Early and late-recorded predictors of health-related quality of life of burn patients on long-term follow-up

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ABSTRACT

Background: Unintentional and intentional burn injuries vary across age groups, gender, income, and global region. In high-income countries, the trend over the last several years has been a reduction in burn incidence, burn severity, length of hospital stay, and mortality rate. However, there is a lack of data on predictors of the health-related quality of life (HRQoL) of major burn survivors extending beyond a follow-up period of 10 years.

Patients and methods: This single-center cross-sectional study is considering 42 long-term severe burn survivors with deep partial thickness burns and an affected total body surface area (TBSA) of ≥20%. For study eligibility design a minimum follow-up of 10 years was obligatory. Entitled individuals were asked to fill in the generic Short Form 36 (SF-36) questionnaire. The physical (PCS) and mental (MCS) component scores of the SF-36 were used as the primary outcome variables. Putative predictor variables were drawn from medical records. Burn-specific functionality and scar tissue quality were assessed using the Burn Specific Health Scale-Brief (BSHS-B) questionnaire and the Patient and Observer Scar Assessment Scale (POSAS), respectively. Correlation between putative predictor variables and SF-36 norm scores were evaluated by Pearson- and Point-Biserial correlation as well as multivariate linear regression. The SF-36 norm scores were compared to the general German population.

Results: Mean follow-up was 14 (±3) years with a minimum and maximum of 10 and 28 years, respectively. Mean age at the time of the incident was 37 (±17) years. The majority of individuals were male (74%). The mean burn size was 39 (±17) % (TBSA) with 76% of the individuals showing a full thickness burn.

SF-36 norm scores were not statistically different from the general population. Statistically significant independent predictor variables of the physical summary score were: age at the time of the injury (−0.381), time since injury (−0.466), length of hospital stay (−0.356), limb amputation (−0.318), unemployment (−0.433), work (0.593), hand function (0.601), body image (0.518), affect (0.355), simple abilities (0.602), burns involving the hands (−0.339) and back (−0.343), POSAS patient- (−0.521) and observer scores (−0.483). In multivariate analysis, work

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(4.315), the POSAS Score (−2.082) and the age at the time of the incident (−0.242) were statistically significant predictors. Statistically significant independent predictor variables of the mental summary score were: duration of mechanical ventilation (−0.459), hand function (0.415), body image (0.502), sexual activity (0.625), social support (0.542), burns involving the back (−0.315) and affect (0.692). In multivariate analysis, affect (13.844) and the length of mechanical ventilation (−0.115) were statistically significant independent predictor variables. *Conclusion:* Ten years after the burn incident, the quality of life was on average comparable to the one in the general population. Multiple variables seem to influence the physical and mental long-term outcome. Herein presented data may support in adapting and designing follow-up strategies tailored to a patient's burn-specific circumstances.

1. Introduction

Burn injuries are a well-known global public health issue. Annually, approximately 6 million individuals fall victim to traumatic burn injuries worldwide and about 265,000 burned patients terminally surrender to their injuries [1,2]. In the USA, burns were reported approximately 2.4% of all traumatic injuries [1]. Most importantly, severe burn injuries that affect deeper tissue layers and a large percentage of the total body surface area (TBSA) are especially challenging with regard to critical acute patient care, surgical management and psychological aftercare [2,3]. Despite recent advances in the fields of wound coverage (e.g. application of ex vivo tissue engineered cultured epidermal autografts (CEA); topical antimicrobial compounds), reconstructive plastic surgery (e.g. with the addition of vascularized composite allotransplants (VCA) to the reconstructive ladder), and significant advances in critical care (e.g. with regard to antimicrobial, anti-fungal therapy and resuscitation protocols), the challenge in achieving an acceptable functional and aesthetic outcome is enormous [4]. Hence, according to the World Health Organization (WHO), burn injuries are one of the most influential causes of disability-adjusted life-years (DALYs) and they entail physical and psychosocial sequelae that negatively impact the perceived health-related quality of life (HRQoL) [4,5]. Thus, it would be desirable to identify predictors of poor health-related quality of life in order to identify individuals that are, given their circumstances, at risk of developing a poor quality of life following a major burn injury.

Recent investigations have identified parameters that seem to impact the short-term mental as well as the physical status of patients following major burn injuries [6–10]. However, there is a great paucity of data on the HRQoL of burn survivors extending beyond a follow-up period of 10 years [11]. Additionally, to the best of our knowledge, there is no investigation that assesses early and late-recorded predictors of HRQoL on long-term follow-up. Furthermore, we wanted to answer whether major burn survivors could achieve similar quality of life measures as non-burn patients on long-term follow-up.

