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Agreement of clinical assessment of burn size and burn depth between referring hospitals and burn centres: A systematic review☆

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ABSTRACT

Background: The quality of burn care is highly dependent on the initial assessment and care. The aim of this systematic review was to investigate the agreement of clinical assessment of burn depth and %TBSA between the referring units and the receiving burn centres.

Methods: Included articles had to meet criteria defined in a PICO (patients, interventions, comparisons, outcomes). Relevant databases were searched using a predetermined search string (November 6th 2021). Data were extracted in a standardised fashion. The Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach for test accuracy was used to assess the certainty of evidence. The QUADAS-2 tool was used to assess the risk of bias of individual studies as 'high', 'low' or 'unclear'.

Results: A total of 412 abstracts were retrieved and of these 28 studies with a total of 6461 patients were included, all reporting %TBSA and one burn depth. All studies were cross-sectional and most of them comprising retrospectively enrolled consecutive cohort. All studies showed a low agreement between %TBSA calculations made at referring units and at burn centres. Most studies directly comparing estimations of %TBSA at referring

☆ The study protocol was registered in PROSPERO (CRD42020167068).

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institutions and burn centers showed a proportion of overestimations of 50% or higher. The study of burn depth showed that 55% were equal to the estimates from the burn centre. Most studies had severe study limitations and the risk of imprecision was high. The overall certainty of evidence for accuracy of clinical estimations in referring centres is low (GRADE ⊕⊕OO) for %TBSA and very low (GRADE ⊕OOO) for burn depth and resuscitation.

Conclusion: Overestimation of %TBSA at referring hospitals occurs very frequently. The overall certainty of evidence for accuracy of clinical estimations in referring centres is low for burn size and very low for burn depth. The findings suggest that the burn community has a significant challenge in educating and communicating better with our colleagues at referring institutions and that high-quality studies are needed.

1. Introduction

The quality of burn care is highly dependent on the assessment and treatment before the patient arrives at a specialised burn centre [1,2]. Incorrect assessment of the extent of the injury (%TBSA, total body surface area) and of the burn depth is common [3], and the estimates at referring hospitals and by emergency services tend to deviate from estimates performed at specialised burn centres [4,5]. Nonetheless, the initial assessment is the basis for the amount of fluid given, indication for escharotomy, and the need for referral to a burn centre. Hence, the initial evaluation may have a significant impact on the morbidity and mortality of these patients [6,7].

Clinical assessment of burn depth [8] and surface area [9,10] can be challenging even for experienced burn surgeons. It is a subjective evaluation based on visual and tactile characteristics: wound appearance, capillary refill, and sensibility to touch and pinprick [11,12]. However, no clinical characteristics are 100 per cent reliable indications for the depth of injury [13]. In brief, it is often easy to evaluate very deep or very superficial burns accurately, but difficult to evaluate burns of intermediate depth [12]. There is considerable inter-rater variability in the clinical evaluation of burn depth and healing potential [14]. Even experienced burn surgeons cannot in more than two-thirds of cases correctly determine whether a burn wound will heal conservatively within three weeks [12].

There are different clinical methods to estimate %TBSA clinically, for example Wallace's Rule of Nines [15], Lund and Browder charts [16], and Palmar Surface Measurement ('rule of palm') [17]. An inter-rater variation exists for all methods [10], even among experienced evaluators [18]. Estimates from Wallace's Rule of Nines are slightly more variable than those made with the Lund and Browder chart, but the estimation is easier to perform [19]. The evaluation methods have several possible sources of errors, for example when assessing lateral burns and burns in obese and/or female patients [20], and with the inclusion of superficial epidermal burns in the calculations. When using the 'rule of palm' method, the assessor sometimes believes that the palm excluding digits represents one per cent of TBSA, whereas the correct estimation is made with the whole hand, including both palm and digits [21].

During the last couple of years, digital tools have been developed to calculate burn surface area [22–24]. E-burn [22] and Mersey Burns [23] exist as mobile and web applications where the physician can fill in the injured area, the estimated depth of the injury, and the patient's age, and thereby perform a guided calculation of the %TBSA. BurnCase 3D [10,24] creates 3D models based on the patient's actual gender, height, and weight. It makes it possible to crossfade digital pictures of the injury onto the 3D model and calculate %TBSA through the software. However, these digital tools are not yet widely adopted.

Knowledge about the direction and magnitude of the discrepancies between evaluations performed at referring hospitals and emergency services and those performed in specialised burn centres could help the burn community tailor training and continuing education in the field of burn care, and thereby create a foundation for further improvement. The information might also improve communication with referring doctors, considering both acute management and whom to transfer. There is one previous review dealing with the topic, demonstrating that there is a discrepancy between the referring centre and the burn centre, but that study does not appraise the quality of the evidence [4].

This study aimed to perform a systematic review of studies on the agreement and level of accuracy of evaluation of burn size and depth between referring units and burn centres and to assess the risk of bias and quality of evidence of the studies. The assessment of the burn centre will be considered the reference evaluation. Data were pooled, and meta-analyses of the assessments of %TBSA and burn depth were attempted, to summarise the current level of knowledge. Fluid resuscitation in the referring centre was considered a surrogate for the assessment's effect on subsequent management (accuracy measure). The research question was how good is the agreement of clinical assessment of burn depth and %TBSA between referring hospitals and burn centres?

2. Methods

2.1. Study registration and reporting

The study protocol was registered in PROSPERO (CRD42020167068). It can be accessed at: https://www.crd.york.ac.uk/prospero/display_record.php?RecordID= 167068

Results were reported according to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) guidelines and PRISMA 2020 Checklist plus PRISMA 2020 for Abstracts Checklist is available in Appendix A[25–27].

2.2. *Eligibility criteria and study selection*

Eligible study designs were cross-sectional and cohort studies with direct comparison of agreement of clinical assessment of burn depth and %TBSA between referring hospitals and burn centres (accuracy studies [30]). Included articles had to meet criteria defined in a PICO (Patients, Intervention test, Comparison test, and Outcome of interest), as modified by Schünemann et al. [28,29]. P: Patients with burn injuries resulting in burn centre referrals; I: Assessment in referring hospital; C: Assessment in the burn centre; O1: Burn size – %TBSA; O2: Burn depth; O3: Resuscitation. The assessment made in the referring hospital was considered the 'index test' and the assessment of the burn centre the 'reference standard' [30]. In contrast to some diagnostic tests, burn assessment does not give a 'positive' or a 'negative' result, as both burn size and depth are continuous variables, where higher values indicate more severe health effects. Nonetheless, most countries have cut-off values for %TBSA for referral to a burn centre [31–33]. Resuscitation was used as a surrogate for the assessment's effect on subsequent management (accuracy measure). When studies contained data from two separate time periods, these series were separated and treated as independent studies. Three authors (RB, SA, and EH) independently assessed if the articles met the inclusion criteria, and disagreements were resolved through discussion among authors. Exclusion criteria were review articles, comments, technical descriptions, communications, and editorials.

2.3. *Information sources and search*

The PubMed database were searched for articles and abstracts published between January 1950 and November 2021. (Last search date November 6th 2021).

