

Our selection of goniometry as the tool for joint measurement was based on its widespread acceptance, ease of execution and simplicity, but the potential for mis-classification of contractures due to small measurement errors is acknowledged as a potential limitation.

While all these factors are limitations, they are common feature of LMIC clinical studies. Future successful research design and implementation in LMIC settings will therefore require the involvement of, and ideally leadership by, local researchers and clinicians.

6. Conclusion

The aim of this study was to identify risk factors for contracture in the low income setting of Bangladesh. Previously reported contracture risk factors have been collated and explored in a limited at-risk population. The findings have clarified that current knowledge of contracture risk factors in LMICs is poor, but they serve as a foundation for future work. It is clear that the dominant risk factors for contracture in LMICs are likely to differ from those recognised in HICs and should be separately investigated. Indeed, the social determinants of health [51] may currently be more immediately powerful risk factors for contractures in LMIC settings than the burn or treatment factors commonly emphasised in HICs.

While HIC researchers may justifiably focus on biomedical and treatment factors affecting their own burn populations, the wider burns community could support LMIC researchers and authors in identifying the contracture risk factors most relevant in their environments and determining how to resolve or mitigate these risks.

Research into contracture risk factors in both high and low income settings also faces serious problems arising from inconsistencies in sampling and measurement. Variations in defining joints at risk and methods of contracture quantification may underlie the large variation in reported contracture prevalence. Variation of contracture risk at different anatomical joints should be investigated further and an agreed, standardised, simple, objective, and reproducible method of defining contracture presence and severity, including time points for measurement, is urgently required. Consensus is needed on what constitutes a joint at risk, taking account of the factors that affect the level of risk at different joints.

While there remains urgent work to do to fully understand the risk factors for burn contracture in LMIC settings, the majority appear to be modifiable, offering the opportunity to reduce human suffering and increase function and productivity for those affected.

Funding

This research was funded by the National Institute for Health and care Research (NIHR) (project reference:16.137.110) using Uinted Kingdom aid from the UK Government to support global health research. The views expressed in this publication are those of the author(s) and not necessarily those of the NIHR or the UK government.

Declaration of Competing Interest

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

Acknowledgements

This study would not have been possible without the help of the management and staff at DMCH/SNHIBPS, the interpreters and particularly the patients and their relatives who participated.

REFERENCES

[1] Falder, S. Burns care overseas—the forgotten health crisis: British Medical Journal Blogs; 2014.
[2] World Health Organisation. (2008). A WHO plan for burn prevention and care. ⟨https://apps.who.int/iris/handle/10665/97852⟩.
[3] Peck MD. Epidemiology of burns throughout the world. Part I: distribution and risk factors. Burns 2011;37(7):1087–100.
[4] Potokar T, Bendell R, Chamania S, Falder S, Nnabuko R, Price PE. A comprehensive, integrated approach to quality improvement and capacity building in burn care and prevention in low and middle-income countries: an overview. Burns 2020;46(8):1756–67.
[5] Puri V, Shrotriya R, Bachhav M. The scourge of burn contractures: who will bell the cat? Burns 2019;45(4):791–7.
[6] Finlay V, Burrows S, Burmaz M, Yawary H, Lee J, Edgar DW, Wood FM. Increased burn healing time is associated with higher Vancouver Scar Scale score. Scars Burn Heal 2017 14;3:2059513117696324.
[7] Wallace HJ, Fear MW, Crowe MM, Martin LJ, Wood FM. Identification of factors predicting scar outcome after burn injury in children: a prospective case-control study. Burns Trauma 2017;5:19. Jul 3.
[8] Finnerty CC, Jeschke MG, Branski LK, Barret JP, Dziewulski P, Herndon DN. Hypertrophic scarring: the greatest unmet challenge after burn injury. Lancet 2016;388(10052):1427–36.
[9] Richard R, Baryza MJ, Carr JA, Dewey WS, Dougherty ME, Forbes-Duchart L, Young A. Burn rehabilitation and research: proceedings of a consensus summit. J Burn Care Res 2009;30(4):543–73.
[10] Ahuja RB, Mulay AM, Ahuja A. Assessment of quality of life (QoL) of burn patients in India using BSHS-RBA scale. (doi:). Burns 2016;42(3):639–47. https://doi.org/10.1016/j.burns.2015.11.011
[11] 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.
[12] 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.
[13] 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.
[14] Iyer C, Soletti AB. Lived experiences of adult burn survivors with post-burn contractures. Soc Work Public Health 2022;37(3):209–23.
[15] 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.
[16] Saaiq M, Zaib S, Ahmad S. The menace of post-burn contractures: a developing country's perspective. Ann Burns fire Disasters 2012;25(3):152–8.
[17] 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.
[18] 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.
[19] Yelvington ML, Parry I. Integration of cutaneous functional units principles in burn rehabilitation: a diffusion of innovations assessment. J Burn Care Res 2023.
[20] 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.
[21] 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.
[22] Hudson DA, Renshaw A. An algorithm for the release of burn contractures of the extremities. Burns 2006;32(6):663–8.
[23] Dobbs ER, Curreri PW. Burns - analysis of results of physical therapy in 681 patients. J Trauma 1972;12(3):242. -&.
[24] 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.
[25] 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.
[26] 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.
[27] Fanstone R, Price P. Global perspectives on risk factors for major joint burn contractures: a literature review. Submitt Consid/Rev Burns 2023.
[28] Fanstone R, Price P. Burn contracture risk factors and measurement in low-middle income countries: a clinical perspective. Submitt Consid/Rev Burns 2023.
[29] Norkin, C.C., & White, D.J. (2016). Measurement of joint motion: a guide to goniometry. ⟨http://site.ebrary.com/lib/uqtr/docDetail.action?docID=11295485⟩.
[30] 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-e36.
[31] ⟨https://www.worlddata.info/average-income.php⟩.
[32] 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.
[33] 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.
[34] 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.
[35] 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.