2. Patients and methods

2.1. Patients

The methods of retrospective patient identification and consecutive screening for prospective study eligibility are presented in Fig. 1, displaying the work-flow in a detailed manner. All patients were treated at the same institution (Department of Plastic Surgery and Hand Surgery, Burn Center, BG Trauma Center Duisburg, Duisburg, Germany) between October 1988 and November 2006. Approval of the investigation was issued by the local ethics committee of the "*Medical Association North Rhine-Westphalia*" (Approval No. 2015302). Non-German patients (individuals without permanent German citizenship at the time of the incident) and patients that died during or after the initial hospital stay were excluded. Patients that met the inclusion criteria (TBSA ≥20%; ≥deep partial thickness (2b) burn; ≥16 years of age; ≥10 years of follow-up), were consecutively invited to participate in the herein presented investigation. All clinical examinations were performed at the Department of Plastic Surgery and Hand Surgery, Burn Center, BG Trauma Center Duisburg, Duisburg, Germany by an experienced plastic surgeon. All gathered data were deidentified prior to statistical analysis and saved in SPSS. Normative data of the German general adult population were drawn from the publication of Ellert and Kurth, published in 2013 [12].

In accordance with Anzarut et al., the physical and mental SF-36 survey components were defined as the primary outcome variables. The two latent variables BSHS-B and POSAS were termed late-recorded variables (=variables recorded at the time of follow-up) [6]. Variables that were present at the time of the injury and at the time of the consecutive hospitalized treatment period were defined as early-recorded variables (variables gathered by retrospective databank search).

2.2. SF-36

The generic Short Form-36 (SF-36) questionnaire mental and physical component sums were selected as the overall outcome variables in order to scan for putative predictor variables of health-related quality of life following a burn injury. The SF-36 is a generic (can fundamentally be applied to any illness) questionnaire that has frequently been used to quantify the health-related quality of life (HRQL) of burn victims and is further defined as a "multi-response, short-form health survey" [11,13,14]. The questionnaire consists of 36 questions which are allocated to 8 distinct domains (vitality, physical functioning, bodily pain, general health perceptions, physical role functioning, role-emotional, social role functioning, mental health) and can be subdivided to measure a mental (vitality, social functioning, role-emotional, mental health) and physical component (physical functioning, role-physical,
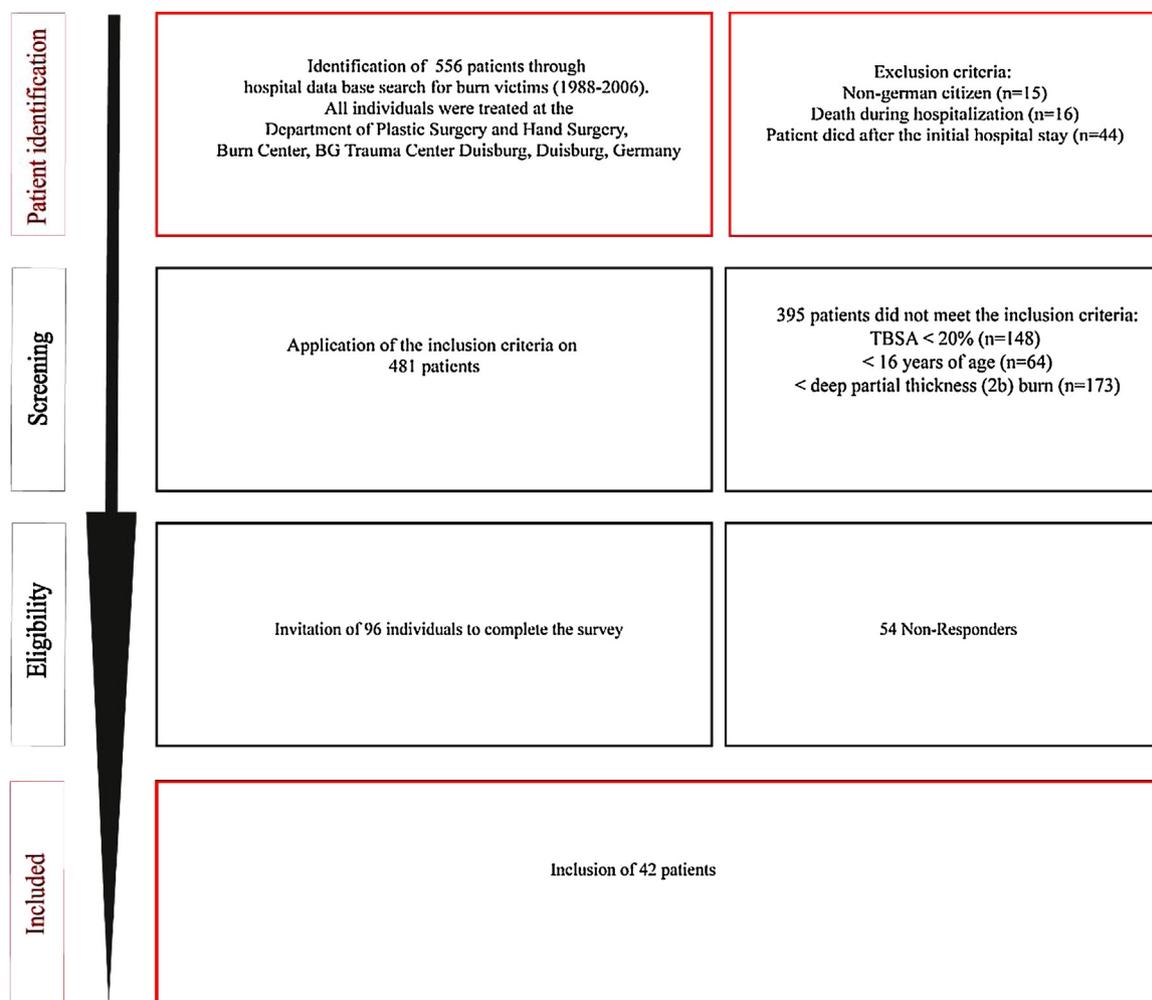
Fig. 1 – Flow-chart of patient identification, testing for eligibility and consecutive inclusion into the survey.