No grey literature sources were searched. The search string was (((((((((accordance) OR accuracy) OR discrepancy) OR consistency) OR overestimation) OR underestimation)) AND (((assessment) OR estimation) OR estimate)) AND (((burn center) OR burn centre) OR burns unit)) AND (((referral) OR referring) OR transfer)) AND ((((((burn depth) OR burn surface) OR burn size) OR TBSA) OR Total body surface area) OR burn resuscitation). The search was limited to studies published in English, French, German, Italian, Swedish, Danish, and Norwegian. Additionally, all bibliographies of included studies were manually checked. Full articles were assessed when eligibility for inclusion could not be assessed based on the abstract alone.

2.4. *Data extraction*

Data were extracted independently by two authors (RB and EH). Any disagreements were resolved through discussion. Information collected included: first author, year of publication, study country, study design, study scope (that is if the study specifically studied agreement between referring centre and the burn centre or if it had another main aim), number of patients assessed and assessment of burn size – %TBSA, burn depth and resuscitation in the referring hospital and in the burn centre, dropouts, and age. When possible, data were extracted as the proportion of correct estimates, overestimates, and underestimates.

2.5. *Risk of bias in individual studies and across studies and certainty of evidence*

We used the Grading of Recommendations Assessment, Development and Evaluation (GRADE) approach for test accuracy to assess the certainty of evidence [28,29,36]. The risk of bias of individual studies was assessed as 'high', 'low', or 'unclear' using the QUADAS-2 tool [30], taking patient selection, execution of the index test and the reference standard, data analysis, and patient flow into consideration [3]. In addition, indirectness, inconsistency, imprecision, and publication bias were assessed [28,29].

According to the GRADE approach, appropriately designed studies start at a high certainty of evidence [36]. The overall certainty of evidence was rated down based on the assessment of the risk of bias, indirectness, inconsistency, imprecision, and publication bias, [28,29] and finally rated as 'High' (⊕⊕⊕⊕), 'Moderate' (⊕⊕⊕⊖), 'Low' (⊕⊕⊖⊖), or 'Very low' (⊕⊖⊖⊖) [36]. Points for which certainty of evidence was rated down will be described in the results section.

2.6. *Statistical analysis*

The results of each article were tabulated per outcome (Tables 2 and 3). A meta-analysis was attempted for %TBSA, using the R package 'meta' [34] in R version 4.0.4 [35], but due to a high heterogeneity in the included studies and their definitions of over- and underestimation, no meaningful central estimates could be calculated. Hence, only graphical summaries of the individual studies and their proportion of over- and underestimations of %TBSA are presented (Figs. 2 and 3).

3. Results

3.1. *Study selection*

A total of 412 abstracts were retrieved following the search and manual bibliography check (Fig. 1). Of these, 371 did not meet the inclusion criteria and were excluded, leaving 41 articles that were read in full. After more detailed scrutiny, a further 13 articles were excluded, leaving 28 studies to be included in the review (Table 1).

3.2. *Study characteristics*

Twenty-eight studies with a total of 6461 patients were included in this review (Table 1). Twenty-eight studies investigated %TBSA assessment (Table 2), one burn depth, and

Table 1 – Included studies burn evaluation.

Author Year Country	Study Design Main scope	Study Duration (years)	Exclusion/ inclusion criteria	Included patients (n) (male/female)	Mean age (years)	Paediatric patients (%) (Definition of paediatric)	Number of excluded patients (n)	Outcome variables
Armstrong[5] 2017 USA	Consecutive case series Accuracy of initial assessment	Jan 2014 – May 2015	Included: All referred burn injuries. Excluded: Missing TBSA ref. unit, direct admissions, isolated inhalation injuries.	326 (NR)	NR	149/326 (46%) (< 18 years of age)	409/735 (55%)	TBSA (Table II)
Ashworth[40] 2001 UK	Consecutive case series Accuracy of initial assessment and treatment	Jan 1998 – Dec 1998	Included: > 15% TBSA adults, > 10% TBSA children Excluded: International transfers, non-acute admissions	31 (19 m/12 f)	Adults: 50 (range 21–94) Children: 4 (range 11 months-14 years)	32% (10/31) (≤14 years, there were no patients aged 15–21 years in the cohort)	NR	TBSA (Table II) Fluid resuscitation (Table III)
Baartmans[39] 2012 The Netherlands	Consecutive case series Accuracy of initial assessment and treatment Differences between two time periods	Jan 2002-Marc 2004 and Jan 2007-Aug 2008	Included: Admitted during the first 24 h Excluded: > 16 years, missing formal referral	622 (395 m/227 f)	Study period 1: median 21 months (IQR 14–48) Study period 2: 23 months (IQR 15–64)	100% (< 16 years of age)	59/681 (9%)	TBSA (Table II) Fluid resuscitation (Table III)
Berkebile[41] 1986 USA	Consecutive case series Accuracy of initial assessment	Jan 1982-Jun 1984	Excluded. Missing TBSA assessment from referring unit	193 (NR)	NR	NR	211/404 (52%)	TBSA (Table II)
Berry[42] 1982 USA	Consecutive case series Accuracy of initial assessment	NR	Included: 2nd and 3rd degree burn according to the referring unit Excluded: TBSA given as a range (e.g. 20%–40%)	105 (NR)	NR	NR	228/333 (68%)	TBSA (Table II)
Carter[56] 2018 USA	Consecutive case series Review pre-burn centre practices within a catchment area and identify areas for improved education and resource utilisation	July 2012-July 2014	Excluded: Suspected Stevens-Johnson syndrome or Toxic epidermal necrolysis, delay in transfer > 24 h, self-referrals, arrival by nonmedical transport	621 (443/178)	38.6 (21.9)	NR	383/1004 (38%)	TBSA (Table II) Fluid resuscitation (Table III)
Chan[43] 2012 Australia	Consecutive case series Accuracy of initial assessment	Jan-Dec 2009	Included: Children < 16 years of age Excluded: Missing TBSA assessment from referring unit,	61 (NR)	NR	100% (< 16 years)	10/71 (14%)	TBSA (Table II)

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Table 1 – (continued)

Author Year Country	Study Design Main scope	Study Duration (years)	Exclusion/ inclusion criteria	Included patients (n) (male/ female)	Mean age (years)	Paediatric patients (%) (Definition of paediatric)	Number of excluded patients (n)	Outcome variables
Collis[44] 1999 UK	Consecutive case series Accuracy of initial assessment and treatment	Jan 1994- Dec 1996	Included: Adults with > 15% TBSA and children (≤12 years) with > 10% Excluded: TBSA < 10% in children and 15% in adults according to both the referring unit and the burn centre, missing TBSA assessment from referring unit,	256 (NR)	NR	130/256 (51%) (< 16 years)	55/311 (18%)	TBSA (Table II) Fluid resuscitation (Table III)
Dulhunty[57] 2008 Australia	Consecutive case series Relationship between fluid, clinical outcome and cause of variance from expected resuscitation volumes	Jan 2000- May 2005	Inclusion: Admission within 48 h of injury TBSA > 15% Exclusion: Incomplete fluid records	80 (64 m/16 f)	37 (SD 15)	NR	NR	TBSA (Table II) Fluid resuscitation (Table III)
Face[45] 2017 Australia	Consecutive case series Accuracy of initial assessment	Jan 2009- Jan 2011	Included: Children ≤ 16 years Excluded: Uncertain diagnosis of burns or scalds, international transfers	123 (< 5 years: 46% m, 54% f, > 10 years of age: 96% m, 4% f)	NR 74/123 were under the age of 5, 40/ 123 were between 1 and 2 years of age	100% (≤16 years)	NR	TBSA (Table II)
Freiburg[7] 2007 USA	Consecutive case series Accuracy of initial assessment and treatment and implications on complications	1999 – 2004	Included: Transfers from an outside unit or directly admitted ≤ 24 h post-injury Excluded: Transfers > 24 h post-injury, children < 18 years	127 (82 transfers, 45 directly admitted) (NR)	Transfers 44.4 (SD18.3) Direct 37.9 (SD 13.2)	0	19/146 (13%)	TBSA (Table II) Fluid resuscitation (Table III)
Frost[46] 2019 UK	Case series Accuracy of initial assessment and appropriateness of 1referrals Evaluation of an intervention (Proformas)	NR	NR	NR	NR	NR	NR	TBSA (Table II)