[36] 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.
[37] 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.
[38] Katsu A, Tyack Z, Mackey M, Elliott JM, Mackenzie L. Return to employment for working-aged adults after burn injury: a scoping review protocol. Br Med J Open 2021;11(1):e044145.
[39] Pham TN, Goldstein R, Carrougher GJ, Gibran NS, Goverman J, Esselman PC, et al. The impact of discharge contracture on return to work after burn injury: A Burn Model System investigation. Burns 2020;46(3). 539-45.
[40] 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.
[41] 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.
[42] 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.
[43] 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-e9.
[44] Gupta S, Wong EG, Mahmood U, Charles AG, Nwomeh BC, Kushner AL. Burn management capacity in low and middle-income countries: a systematic review of 458 hospitals across 14 countries. Int J Surg 2014;12(10):1070–3.
[45] Edgar D. Active burn rehabilitation starts at time of injury: an Australian perspective. J Burn Care Res 2009;30(2):367.
[46] Zaman, S. (2005) Broken Limbs, Broken Lives: Ethnography of a Hospital Ward in Bangladesh. University Press Limited. ISBN 9789055892297.
[47] Gorga D, Johnson J, Bentley A, Silverberg R, Glassman M, Madden M, Yurt R, Nagler W. The physical, functional, and developmental outcome of paediatric burn survivors from 1 to 12 months postinjury. The Journal of burn care. Res Rehabil 1999;20(2):171–8. discussion 170.
[48] Kolmus AM, Holland AE, Byrne MJ, Cleland HJ. The effects of splinting on shoulder function in adult burns. Burns 2012;38(5). 638-44.
[49] 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.
[50] 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.
[51] 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.
[52] 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.
[53] Richard RL, Lester ME, Miller SF, Bailey JK, Hedman TL, Dewey WS, Greer M, Renz EM, Wolf SE, Blackbourne LH. Identification of cutaneous functional units related to burn scar contracture development. J Burn Care Res 2009;30(4):625–31.
[54] Richard R, Ford J, Miller SF, Staley M. Photographic measurement of volar forearm skin movement with wrist extension: the influence of elbow position. J Burn Care Rehabil 1994;15(1):58–61.
[55] Parry I, Richard R, Aden JK, Yelvington M, Ware L, Dewey W, Jacobson K, Caffrey J, Sen S. Goniometric measurement of burn scar contracture: a paradigm shift challenging the standard. J Burn Care Res 2019;40(4):377–85.
[56] Bashaireh KM, Yabroudi MA, Nawasreh ZH, Al-Zyoud SM, Bashir NB, Aleshawi AJ, Allouh MZ. Racial variations in knee joint laxity: a comparative study of the Jordanian Arab and Malay populations. Knee 2020;27(4):1205–11.
[57] 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.
[58] 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.