bodily pain, general health) [13]. A higher score indicates a better physical and mental health-related quality of life as perceived by the individual. The physical (PCS) and mental (MCS) component scores are created by the process of "norm-based scoring" in order to enhance international comparability, resulting in two summary scores that have a mean of 50 and a standard deviation (SD) of 10 [12,13]. Scoring less than 50 indicates a result which is below average. According to Ware and Gandek, a high physical component summary score relates to "no physical limitations, disabilities, or decrements in well-being, high energy level and health rated "excellent"" [13]. The same accounts for a high mental component summary score which is defined by reporting of "frequent positive affect, absence of psychological distress and limitations in usual social/role activities due to emotional problems and health rated "excellent"" [13]. The summary scores were used as the primary outcome variables in order to provide stability, clarity and stress the overall scope of the study which is the identification of factors that can impact the overall physical and mental outcome as objectified by the two summary components.

2.3. Burn Specific Health Scale-Brief (BSHS-B)

The most commonly used questionnaire to quantify the burn-specific health-related quality of life is the "*Burn Specific Health Scale-Brief (BSHS-B)*" questionnaire [11]. The BSHS-B is a validated 40-item questionnaire intended to objectify the patient's burn-specific outcome with regard to the following categories: hand function, work, sexuality, interpersonal relationships, heat sensitivity, affect, treatment regimens, simple abilities and body image [14]. The BSHS-B is defined as a disease-specific questionnaire that was designed to quantify the HRQoL of burn patients [11]. Each item requires an answer on a 5-point Likert-scale, ranging from "0 = extremely" to "4 = not/none at all". Generally, the higher the BSHS-B score, the better the post-burn specific health status and body functionality [5,15]. Summary scores of the subcategories were divided by the number of questions and consecutively used as late-recorded variables in the context of SF-36 PCS and MCS prediction. The German version of the BSHS-B was validated by Mueller et al. in 2015 [5].

2.4. Patient and Observer Scar Assessment Scale

The "*Patient and Observer Scar Assessment Scale*" (POSAS) is intended to objectify the quality of scar tissue, quantifying both the patient's as well as the physician's judgment. The observer rates the quality based on 6 items: surface area, thickness, pliability, pigmentation, vascularization and surface roughness [16,17]. Each item is scored on a scale from 1 to 10, with 1 indicating that the scar is comparable to "healthy skin" and 10 indicating the "worst imaginable scar" [17]. Consecutively, the patient is asked to answer questions with regard to the following items: painfulness, pruritus, color, stiffness, thickness, and irregularity [17]. Ordinarily, the patient is asked to rate the scar on a scale from 1 (e.g. no, the scar has not been painful the past few weeks) to 10 (e.g. yes, very much, the scar has been painful for the past few weeks) [17]. The higher the score, the worse the appearance and quality of the scar as perceived by patient and physician.

2.5. Retrospective clinical data collection

Patient charts, surgical protocols, and histopathological reports were searched for clinical information. Thereby identified clinical data were used to identify early-recorded predictors of the health-related quality of life. Clinical parameters that were identified for each individual: age at the time of the incident; sex (male/female); percentage of the total body surface area (TBSA) affected; depth of burn (epidermal superficial, superficial partial thickness; deep partial thickness; full thickness); length of the hospital stay (days); length of mechanical respiration (days); exact burn location with the following categories: upper and lower extremity, face, genitalia, hands, feet, abdomen, back, thorax; number of skin and soft tissue reconstructive surgeries per individual (includes every surgical intervention that was performed under general anesthesia from admission until discharge over the course of the primary hospital stay); inhalation injury (yes/no); circumstances of the burn injury with the following categories: work-related, felony-related, suicide attempt, in-house accident; etiology of the injury with the following categories: thermal burns (scalds, contact burns, flame burns), electrical burns, other; return to work (same occupation and same workplace) (yes/no); Work status one year post-discharge (employed(unchanged)/unemployed (changed); limb amputation (yes/no); physiotherapy or psychotherapy following the burn incident (yes/no); rehab stay (yes/no). The data were further subjected to statistical analysis.

2.6. Surgical treatment decision-making algorithm for skin and soft tissue reconstruction

Skin and soft tissue surgical treatment decision-making followed an institutional protocol. Debridement was reserved for deep partial thickness burns or higher. Immediately at admission, primary debridement and if necessary early decompression fasciotomies are performed. Within 48 h secondary debridement and tangential or epifascial necrosectomy with or without split skin grafting were performed. In one surgical session, a maximum of 30% TBSA was assessed. No

grafting of the face and genitalia. Scar release or reconstruction was offered 1-year after burn, in case of severe functional impairment (e.g. joint contractures) earlier.