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Table 1 – (continued)

Author Year Country	Study Design Main scope	Study Duration (years)	Exclusion/ inclusion criteria	Included patients (n) (male/ female)	Mean age (years)	Paediatric patients (%) (Definition of paediatric)	Number of excluded patients (n)	Outcome variables
Goverman[37] 2015 USA	Consecutive case series Accuracy of initial assessment and treatment	Oct 2011-April 2012	Included: Fluid resuscitation initiated ≤ 6 h post-injury, transfers ≤ 6 h post-injury Excluded: Isolated inhalation injury, concomitant trauma, high voltage electric injury, missing TBSA assessment from referring unit, enrolment in any clinical trial involving fluid resuscitation	50 (NR)	4.1 (SD 0.67, range 25 days-16 years)	100% (≤16 years)	NR	TBSA (Table II) Fluid resuscitation (Table III)
Hagstrom[47] 2003 USA	Consecutive case series Accuracy of initial assessment and treatment	1 year (time period not stated)	Included: Transfers meeting the ABAs admission criteria, as of 1987 Excluded: Direct admissions and in-house referrals, missing TBSA assessment from referring unit	41 (NR)	34.2 (average) (range 0.833–92)	NR	NR	TBSA (Table II) Fluid resuscitation (Table III)
Hall[63] 2017 Australia	Consecutive case series Describe the burn caseload of a helicopter emergency medical service	Jan 2010-Aug 2015		490 (371 m/119 f)	37 (median) (IQR 23–50)	28/490 (5.7%) (not defined)	NR	TBSA (Table II)
Hammond[48] 1987 USA	Consecutive case series Accuracy of initial assessment	Jan 1983-Jul 1985	Excluded: International transfers, transfers > 48 h post-injury, skin loss from other causes than burn, patients not requiring admission	132 (NR)	NR	NR	32/164 (20%)	TBSA (Table II)
Harish[49] 2015 Australia	Consecutive case series Accuracy of initial assessment	Jan 2009-Aug 2013	Included: Adults Excluded: Missing TBSA assessment from referring unit	698 (NR)	NR	0	71/769 (9%)	TBSA (Table II)
Irwin[50] 1993 UK	Consecutive case series Accuracy of initial assessment made by casualty officers	Oct-Dec 1989	Included: Children	100 (59 m/41 f)	3.65	100% (not defined)	0	TBSA (Table II) Depth: Comment in text

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Table 1 – (continued)

Author Year Country	Study Design Main scope	Study Duration (years)	Exclusion/ inclusion criteria	Included patients (n) (male/ female)	Mean age (years)	Paediatric patients (%) (Definition of paediatric)	Number of excluded patients (n)	Outcome variables
Klein[55] 2007 USA	Consecutive case series To identify systematic errors in either the initial assessment or care of burn patients requiring transport of more than 90 miles	2000 – 2003	Included: Transfers from an outside facility more than 90 miles from the burn centre	424 (324 m/100 f)	31.8 (SD22)	NR	525/949 (55%)	TBSA (Table II) Fluid resuscitation (Table III)
Laing[51] 1991 UK	Consecutive case series Accuracy of initial assessment	Mar 1989- Feb 1990	Excluded: Missing TBSA assessment from referring unit, direct admission	100 (NR)	NR	NR	27/127 (21%)	TBSA (Table II)
Lam[38] 2008 Vietnam	Consecutive case series Accuracy of initial assessment	Jun 2004 – June 2006	Included: Children	247 (152 m/95 f)	NR	100% (NR)	0	TBSA (Table II)
Manning Ryan[64] 2019 USA	Consecutive cohort study. Prospective Accuracy of initial assessment Evaluation of intervention (common clinical assessment instrument (Lund and Browder form) and educational outreach)	July 2014-June 2015 Dec 2017- June 2018	Included: Children with a transport registry entry	106 (61 m/45 f) + 78 (47 m/31 f)	4.7 years (SD 4.5) 4.5 years (SD 5.1)	NR	NR	TBSA (Table II)
Naumeri[65] 2018 Paki11stan	Adequacy of initial treatment and transfer	March 2017- May 20178	Included: Children < 13 years Excluded: Direct admission History of child abuse Associated trauma Associated congenital malformation	114 (52/62)	3.9 years (SD 2.9)	100% (< 13 years)	NR	TBSA (Table II)
Nguyen[58] 2002 Vietnam	Consecutive case series Improve the quality of burns management and promote community-based burn interventions	Jan 1997- Dec 1999	Included; Children < 15 years TBSA 10–60% Transported within 72 h Deep partial-thickness or full-thickness < 40% TBSA Excluded: Associated injury Electrical burn Inhalation injury	695 (434 m/261 f)	40 months (SD 38 months, range2 months –15 years)	100% (< 15 years)	NR	TBSA (Table II) Fluid resuscitation (Table III)

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Table 1 – (continued)

Author Year Country	Study Design Main scope	Study Duration (years)	Exclusion/ inclusion criteria	Included patients (n) (male/ female)	Mean age (years)	Paediatric patients (%) (Definition of paediatric)	Number of excluded patients (n)	Outcome variables
Sadideen[52] 2017 UK	Consecutive case series Accuracy of initial assessment and implications on fluid resuscitation	May 2009- Dec 2012	Included: Children < 16 years of age, > 10% TBSA requiring fluid resuscitation Excluded: Direct admission, transfer > 24 h post-injury, missing TBSA assessment from referring unit, skin loss from other causes than burn	46 (24 m/22 f)	3.9 (SD 3.4, range: 9 months- 11 years 9 and months)	100% (< 16 years)	57/103 (55%)	TBSA (Table II) Fluid resuscitation (Table III)
Saffle[66] 2004 USA	Consecutive case series Accuracy of initial assessment and of using air transport. Feasibility of using telemedicine.	Jan 2000 – Dec 2001	Included: Transported by air Excluded: Non-air transport or scene flight, non-burn conditions	225 (182 m/43 f)	31.8 (SD 1.6, range 0.7–94)	NR	33/258 (13%)	TBSA (Table II)
Swords[53] 2015 USA	Consecutive case series1 Accuracy of initial assessment and treatment	Jan 2005- March 2012	Included: Children < 16 years of age Excluded: Referred by primary care physicians, direct admission, transfer > 24 h post-injury, missing TBSA assessment from referring unit, re-admissions, isolated caustic oesophageal or inhalation injuries	201 (124 m/77 f)	5.2 (SD 4.7)	100% (< 16 years)	222/423 (52%)	TBSA (Table II) Fluid resuscitation (Table III)
Wong[54] 2002 Australia	Consecutive case series Accuracy of initial assessment Changes in practice over a 12-year period	June 1989- May 1990 April 2000- March 2001	NR	108 (NR)	NR	NR	NR	TBSA (Table II)

ABA= American Burn Association
F=female
H= hour
IQR= interquartile range
NR= Not reported
M= male
SD= standard deviation
TBSA= Total body surface area

Table 2 – Included studies TBSA estimation.