2.7. Statistical analysis

We employed SPSS Statistics 24.0 (IBM Corp. Released 2013. IBM SPSS Statistics for Windows, Version 24.0. Armonk, NY: IBM Corp) for data storage of retrospectively extracted clinical as well as consecutive statistical analysis and interpretation. To test the correlation between putative predictor variables and the SF-36 summary scores, both the Pearson correlation and point-biserial correlation (for dichotomous variables) were used. Only a p-value <0.05 was considered statistically significant. Parameters with a p-value of 0.1 or lower in univariate analysis were found eligible for consideration in a multivariate linear regression model. The p-value to enter and for removal were set to 0.05 and 0.10, respectively. We provide the adjusted R^2 for each model and simultaneously indicate the unstandardized coefficients-β and their 95% CI. The compound model respected both early recorded- and latent variables. For the partial model, early recorded variables were isolated.

Furthermore, the presence of multicollinearity was investigated. The cutoff values for tolerance and VIF (variance inflation factor) were set to 0.2 and 5, respectively [18,19]. Variables with a value exceeding the cutoff were omitted from multivariate analysis. If indicated, mean values are accompanied by the standard deviation (SD). The Wilcoxon–Mann–Whitney test was utilized to compare two independent sample means.

3. Results

3.1. General

Ninety-six individuals were potentially eligible for the present investigation. In total, 42 long-term burn survivors met the inclusion criteria, consecutively completed the questionnaires and were then subjected to statistical analysis. The non-responder rate was 56%. Key demographic and injury details were compared and suggest similarity between responders and non-responders (see Table 1).

Mean follow-up of responders was 14.2 ($\pm$3.4) years with a minimum and maximum of 10 and 28 years, respectively. Mean age at the time of the incident was 37 ($\pm$17) years. The majority of individuals were males (74%). The mean burn size was 39 ($\pm$17) % TBSA with 76% of the individuals showing a full thickness burn.

The majority of individuals (86%) showed involvement of the upper extremity. Thermal burns were the leading cause of injury (80%). Supplementary 1 provides a summarization on patient demographics and the clinical data that were retrospectively collected.

3.2. Work status

None of the individuals were unemployed at the time of the injury. For individuals under 18 years of age, school was

Table 1 – Comparison of key characteristics between responders and non-responders.

	Responders (42)	Non-responders (54)	Total (96)
TBSA, % (mean ± SD)	39 ± 17	37 ± 16	36 ± 16
Sex, n (%) (male)	31 (74)	39 (72)	70 (73)
Age ± SD	5 ± 17	52 ± 17	51 ± 17
Length of hospital stay, days (mean ± SD)	79 ± 61	81 ± 59	80 ± 60
Number of reconstructive surgeries per individual, n (mean ± SD)	7 ± 6	6 ± 8	7 ± 7
Depth of burn, n (%) (deep partial thickness)	10 (24)	14 (25)	21 (22)
Depth of burn, n (%) (full thickness)	32 (76)	40 (75)	75 (78)
Work-related injury, n (%)	16 (38)	18 (33)	34 (35)

considered their main occupation if not engaged in an employment relationship. Individuals that returned to work/their main occupation or were employed/occupied elsewhere one-year post-discharge showed a higher PCS score when compared to those that remained unemployed/prematurely retired. We identified other variables that were collinear with the employment status. The following variables with regard to body functionality and injury severity showed statistically significant correlation (Pearson Correlation; p-value): Hand Function (0.362; 0.018); Simple abilities (0.570; 0.002); Work BSHS (0.367; 0.017); POSAS Patient score (−0.422; 0.005); POSAS Observer score (−0.340; 0.028); Depth of burn injury (−0.324; 0.036), length of hospital stay (−0.463; 0.002).

3.3. Questionnaires

The exact results of the questionnaires (SF-36, BSHS-B, and POSAS) are provided in Table 2.

Table 2 – Scores of the SF-36, POSAS and BSHS-B.

SF-36 component scores, score (mean ± SD)		
	Physical functioning	82 ± 24
	Role-physical	81 ± 38
	Bodily pain	70 ± 27
	General health	70 ± 23
	Vitality	68 ± 18
	Social functioning	86 ± 18
	Role-emotional	92 ± 26
	Mental health	82 ± 17
	PCS[b] (z-transformed)	47 ± 10
	MCS[a] (z-transformed)	54 ± 10
POSAS, score (mean ± SD)	Patient score	2.8 ± 1.5
	Observer score	2.7 ± 1.3
BSHS-B, total score per item (mean ± SD)	Total score	140 ± 25
	Affect	26.5 ± 3.4
	Interpersonal Relationships	16 ± 0.8
	Sexuality	11.5 ± 1.8
	Simple abilities	11 ± 2
	Hand function	18.4 ± 3.6
	Work	13.3 ± 4.6
	Heat sensitivity	14.6 ± 5.8
	Treatment regimens	16.2 ± 5.2
	Body image	13.4 ± 3.3
BSHS-B, mean score per item (mean ± SD)	Affect	3.8 ± 0.5
	Interpersonal relationships	4 ± 0.2
	Sexuality	3.8 ± 0.6
	Simple abilities	3.7 ± 0.7
	Hand function	3.7 ± 0.7
	Work	3.3 ± 1.2
	Heat sensitivity	2.9 ± 1.2
	Treatment regimens	3.2 ± 1
	Body image	3.3 ± 0.8

[a] MCS = mental component summary.
[b] PCS = physical component summary.

3.4. SF-36

The arithmetic means of the mental and physical component summary scores were 54 (range 20–63) and 47 (range 19–61), respectively. The highest scores were reached within the subcategories role-emotional (92), mental health (82), social functioning (86), physical functioning (82) and role-physical (81). The lowest score was reached in the category vitality with 68 points. Role-physical showed the greatest intra-group variability with an SD of 38.

3.5. Comparison to the general German population with regard to SF-36 results

Both, the SF-36 subcomponent- and summary scores were compared to the general German adult population. Fig. 2 graphically illustrates the specific subcomponent scores of the SF-36 in direct comparison. None of the differences in mean values were statistically significant. There was a tendency that the general German population showed better overall physical function. However, burn patients showed a tendency to have a higher mental component summary score. Importantly, the burn cohort shows a significant variation around the mean as compared to the German norms cohort. This fact might be attributable to the significantly lower sample size of the burn cohort as well as the differences in burn severity and burn characteristics (e.g. varying degree of TBSA) among individuals of the herein presented cohort.

3.6. BSHS-B

The arithmetic mean of the BSHS-B score was 140 ± 25. The herein presented cohort showed the highest scores in the following categories: affect (3.8), Interpersonal relationships (4). Heat sensitivity (2.9) and Treatment regimens (3.2) showed the poorest scores. The highest intragroup variability was seen in the categories work (SD 1.2) and heat sensitivity (SD 1.2). Table 2 provides detailed information on both the summary scores per category and on the mean scores per category including standard deviation.
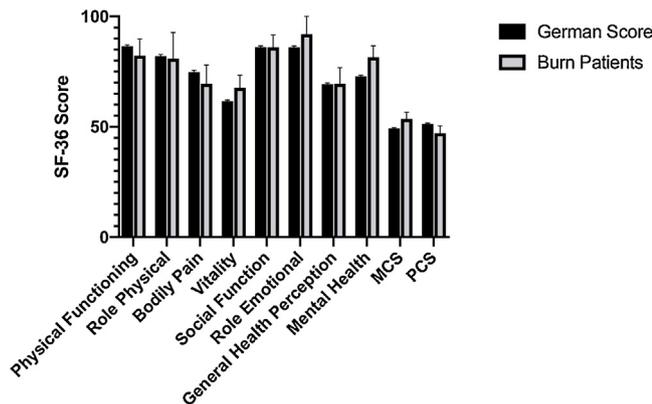

Fig. 2 – Comparison of SF-36 scores between German burn patients and the general German population (mean scores and corresponding 95% confidence intervals).
MCS = mental component summary; PCS = physical component summary.

3.7. POSAS

In summary, mean values of the patient- and observer scores were 2.8 ($\pm$1.5) and 2.7 ($\pm$1.3), respectively. The following subcomponent scores were noted (mean $\pm$ SD): (a) POSAS patient score: painfulness (1.8 $\pm$ 1.3), pruritus (1.8 $\pm$ 1,3), color (2.8 $\pm$ 1,6), stiffness (2.9 $\pm$ 1.8), thickness (2.9 $\pm$ 1.9) and irregularity (3.1 $\pm$ 2.1); (b) POSAS observer score: surface area (2.7 $\pm$ 1.4), thickness (2.5 $\pm$ 1,4), pliability (2.7 $\pm$ 1.3), pigmentation (2.4 $\pm$ 1.3), vascularization (2 $\pm$ 1) and surface roughness (2.5 $\pm$ 1.3).

3.8. Early and late-recorded independent influencer variables of SF-36 scores

The PCS and MCS were correlated with early- and late-recorded independent influencer variables variables. Table 3 shows the exact results of statistical analysis. Statistically significant independent influencer variables of favorable SF-36 PCS were: return to work/different job (0.433), BSHS-B hand function (0.601), BSHS body image (0.601), BSHS Heat sensitivity (0.475), BSHS simple abilities (0.602), BSHS treatment regimens (0.497), BSHS Affect (0.355), BSHS work (0.593). Statistically significant independent influencer variables of poorer SF-36 PCS were: higher age at the time of the injury (−0.381), time since injury (−0.466), length of hospital stay (−0.356), unemployment/early retirement (−0.433), limb amputation (−0.318), burns involving the hands (−0.339), POSAS higher Patient score (−0.521) and higher observer score (−0.483).