Author year country	Number of patients with complete TBSA data	Accuracy	Number of patients with incomplete TBSA data	Results Initial evaluation n/n (%)	Burn centre evaluation n/n (%)	Comments
Armstrong[5] 2017 USA	125	Satisfactory: -25–25% Underestimated: < −25% Overestimated: > 25%	245/735 (33%)		Correctly assessed: 63/326 (19%) Underestimated: 13/326 (4%) Overestimated: 250/326 (77%) $p < 0.0001$	Mean difference in TBSA: 7.49 (SD 7.82) The ratio of overestimation to underestimation 19:1 The ratio of overestimation to satisfactory estimation 4:1
Ashworth[40] 2001 UK	31	Absolute difference	NR		Correctly assessed: 4/31 (13%) Underestimated: 13/31 (42%) Overestimated: 14/31 (45%) $p = 0.6$	Average underestimation: 7.5% (range 0.5%–23%) Average overestimation: 9% (range 2%–19%)
Baartmans[39] 2012 The Netherlands	622	Absolute difference	150/622 (24%)	Study period 1 Median TBSA: 10 (IQR 8–15) Study period 2 Median TBSA: 10 (IQR 7–16.5)	Study period 1 Median TBSA: 6 (IQR 4–9) Study period 2 Median TBSA: 5 (IQR 4–8)	Mean difference in TBSA assessment during study period 1: 5.8 (SD5.5) and study period 2: 5.9 (SD5.6) TBSA was on average 6% higher according to the assessment made by the referring unit
Berkebile[41] 1986 USA	193	Absolute difference	211/404 (52%)		Correctly assessed: 21/193 (11%) Underestimated: 59/193 (31%) Overestimated: 113/193 (59%)	The ratio of overestimation to underestimation 1.92:1 Average underestimation: 16.24% (SD 23.90%) Average overestimation: 12.16% (SD 15.62%)
Berry[42] 1982 USA	105	Absolute difference	228/333 (68%)		Correctly assessed: 12/105 (11%) Underestimated: 28/105 (27%) Overestimated: 65/105 (62%) $p < 0.01$	Absolute difference in estimates: 5% (27.5% vs. 22.5%) Correlation of ratings given by referring centre and the burn centre: 0.799

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Table 2 – (continued)

Author year country	Number of patients with complete TBSA data	Accuracy	Number of patients with incomplete TBSA data	Results Initial evaluation n/n (%)	Burn centre evaluation n/n (%)	Comments
Carter[56] 2018 USA	360	Absolute difference	261/621 (42%)		The best-fit line has a slope of 1.12, demonstrating that the referring hospital tended to overestimate burn size	
Chan[43] 2012 Australia	61	Absolute difference	10/71 (14%)		Correctly assessed: 13/61 (21%) Underestimated: 15/61 (25%) Overestimated: 33/61 (54%) $p = 0.002$	The ratio of overestimation to underestimation 2.2:1 Mean underestimation: 23.4% (95% CI 16.3–30.5, range 6.3%–44.4%) Mean overestimation: 86.4% (95% CI 53.8–119, range 4%–450%) Most of the underestimations were within the range of 1–5% (24/33) Assessments performed within 24 h of each other were more accurate ($p < 0.005$)
Collis[44] 1999 UK	256	Absolute difference	10/266 (4%)		Correctly assessed* : 20/256 (8%) Underestimated* : 68/256 (27%) Overestimated* : 168/256 (66%)	Standard distribution in error: 20.5% Correlation between assessments: 0.81 ($p < 0.001$) Small burns were more overestimated Burns around 20% seem to be the most accurately assessed
Dulhunty[57] 2008 Australia	80	Absolute difference	0		In 25/80 there was a > 10% difference Overestimated: 17/80 (24%)	
Face[45] 2017 Australia	81	Patients were dichotomised to < 10% or > 10% TBSA	42/123 (34%)	< 10% TBSA n = 26 > 10% TBSA n = 55	< 10% TBSA n = 21 > 10% TBSA n = 33 Correctly assessed: 54/81 (67%) Underestimated: 5/81 (6%) Overestimated: 22/181 (27%)	

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Table 2 – (continued)

Author year country	Number of patients with complete TBSA data	Accuracy	Number of patients with incomplete TBSA data	Results Initial evaluation n/n (%)	Burn centre evaluation n/n (%)	Comments
Freiburg[7] 2007 USA	47	Absolute difference Assessments were considered to agree if the difference was + /- 5%	35/82 (43%)		Correctly assessed: 28/47 (60%) Underestimated: 6/47 (13%) Overestimated: 13/47 (27%) $p < 0.0002$	Mean difference for < 20% 4.3% (SD 6.9) and for ≥ 20% – 4.9% (SD 9.1) Smaller burns tended to be overestimated and large burns underestimated
Frost[46] 2019 UK	67% (91% post-intervention)	TBSA < 10% assessment should be within 1 SD (%TBSA) TBSA > 10% within 2 SD	33% (9% post-intervention)		Pre-intervention Correctly assessed: 41% Post-intervention Correctly assessed: 59%	Intervention: Proformas
Goverman[37] 2015 USA	50	Absolute difference	NR	Mean TBSA: 12.87% (range 1–75)	Mean TBSA: 7.20% (range 0.25–55) $p < 0.05$ Overestimated: 47/50 (94%)	Differences in assessments were statistically significant for scalds and contact burns but not for flame burns. Average overestimation: 224% (range 0–3500%) Overestimation clustered around ages 0–3 and 13–15 years
Hagstrom[47] 2003 USA	41	Absolute difference "correct range" not defined	NR	Average TBSA: 23.9% (range 5–70)	Average TBSA: 17.8% (range 2–55) Correctly assessed: 9/42 (22%)	The discrepancy was > 50% for 33% of the patients
Hall[63] 2017 Australia	490	Absolute difference	NR		Pre-hospital admission Correctly assessed* : 27/105 (26%) Underestimated* : 20/105 (18%) Overestimated* : 58/105 (56%) Inter-hospital admissions Correctly assessed* : 121/385 (31%) Underestimated* : 79/385 (21%) Overestimated* : 185/385 (48%)	The ratio of overestimation to underestimation was 2.5:1

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Table 2 – (continued)