Statistically significant independent influencer variables of favorable SF-36 MCS were: BSHS- hand function (0.415), body image (0.542), social support (0.542), sexual activity (0.625), heat sensitivity (0.515), treatment regimen (0.430), affect (0.692) and work (0.311). Statistically significant independent influencer variables of poorer SF-36 MCS were: duration of mechanical respiration (−0.459) and burns involving the back (−0.315).

Univariate independent influencer variables with a p-value of 0.1 or lower were introduced into a stepwise multivariate linear regression model. The results are listed in Tables 4 and 5. 44% and 14% of the SF-36 PCS variability were explained by the compound and partial model, respectively. The compound model included Work (BSHS component) (p < 0.01) as a positive independent influencer variable of the PCS and the POSAS Patient Score (p < 0.05) as a negative independent influencer variable of the PCS. The partial model solely included the age at the time of the incident as a negative independent influencer variable of PCS (p < 0.05).

Concerning the SF-36 mental component prediction, we found that 48% of the variability could be explained by the BSHS component Affect alone (p < 0.02). The partial model included the length of mechanical ventilation (p < 0.02) as a negative independent influencer variable of MCS, explaining 21% of its variability.

Across all variables and models, the largest VIF was 4.6, not surpassing the generally used cutoffs of 5 or 10, which would indicate high multicollinearity [18,20,21]. Hence, the present data should not be affected by high multicollinearity and none of the variables were omitted from multivariate analysis [19,22].

Table 3 – Bivariate correlation between putative predictor variables and the outcome scores of the SF36 physical as well as mental component. Numerics in bold characters indicate that statistical significance was reached.

Predictor variable	SF36 physical component	SF36 mental component
Age (at the time of the injury)	**−0.381**[*]	**−0.273**[#]
Time since injury	**−0.466**[**]	−0.013
Gender, male	0.081	−0.006
Depth of burn injury	−0.254	0.068
Full thickness injury	−0.140	0.070
Length of hospital stay	**−0.356**[*]	−0.232
TBSA	−0.037	−0.077
Duration of mechanical ventilation	−0.194	**−0.459**[**]
Number of skin and soft tissue reconstructive surgeries performed	−0.254	−0.153
Inhalation injury	−0.134	0.06
Work related injury	−0.155	−0.237
Felony related injury	0.113	0.005
Physiotherapy	0.101	−0.225
Psychotherapy	−0.106	−0.177
Rehab stay	−0.109	0.028
Active smoker	−0.127	0.049
Employed (same or different occupation)	**0.433**[**]	0.153
Unemployment/early retirement	**−0.433**[**]	−0.153
Limb amputation	**−0.318**[*]	0.104
Hand function (BSHS component)	**0.601**[**]	**0.415**[**]
Body image (BSHS component)	**0.518**[**]	**0.502**[**]
Social support (BSHS component)	0.178	**0.542**[**]
Sexual activity (BSHS component)	**0.280**[#]	**0.625**[**]
Heat sensitivity (BSHS component)	**0.475**[**]	**0.515**[**]
Simple abilities (BSHS component)	**0.602**[**]	0.197
Treatment regimen (BSHS component)	**0.497**[**]	**0.430**[**]
Affect (BSHS component)	**0.355**[*]	**0.692**[**]
Work (BSHS component)	**0.593**[**]	0.311
Burns involving genitalia	−0.043	−0.051
Burns involving the hands	**−0.339**[*]	−0.036
Burns involving the face	−0.219	−0.083
Burns involving the abdomen	−0.208	−0.081
Burns involving the anterior thorax	−0.021	−0.242
Burns involving the back	**−0.343**[*]	**−0.315**[*]
Burns involving the feet	0.100	0.127
[a]POSAS (Patient score)	**−0.521**[**]	−0.162
[a]POSAS (Observer Score)	**−0.483**[**]	−0.231
Scar related pain	**−0.501**[**]	−0.218
Itching of the scar	**−0.432**[**]	−0.174

[*] $p < 0.05$.
[**] $p < 0.01$.
[#] $p < 0.1$ but > 0.05.
[a] POSAS = The Patient and Observer Scar Assessment Scale.

Table 4 – Models by stepwise multiple regression for SF36 physical component prediction.

Independent influencer variable	Coefficient (β) (95% CI)
Compound model for all variables (both, variables available at the time of the incident and those gathered at the time of follow-up); adjusted R Squared for the model: 0.438	
Work (BSHS component)	4.315 (1.730–6.900)[**]
POSAS patient Score	−2.082 (−4.082 to −0.081)[*]
Partial model solely respecting variables available at the time of the burn incident; adjusted R Squared 0.142	
Age at the time of the incident	−0.242 (−0.435 to −0.049)[*]

[*] $p < 0.05$.
[**] $p < 0.01$.

Table 5 – Models by stepwise multiple regression for SF-36 mental component prediction.	
Independent influencer variable	Coefficient (β) (95% CI)
Compound model for all variables (both, variables available at the time of the incident and those gathered at the time of follow-up); adjusted R Squared: 0.476)	
Affect	13.844 (9.140–18.547)[**]
Partial model solely respecting variables available at the time of the burn incident; adjusted R Squared 0.211)	
Duration of mechanical ventilation	−0.115 (−0.186 to −0.043)[**]
[**] p < 0.01.	

4.   Discussion

We herein present an extensive study on the long-term outcome (mean follow-up: 14 years) with regard to the health-related quality of life (HRQoL) of major burn patients. Although the small sample size forbids strong conclusions, the data suggest that major burn victims can potentially reach the same HRQoL as the general German population. Comparing means of the SF-36 subcomponent scores did not yield statistically significant differences between both cohorts. These findings are consistent with previous investigations, stating that burn incidents are initially detrimental to one's mental- and physical status [11], however, over the course of time, depending on the location and extent of the burn injury, patients seem to adjust well to their situation and sound long-term results are frequently achieved [6,23,24]. However, in accordance with the disabling burn incident, the physical summary score and subscores were slightly lower than the German normative score. Importantly, especially those individuals that returned to work or were employed elsewhere, showed significantly higher SF-36 physical component summary scores than those who were unemployed on follow-up. This fact underlines the importance of rigorous physical rehabilitation and stresses the importance of restoring musculoskeletal functionality and consecutive return to work as a major determinant of rehabilitation.

Interestingly, there was a trend that the SF-36 mental component summary score (MCS) was slightly higher when compared to the general German population. Though not statistically significant, it is possible that the burn incident had a long-term positive influence on the herein examined cohort's overall mental state. This phenomenon, coined post-traumatic growth, has been reported to occur in burn patients and is further defined as "the subjective experience of positive psychological change reported by an individual as a result of the struggle with trauma" [25]. Our data thus support and add valuable information to the findings of Spronk et al. [11]. The authors describe the SF-36 recovery pattern (0–48 months after burn). Their findings suggest that the mental component summary score normalizes over the course of time. Our results (MCS of 54) indicate that the MCS can even surpass the norm score of 49.3 on long-term follow-up. However, regarding the PCS, long-term major burn survivors seem to be worse off when compared to the general population. The average PCS did not surpass the norm score of 51.4. This finding is consistent with the PCS recovery pattern Spronk et al. describe within their investigation, indicating that the PCS does not reach the norm on long-term follow-up [11].

Bearing the findings in mind, it is important to note that the mental and physical recovery processes are interdependent. Past studies show that a poor mental recovery process or preexisting psychiatric disorders can negatively impact an individuals' adherence to post-burn physical rehabilitation modalities, ultimately resulting in a poorer physical outcome [26–28]. Likewise, poor physical recovery (e.g. due to excessive scarring with perpetual impairment of an extremities functionality or facial deformation) can impede with an individual's psychological recovery process [28].

In summary, the present data suggest that major burn patients, on average, do not regain the same physical capabilities and function as the average German citizen, even after a follow-up of more than 10 years (120 months). Taking these facts into consideration, it would be highly desirable to identify independent influencer variables of poor (or favorable) HRQoL that might aid in clinical decision making and might thereby potentially improve the overall outcome of major burn survivors.

Nevertheless, conducting long-term follow-up studies on burn patients is especially difficult due to high attrition rates [11]. Hence, there is a great lack of data on independent influencer variables of the mental and physical outcome extending beyond a follow-up period of 10 years [11]. According to Spronk et al., the current literature presents four investigations assessing the HRQoL of burn survivors after a time period of 10 years [11]. Hence, we aimed to collect data on putative independent influencer variables of HRQoL in major burn survivors at a minimum of 10 years following the incident. The data was used to assess early and late-recorded independent influencer variables variables of poor and favorable long-term HRQoL outcomes. The goal was set to identify independent influencer variables that might aid in adapting and designing follow-up strategies tailored to a patient's burn-specific circumstances.

The most relevant independent influencer variables of a favorable PCS and poor PCS were a higher work- (BSHS component) and POSAS patient score, respectively. In combination, both variables explained 44% of the PCS variability within the herein presented patient cohort. Previous investigations have already unveiled a strong correlation between "return to work/employment" and the HRQoL as quantified by the SF-36 questionnaire [29]. Our results thus confirm these results. It is important to note that additional findings with regard to body functionality are interrelated with the employment status and the ability to work as already suggested by Dyster-Aas et al. [29]. We found a positive correlation between

the employment status one-year after burn and the BSHS-B components Work, Hand Function and Simple abilities. The variables POSAS (Patient and Observer scores), length of hospital stay and the depth of the burn injury were inversely correlated to the work status. However, returning to work can also be influenced by other factors such as pre-burn employment and pre-burn existing personality traits that were not evaluated within the herein presented investigation [29].

Furthermore, we identified the POSAS Patient score as an independent influencer variable of a poor SF-36 PCS (see Table 3). Furthermore, scar-related pain and itching of the scar (POSAS components) alone were identified as potential independent influencer variables of a poorer PSC score in univariate analysis. These findings are consistent with previously published literature [30]. Factors such as wound infection have been shown to negatively impact the wound healing process in burn patients, ultimately leading to poorer scar tissue quality and higher scar tissue quantity [31,32]. It is important to note that excessive scarring and delayed mobilization can promote functional- (e.g. joint contractures) and aesthetic impairment in major burn patients [28,29,31]. Hence, it seems important to make use of the extensive armamentarium of therapeutic options (both surgical and non-invasive) that can positively influence the wound healing process and that aim at minimizing excessive scarring and tissue loss.