Author year country	Number of patients with complete TBSA data	Accuracy	Number of patients with incomplete TBSA data	Results Initial evaluation n/n (%)	Burn centre evaluation n/n (%)	Comments
Hammond[48] 1987 US	132	Absolute difference Satisfactory: -25–25% Underestimated: < −25% Overestimated: > 25%	7/132 (5%)		Correctly assessed: 56/132 (42%) Underestimated: 8/132 (6%) Overestimated: 61/132 (46%)	24/132 (18%) were > 100% overestimated For burns < 20%TBSA > 50% error was made for 45% and for burns > 20% > 50% error was made for 27% of the patients
Harish[49] 2015 Australia	698	Absolute difference Satisfactory estimation: > −25% Significant underestimation: < −25% Significant overestimation: > 25%	71/769 (9%)	Mean TBSA: 12.3 (SD 14.2)	Mean TBS1A: 8.5 (SD 12.7%) $p < 0.001$ Correctly assessed: 212/698 (30%) Underestimated: 116/698 (17%) Overestimated: 370/698 (53%) Satisfactory estimation: 371/698 (57.5%) Significant underestimation: 39/698 (6%) Significant overestimation: 235/698 (36.5%)	The ratio of overestimation to underestimation was 3.2:1 Mean inaccuracy for overestimated patients was 172% and for underestimated patients 25%
Irwin[50] 1993 UK	40	Absolute difference Assessment was considered to agree ± 1% for TBSA > 2% and ± 0.5% for TBSA ≤ 2% .	60/100 (60%)		Correctly assessed: 13/40 (33%)	Of the 20 patients initially assessed as having > 5% TBSA, 3 patients were considered accurately assessed (15%). Of the 17 patients who actually had > 5% TBS, 3 patients had been accurately assessed (18%).
Klein[55] 2007 USA	424	Absolute difference	NR	Mean TBSA: 22.8%	Mean TBSA: 16.7% $p < 0.001$	The difference in estimates was more extreme at smaller burn sizes but similar across age strata. A lot of patients with burn size of less than 15%TBSA were estimated by the referring hospital to have an injury above 15% The variance was significantly greater in burn size estimates with increasing burn size ($p < 0.001$)

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Table 2 – (continued)

Author year country	Number of patients with complete TBSA data	Accuracy	Number of patients with incomplete TBSA data	Results Initial evaluation n/n (%)	Burn centre evaluation n/n (%)	Comments
Laing[51] 1991 UK	100	Absolute difference	20/127 (16%)		Overestimated* : 85/100 (85%)	Mean error by grade of assessor: A&E SHO 133% Pedi SHO/Registrar 117% Orthos/surg SHO 100% Ortho/surg Registrar/SR 60% A&E Registrar/SR 40% A&E Consultant 8% Plast surg SHO/Registrar 7%
Lam[38] 2008 Vietnam	103	Absolute difference	29/132 (22%)		Correctly assessed: 29/132 (21.9%) Underestimated: 14/132 (10.6%) Overestimated: 60/132 (45.5%)	
Manning Ryan[64] 2019 USA	56 + 73	Absolute difference > 5% difference was considered clinically significant	47/106 (44%) + 5/78 (6.4%)		Pre-intervention Correctly assessed: 4/59 (7%) Underestimated: 4/59 (7%) Overestimated: 51/59 (86%)	Pre-intervention Overestimations: Range of difference 0.5–27%; mean difference 5.1% (SD5%). 18/51 (35%) clinically significant differences Underestimations: Range of difference 0.5–2%, mean difference 1% (SD0.7%), none of these were clinically significant Post-intervention Significant improvement in patients with complete TBSA data ($p < 0.001$) Reduction in clinically significant discrepancies (10% vs 31%, $p = 0.002$) Intervention: common clinical assessment instrument (Lund and Browder form) and educational outreach
Naumeri[65] 2018 Pakistan	21	Absolute difference	93 (82%)	Mean TBSA: 37.8% (SD 19.6%)	Mean TBSA: 33.4% (SD 17.4%) Correctly assessed: 11/21 (52%)	There was a discrepancy between the assessments in 103 (90.4% cases.
Nguyen[58] 2002 Vietnam	611	Absolute difference	84/695 (12%)		Correctly assessed: 14%	

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Table 2 – (*continued*)

Author year country	Number of patients with complete TBSA data	Accuracy	Number of patients with incomplete TBSA data	Results Initial evaluation n/n (%)	Burn centre evaluation n/n (%)	Comments
Sadideen[52] 2017 UK	46	Absolute difference	19/65 (29%)	Mean TBSA: 21% (range 7.5–44)	Mean TBSA: 16% (range 10–41) $p < 0.05$ Correctly assessed: 7/46 (15%) Underestimated: 7/46 (15%) Overestimated: 32/46 (70%)	Mean error: 5% The overestimated patients were overestimated by a range of 3–15% and the underestimated patients were underestimated by a range of 3–25%. There was no correlation between error and size of TBSA Flame burns were more accurately assessed than scalds ($p < 0.05$)
Saffle[66] 2004 USA	169	Absolute difference	56/225 (25%)	Mean TBSA: 29% (SEM 2)	Mean TBSA: 20 (SEM 2)	Mean error: 9%
Swords[53] 2015 USA	201	Absolute difference Overestimation was defined as > 5% When TBSA was documented as a range, the mean was recorded	58/298 (19%)	Mean TBSA: 15.5% (SD 11.8)	Mean TBSA: 9.5 (SD8.3) $p < 0.0001$ Correctly assessed: 97/201 (48.3%) Underestimated: 5/201 (2.5%) Overestimated 99/201 (49.3%)	The average difference was 103.7% Overestimation was more common in the groups < 10% TBSA and 10–19.9% TBSA than in the > 20% TBSA.
Wong[54] 2002 Australia	108	NR	NR		Correctly assessed: 44/108 (41%)	There was no difference in correct initial assessment between the two time periods (39% vs 42%, p = 0.76)

IQR= interquartile range
NR= not reported
SEM = standard error of the mean
SD= standard deviation
*Only percentages were given in the original article. The authors of the present review have calculated the actual number of patients from that.