Additionally, multivariate analysis identified higher age at the time of the incident as an independent early-recorded independent influencer variable of a poorer SF-36 PCS. Interestingly, age has previously been identified as a negative independent influencer variable of the SF-36 mental component summary score [6]. Thus, one can conclude that higher age at the time of a burn incident warrants particular attention to both, psychological and physical rehabilitation care. Older individuals seem to be especially susceptible to physical and psychological sequelae of a major burn-incident. However, other investigations in an adult cohort context have implicated age as a protective factor for psychological outcomes after burn injuries [33]. Therefore, further studies are necessary to evaluate the impact of age on the long-term mental outcome.

Univariate data analysis yielded five accessory early-recorded independent influencer variables of a poorer PCS on long-term follow-up: time since injury, length of hospital stay, burns involving the back and hands as well as limb amputation. The fact that the time since the injury is a negative independent influencer variable of PCS is most likely reflective of the improvements in patient care, especially with regard to critical patient care, wound coverage and reconstructive surgery over the course of time [34]. Most importantly, our data suggest that hand and extremity functionality are of particular importance to one's physical well-being following a traumatic burn injury. Hand function (BSHS-B component) was a strong positive independent influencer variable of SF-36 PCS whereas the involvement of the hands alone (and limb amputation) showed a negative impact on the overall physical well-being. In accordance with Anzarut et al., early and stringent treatment of limb burns seems paramount to the overall physical outcome [6].

With regard to the mental component score prediction, multivariate analysis identified Affect (BSHS-B component) as an independent influencer variable of a favorable outcome. Based on the questionnaire, the Affect subcomponent quantifies an individual's emotional stability and the availability as well as receptiveness for social support [15,35]. Our findings (positive correlation between SF-36 MCS and affect, social support and emotional stability) thus confirm previous reports, that the emotional support and psychological care are important pillars in the rehabilitation process following a traumatic burn injury [6]. This is further supported by the fact that sexual activity, as part of a functioning interpersonal relationship, seems to positively influence the mental outcome [6].

Additionally, in multivariate analysis, the partial model included the duration of mechanical ventilation as an independent influencer variable of a poorer MCS. This fact is at least partially attributable to an associated prolonged ICU stay and a higher degree of disease severity compared to those individuals that did not receive prolonged mechanical ventilation. Nevertheless, long-term mechanical ventilation and an extended ICU stay are known as independent risk factors for mental health issues [36]. Individuals can perceive their body as foreign and the experience of scary nightmares and increased levels of pain, anxiety and panic attacks can ensue [36]. The duration of mechanical ventilation must be considered as a surrogate marker of disease severity, initial physiologic derangement and overall patient health status at the time of admission [37,38]. Thus, one must bear in mind that multiple factors contribute to the herein presented results. Altogether, prolonged mechanical ventilation seems to be an indicator of a poorer mental health outcome in burn patients. Special care must be taken to provide early and intensive psychological support to critically ill individuals with extensive ICU stays.

Finally, several limitations of the herein presented investigation must be outlined. High attrition rates over the course of time (e.g. deterioration, patient withdrawal) are frequently encountered in the context of burn patient aftercare. As a result, one limitation is the relatively small sample size we present. Consequently, an attrition bias might be inherent to the investigation if patients lost to follow-up were far worse off than those that ultimately participated and completed the questionnaire. We present a non-responder rate (individuals that were potentially eligible but did not complete the questionnaires) of 56% which is slightly higher when compared to other investigations in this field of study. However, key characteristics were comparable between responders and non-responders. Thus, similarity between the cohorts can be assumed.

In addition to that, one must acknowledge the general disadvantages of retrospective data extraction such as the difficulty of definitely coming to a conclusion about cause and effect between retrospectively extracted parameters and the long-term physical and mental outcome. The retrospectively extracted data was primarily not intended for research purposes and there was no standardization in data documentation and storage. Additionally, some variables such as the rate of wound infection and time to wound healing were not available for statistical analysis. Thus, further investigations, ideally with larger cohorts and in a prospective study design, are necessary to add data on variables and their predictive

value for the physical and mental outcome following major burn injury.

5. Conclusion

Independent significant influencer variables of a favorable health-related quality of life more than 10 years after burn were the ability to return to work, emotional stability and a high level of social support. Less favorable outcomes were associated with unfavorable scarring, increased age at the time of the injury, severe impairment of hand function and prolonged mechanical ventilation negatively impacted the health-related quality of life on long-term follow-up.

Conflicts of interest

None declared.

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Ethical approval

Approval of the investigation was issued by the local ethics committee of the "*Medical Association North Rhine-Westphalia*" (Approval No. 2015302).

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Appendix A. Supplementary data

Supplementary material related to this article can be found, in the online version, at doi:https://doi.org/10.1016/j.burns.2019.03.016.

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