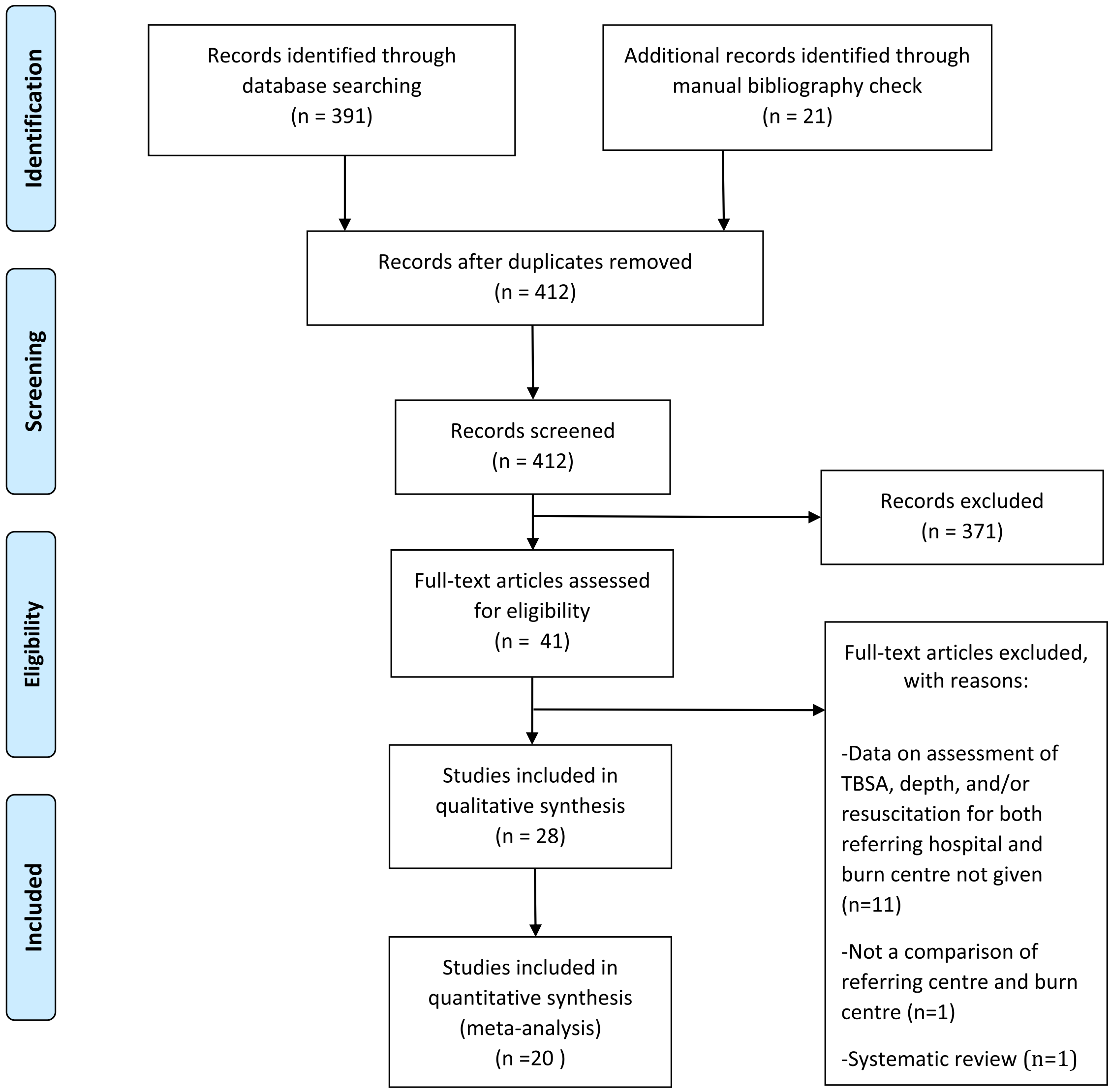

Fig. 1 – PRISMA flow diagram.

twelve fluid resuscitation (Table 3). All included studies were cross-sectional studies, most of them comprising retrospectively enrolled consecutive patients over a specific period. Only two studies [37,38] were prospective, and one study had a mix of retro- and prospective sampling [39]. Twenty studies [5,7,37–54], with a total of 3010 patients, were designed to analyse the test accuracy of the evaluation of burns, comparing the results from the referring institution to the results from the burn centre, while the other eight studies had other primary scopes (Table 1). Two studies included only adult patients, 10 only children (defined as < 14, > 16 or < 18 years of age), four studies had a proportion of children, ranging from 5.7 to 51 per cent, and 12 studies did not report the proportion of children included (Table 1). The range of reference %TBSA reported by the studies were 0,25–100 [37,55].

3.3. *Result of individual studies and synthesis of results*

All twenty-eight studies reporting accuracy of %TBSA (Table 2) showed a low agreement between %TBSA calculations made at referring units and at burn centres. In the twenty studies [5,7,37–54] that compared the results from the referring institution to the results from the burn centre, the proportion of overestimation of %TBSA was very high. Twelve of the studies showed a proportion of 50% or higher (range 16–94%) (Fig. 2). The proportion of underestimations were considerably smaller (range 2–45%) (Fig. 3). The size of overestimation varied. For example, one study presented a ratio of overestimation to underestimation of 19:1, and of overestimation to correct estimation of 4:1 [5], whereas another found that the referring unit overestimated the pediatric injuries by 100% [39]. There seems to be a tendency to

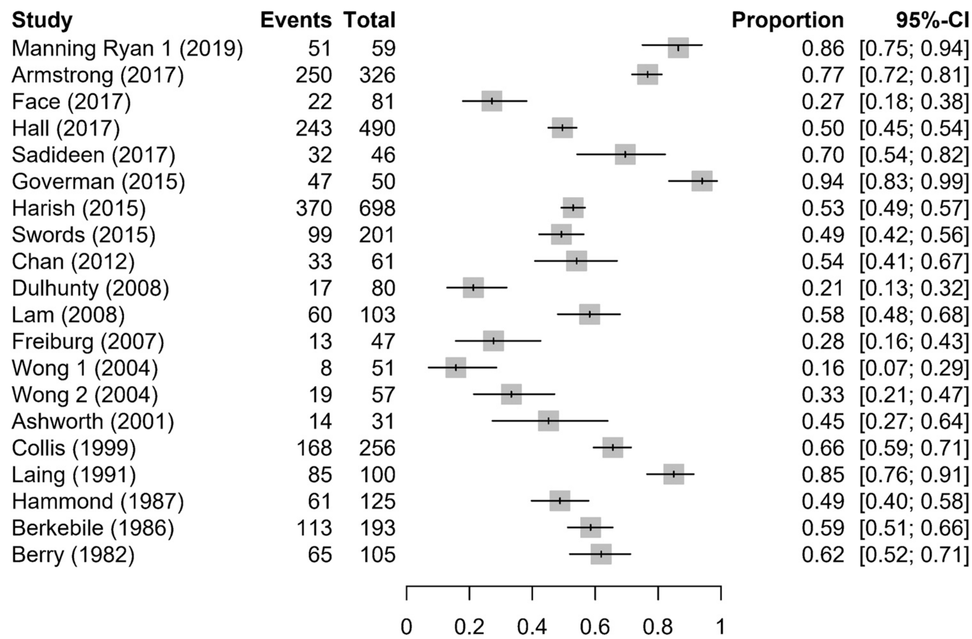

Fig. 2 – Forest plot of studies comparing TBSA% in referring hospitals and burn centres, overestimation.

assess more extensive burns more accurately. For example, two studies concluded that more extensive burns (TBSA > 20% [49]) are more accurately estimated than more minor burns [5,49] and one study concluded that the difference in burn estimates tend to be more extreme at smaller burn sizes [55]. Moreover, one study reported a tendency to over-estimate and over-resuscitate smaller burns and under-estimate and under-resuscitate larger burns [7] and another pointed out that underestimation rises with increasing time from injury and increasing %TBSA [49]. The study comparing the estimation of burn depth between referring hospital and burn centre found that 55% (n = 27) of the estimates were equal to the estimates from the burn centre [50].

Twelve studies compared the fluid resuscitation at the referring hospital and the burn centre (Table 3) [7,37,39,40,44,47,52,53,55–58]. In accordance with the over-estimation of %TBSA (Table 2), most of the included studies showed a tendency to over-resuscitate the patients. Due to the low number of studies and the different formats in which the fluid resuscitation was compared, no meaningful meta-analyses could be done.

3.4. *Overall certainty of evidence*

The overall certainty of evidence was low (GRADE ⊕⊕⊖⊖) for the accuracy of clinical estimations of %TBSA in referring centres, very low (GRADE ⊕⊖⊖⊖) for the accuracy of clinical estimations of burn depth in referring centres and very low (GRADE ⊕⊖⊖⊖) for accuracy of fluid resuscitation in referring centres was. Explanations of how studies are rated down are given below.

3.5. *Risk of bias*

Although the patients were consecutively enrolled, the retrospective design could lead to missing data and the QUADAS-2 score was rated down if more than 30% of patients were excluded. Different assessors performed both the index tests and the reference standard tests, probably using various assessment techniques, giving rise to another possible bias. Possible confounding factors, that could have affected the assessment, such as time from injury to presentation (that is time between index and reference test), the patient's age, involved body areas, and causal agents, were seldom mentioned, and could have introduced a bias as a burn injury is dynamic in its nature. Moreover, different definitions of over- and underestimations were applied, and most studies did not state how the statistical analyses had been performed. In summary, there was a critical risk for bias across the studies and we rated down according to Table 4.

3.6. *Indirectness*

The cohorts of the studies included most of the possible test settings and the entire spectrum of burn injuries in all types of patients, compatible with a real-life setting and therefore the risk for indirectness is very low. We did not rate down for indirectness.

3.7. *Inconsistency*

The results comparing %TBSA showed a high degree of consistency. All study populations except one [54] showed a

Table 3 – Included studies fluid resuscitation.

Author year country	Accuracy	Number of patients with complete fluid data	Number of patients with incomplete fluid data	Results Initial evaluation	Comments	Burn centre evaluation n/n (%)
Ashworth[40] 2001 UK		25	6/31 (19%)		Adequately resuscitated: 10/26 (38%)	7 patients were resuscitated using the Muir Barclay formula but with Hartmann's solution and 6 using the Parkland formula with other crystalloids
Baartmans[39] 2012 The Netherlands	Absolute difference Fluid resuscitation was not evaluated in patients referred from GPs	76	No data:58/567 (10%) Insufficient data: About 37%	Given fluids (ml) mean (SD) TBSA < 10% (n = 16): 327 (259) TBSA referred > 10%; burn centre < 10% (n = 40): 340 (318) TBSA > 10% (n = 21): 677 (879)	Calculated fluids (ml) mean (SD) TBSA (n = 16) < 10%: 0 (0) TBSA referred > 10%; burn centre < 10% (n = 40): 0 (0) TBSA > 10% (n = 21): 695 (646) $p < 0.05$	Mean difference (ml) mean (SD) TBSA < 10% (n = 16): 327 (259) (range 100–1120) TBSA referred > 10%; burn centre < 10% (n = 40): 340 (318) (range 30–1500) TBSA > 10% (n = 21): -18 (567) (range −1544 to 951)
Carter[56] 2018 USA					< 10% TBSA: 41% given fluid bolus 10–20% TBSA: 55% given fluid bolus > 20% TBSA: 58% given fluid bolus	Only a description of which patients were given fluid boluses compared to guidelines (only indicated when TBSA % > 20)
Collis[44] 1999 UK	Between 76% and 125% of the amount calculated by the burn centre was considered correct	247	9/256 (3.5%)		Adequately resuscitated: 59/247 (24%) Overresuscitated: 136/247 (55%) Underresuscitated: 52/247 (21%)	Burns under 20% TBSA received more than 125% of calculated fluid Burns over 21% TBSA 28% received less than 75% of the calculated fluids and 42% more than 125% According to the resuscitation formula, the mean fluid based on the initial assessment was 145% of what should have been given. When the burn centre assessment is applied, it rises to 204% with 55% of patients receiving more than 125% of recommended fluids.
Dulhunty[57] 2008 Australia		80		NA	NA	Only a description of what was done: Parkland formula used: 65/80 3 ml/kg/TBSA: 4/80 No formula: 11/80
Freiburg[7] 2007 USA	A difference of < 500 ml was considered correct	53	29/82 (35%)	1	Correctly resuscitated: 21/53 (39%) Underresuscitated: 12/53 (23%) Overresuscitated: 20/53 (38%)	Correlation between given by referring hospital and calculated fluid by the burn centre: r = 0.65, $p < 0.0001$
Goverman[37] 2015 USA	Absolute difference	50	NR		Overresuscitated: 29/50 (59%)	

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Table 3 – (*continued*)

Author year country	Accuracy	Number of patients with complete fluid data	Number of patients with incomplete fluid data	Results Initial evaluation	Comments	Burn centre evaluation n/n (%)
Hagstrom[47] 2003 USA	Absolute difference	41	NR		Adequately resuscitated 10/41 (24%) Overrescusitated: 12/41 (29%) Underresuscitated: 19/41 (46%)	1 patient was "critically overresuscitated" and 5 "critically underresuscitated" A total of 6 patients (15%), "grossly over- or underresuscitated" (the notions were not defined)
Klein[55] 2007 USA	Absolute difference Predicted volume vs actual fluids given	424	NR	Mean fluids received: 2872 ml (SD 2857)	Mean calculated fluids: 2930 ml (SD 5397) P = 0.826	The average difference between predicted and actual fluids was 1900 ml (SD 3300)
Nguyen[58] 2002 Vietnam	A volume within 15% of estimate according to Parkland formula + maintenance fluid was considered correct	695			Adequately resuscitated 363/695 (52%) Not adequately resuscitated 332/695 (48%)	Adequately resuscitated patients had a significantly lower risk of hypovolemic shock (OR 0076, 95%CI 0011–0,53, p = 0,01) and death (OR 0065, 95% CI 0012–0,36 p = 0002)
Sadideen[52] 2017 UK	Absolute difference	46	NR		TBSA overestimated Adequately resuscitated: 3/32 (9%) Overresuscitated: 5/32 (16%) Underresuscitated: 24/32 (75%)	Data are only given for patients with an overestimated TBSA at the referring hospital
Swords[53] 2015 USA	Absolute difference	201	NR		TBSA correctly estimated Adequately resuscitated: 49/97 (50.5%) Overresuscitated: 24/97 (24.7%) Underresuscitated: 24/97 (24.7%) TBSA overestiamted by > 5% Adequately resuscitated: 49/99 (49.5%) Overresuscitated: 41/99 (41.4) Underresuscitated: 9/99 (9.3%) TBSA underestimated by > 5% Adequately resuscitated: 2/5 (40%) Overresuscitated: 2/5 (40%) Underresuscitated: 1/5 (20%)	There was a statistically significant association between over-estimation and overresuscitation by 10 ml/kg or greater (p = 0.02)

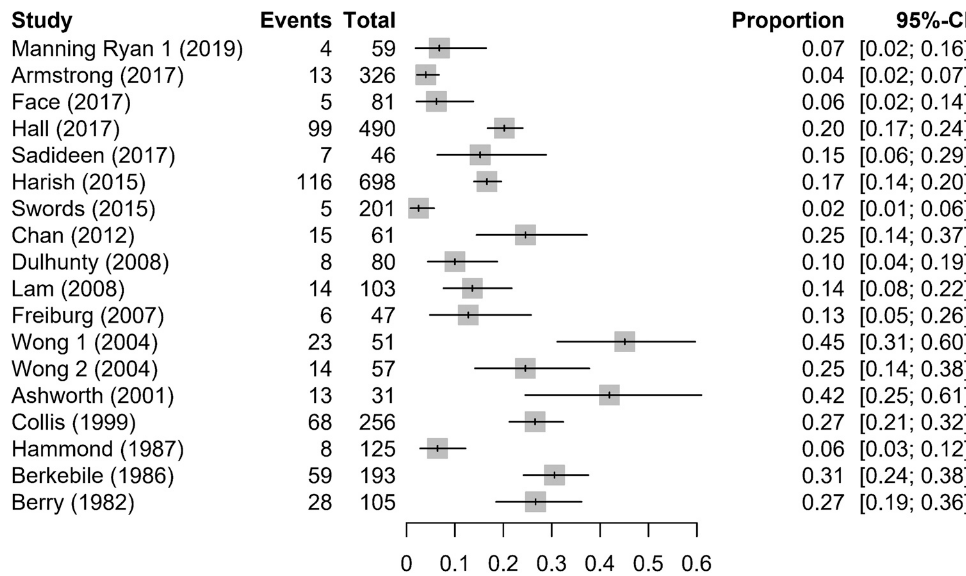

Fig. 3 – Forest plot of studies comparing TBSA% in referring hospitals and burn centres, underestimation.

higher degree of overestimation compared to underestimation (Figs. 2 and 3), although confidence intervals seldom were given (except for in study [43,49]). The overall risk for inconsistency is very low, and we did not rate down for inconsistency.

3.8. *Imprecision*

The cohorts are case series with a small number of patients, and sample size calculations were missing in all studies except one [7]. The risk for imprecision problems was high and all studies were rated down due to this.

3.9. *Publication bias*

All the studies were conducted by burn surgeons and published in surgical journals, but the risk of bias arising from expertise was considered low, since the studies did not address which assessment was the most accurate. None of the studies were industry sponsored. The risk for publication bias was low and we did not rate down for this.

4. Discussion

This is the first systematic review that investigates agreement of the clinical evaluations of %TBSA, burn depth, and resuscitation between referring centres and burn centres and examines the certainty of evidence. A total of 28 studies were included. The main finding is that a majority of included studies demonstrate that overestimation of %TBSA at referring hospitals occurs in more than half of the patients transferred to a burn centre. The overall certainty of evidence for accuracy of clinical estimation in referring centres is low (GRADE ⊕⊕⊖⊖) for %TBSA and very low (GRADE ⊕⊖⊖⊖) for burn depth and resuscitation.

4.1. *Considerations regarding the results and previous findings*

In line with previous reports, we found that a very high proportion of patients transferred to burn centres seem to have an overestimated %TBSA from the referring institutions [4,61] [3,62], and that there is a strong trend of overestimating %TBSA in more minor injuries and underestimating it in more extensive injuries [5]. This combined with the finding that the overestimates outnumbered the underestimates, in all studies except one [54], strengthens the findings. Nonetheless, better quality studies are needed to explore the reasons for the overestimations and how better results can be achieved.

4.2. *Considerations regarding the certainty of evidence*

The retrospective design of majority of studies could have affected the results[59]. A lack of information on who evaluated the burns and on the clinical evaluation methods means that we do not know whether or not the comparisons were apt. Accuracy of clinical burn evaluation is highly dependent on both the evaluator's clinical experience with burns [60], on the clinical evaluation method used [19], and on how the clinical method is interpreted [21]. For example, the rule of nine often overestimates TBSA% more than Lund and Browder charts [19] and palmar surface measurement, 'the rule of palm', is infamous for being interpreted in different ways [21]. The natural course of burns, where depth tends to develop over time, also makes it difficult to obtain meaningful results regarding depth assessment. A few of the authors of the included studies commented that this was why they had not included depth as a study variable. Moreover, as the data was collected a part of routine practice without a specific study design for the burn centre assessment, there was a lack of blinding in all the included studies.

Table 4 – QUADAS-2 results.

	Risk of bias				Applicability concerns		
	Patient selection	Index test	Reference standard	Flow and timing	Patient selection	Index test	Reference standard
Armstrong	☹	☺	☹	☹	☺	☺	☺
Ashworth	☺	☺	☹	?	☺	☺	☺
Baartmans 1	☺	☺	☹	?	☺	☺	☺
Baartmans 2	☺	☺	☹	?	☺	☺	☺
Berkebile	☹	☺	☹	☹	☺	☺	☺
Berry	☹	☺	☹	☹	☺	☺	☺
Carter	☹	☺	☹	?	☺	☺	☺
Chan	☺	☺	☹	?	☺	☺	☺
Collis	☺	☺	☹	?	☺	☺	☺
Dulhunty	☺	☺	☹	?	☺	☺	☺
Face	☺	☺	☹	?	☺	☺	☺
Freiburg	☺	☺	☹	?	☺	☺	☺
Frost	☹	☺	☹	☹	☺	☺	☺
Goverman	☺	☺	☹	?	☺	☺	☺
Hagstrom	☺	☺	☹	?	☺	☺	☺
Hall	☺	☺	☹	?	☺	☺	☺
Hammond	☺	☺	☹	☺	☺	☺	☺
Harish	☺	☺	☹	?	☺	☺	☺
Irwin	☹	☺	☹	?	☺	☺	☺
Klein	☺	☺	☹	?	☺	☺	☺
Laing	☺	☺	☹	?	☺	☺	☺
Lam	☺	☺	☹	?	☺	☺	☺
Manning Ryan 1	☹	☺	☹	?	☺	☺	☺
Manning Ryan 2	☺	☺	☹	?	☺	☺	☺
Naumeri	☹	☺	☹	☹	☺	☺	☺
Nguyen	☺	☺	☹	?	☺	☺	☺
Sadideen	☺	☺	☹	?	☺	☺	☺
Saffle	☺	☺	☹	?	☺	☺	☺
Swords	☺	☺	☹	?	☺	☺	☺
Wong 1	☺	☺	☹	?	☺	☺	☺
Wong 2	☺	☺	☹	?	☺	☺	☺

low risk = ☺, high risk = ☹, unclear risk = ?

There was a considerable amount of missing data in many of the studies, both from the referring institution but also from the burn centre and this could have affected the results.

For example, it could be hypothesised that calculations are more likely to be missing for very small or extensive injuries, or for specific injury mechanisms.

4.3. *Considerations regarding the strengths and limitations of the present study*

There are no specific guidelines for quality assessment of studies assessing clinical evaluation of burns. The GRADE guidelines for assessing the body of evidence for test accuracy were considered the most methodologically apt [28,29]. Studies analysing test accuracy should ideally include patients with an uncertain diagnosis and be performed in a standardised fashion [28,29]. However, when considering %TBSA assessments, standardisation is challenged by the heterogeneity of real-life populations of burn patients. As all the studies included 'real life' data from significant catchment areas, it can be assumed that there were more evaluators involved in the referring units than in the burn centres. Moreover, the referring evaluators were likely considerably less experienced in assessing burns, sometimes even novice, than the burn centre evaluators. Hence, the index and reference test were not defined by the method used but rather according to which setting they were performed in – a hospital with a low volume of burns or a high-volume burn centre. It was presumed that the people performing the index tests were inexperienced assessors of burn and that the people performing the reference standard tests were experienced. However, 'real life' data can also be considered a strength, as it reflects the actual situation and probably gives valuable data for comparison that a clinical trial on accuracy could easily miss.

4.4. *Conclusions and clinical implications*

The overall certainty of evidence for accuracy of clinical estimation in referring centres is low (GRADE ⊕⊕⊖⊖) for %TBSA and very low (GRADE ⊕⊖⊖⊖) for burn depth and resuscitation. Overestimation of %TBSA at referring hospitals occurs in a very high proportion of the patients transferred to a burn centre, even though underestimation also occurs. Further studies on why overestimations occur are needed, to enable improvement. A prospective study design could allow for standardised assessment at standardised time points and blinding of the burn centre evaluator, as well as facilitate a better documentation. Moreover, adequate sample calculations and data treatment could have been performed.

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Declarations of interest

None.

Availability of Data

The templates for data collection, data extracted from included studies and other materials can be made available upon request. Please contact corresponding author Ragnvald Brekke.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.burns.2022.05.007.

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