Epidemiology of burns

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Chapter 2

Epidemiology and trends in severe burns in the Netherlands

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ABSTRACT

Introduction: The aim of this study was to characterize the epidemiology of severe burns in the Netherlands, including trends in burn centre admissions, non-burn centre admissions and differences by age.

Methods: Patients with burn-related primary admission in a Dutch centre from 1995 to 2011were included. Nationwide prospectively collected data were used from three separate historical databases and the uniform Dutch Burn Repository R3 (2009 onwards). General hospital data were derived from the National Hospital Discharge Register. Age and gender-adjusted rates were calculated by direct standardization, using the 2005 population as the reference standard.

Results: The annual number of admitted patients increased from 430 in 1995 to 747 in 2011, incidence rates increased from 2.72 to 4.66 per 100,000. Incidence rates were high in young children, aged 0–4 years and doubled from 10.26 to 22.96 per 100,000. Incidence rates in personsfrom 5 up to 59 increased as well, in older adults (60 years and older) admission rates were stable. Overall burn centre mortality rate was 4.1%, and significantly decreased over time.
There was a trend towards admissions of less extensive burns, median total burned surface area (TBSA) decreased from 8% to 4%. Length of stay and length of stay per percent TBSA decreased over time as well.

Conclusions: Data on 9031 patients admitted in a 17-year period showed an increasing incidence rate of burn-related burn centre admissions, with a decreasing TBSA and decreasing in-burn centre mortality.
These data are important for prevention and establishment of required burn care capacity.

1. INTRODUCTION

The epidemiology of burns has been described in multiple publications, traditionally based on data from one burn centre.

In the past decade, publications have become available describing the epidemiology of burns in a series of burn centres from one country, for instance from Germany [1] or the USA [2]. In addition, nationwide data were published on burnrelated Emergency Department (ED) treatments from North

Carolina, USA [3] and hospital admissions from Norway [4], Sweden [5], China [6]. In some publications several health care settings are included, for instance emergency department presentations, hospital admissions and injury mortality in a paper on data from Victoria, Australia [7].

Nationwide data on burn centre admissions are scarce, because of the necessary participation of all burn centres in one data repository. In the Netherlands, a uniform nationwide burn centre registration was established in 2009, including the three burn centres, with 100% coverage of admitted burn centre patients. The Dutch Burn Repository R3 was combined with the historical databases from each burn centre to investigate the epidemiology of burns in the past decades.

Up to now, a few mostly outdated publications presented incidence rates, on medically treated burns including Dutch burn centres [8] and on burn-related ED treatments and hospital treatments [9]. Recent publications addressed the epidemiology of specific risk groups, i.e. children [10] and patients with facial burns [11]. A recent complete overview however, including nationwide incidence rates on burn centre admissions and trends, is still lacking.

Recently, Brusselaers et al. [12] and Peck [13] reviewed the epidemiology of burns in Europe and worldwide. Both reviewers conclude there is a decline in burn incidence and in burn severity in high-income countries. In low and middle income countries mixed trends are described [14].

In the Netherlands, criteria for referral to a burn centre were introduced in 1980 [15], but were used as an advise [10]. In 1998 the course Emergency Management of Severe Burns (EMSB) was introduced, with new referral criteria [16]. These criteria were more compulsory and nowadays well adopted in the Netherlands [10]. All children with burns over 5% and adults with burns over 10% TBSA are advised to be referred Additional referral criteria are largely similar to the ABA referral criteria (see Table 1).

The aim of this study is to characterize the epidemiology of severe burns in the Netherlands, including trends in burn centre admissions, non-burn centre admissions and differences by age.

First, trends are described in number of burn centre admissions, burn size, length of stay, time to first surgery and mortality. Trends in burn centre admissions will be compared to burn-related primary hospital admissions in non-specialized burn care hospitals. Next, differences in severe burns by age are described.

Table 1. Criteria for referral to a Dutch burn centre.

Period 1980–1999 [15]
• Burns greater than 25% TBSA in adults or deep burns over 10%TBSA • Burns greater than 10% TBSA in children and elderly, irrespectively the depth Minor burns associated with another injury or pre-existent disease that may increase the risk for complications
Period 1998 onwards: EMBS Criteria for referral to a Dutch Burn Centre [16]
• Burns greater than 10% Total Body Surface Area (TBSA) in adults. • Burns greater than 5% TBSA in children. • Burns of special areas–face, hands, feet, perineum, genitalia and major joints. • Full thickness burns greater than 5% TBSA. • Electrical burns. • Chemical burns. • Burns with associated inhalation injury. • Circumferential burns of the limbs or chest. • Burns at the extremes of age – children and the elderly. • Burn in patients with pre-existing medical disorders which could complicate management and prolong recovery or effect mortality. • Any burn patient with associated trauma.

2. METHODS

2.1. Patients and setting specialized burn care

All patients with a burn-related primary (i.e. first) admission in a burn centre in the Netherlands from 1 January 1995 to 31 December 2011 were included. In the Netherlands (population 2011: 16.75 million, area 41,528 km^2), three burn centres deliver specialized burn care (Red Cross Hospital Beverwijk, Martini Hospital Groningen and Maasstad Hospital Rotterdam) with a total of 65 beds, including 11 ICU beds. In 1995 42 beds, and from 2001 onwards a total of 60 beds was available.

To compare trends in specialized burn care to trends in non-specialized burn care, data on burn related admissions in general hospitals in this study period were derived from the National Hospital Discharge Register (NHDR).

2.2. Data collection

Data on specialized burn care were prospectively collected in separate databases, by burn care professionals in each Dutch burn centre from 1995 to 2008. From 2009 onwards the uniform Dutch Burn Repository R3 is used in all three burn centres.

The Dutch Burn Repository R3 is an extensive database including data on all admitted patients in specialized burn care, including patients for reconstructive surgery after burns. The database is filled by dedicated burn care professionals, and quality monitoring by a coordinator and improvement is formally organized. The Dutch Burn Repository is supported by the participating hospitals, the Association of Dutch Burn Centres (ADBC) and the Dutch Burns Foundation.

The historical databases of each burn centre were combined, after permission of relevant representatives from the three burn centres. Next, the historical database was merged with the Dutch Burn Repository into one nation-wide database including 17 years of specialized burn care with data on numbers and characteristics of patient (age, gender) injury (aetiology, referral, the total body surface area (TBSA), inhalation injury (based on clinical diagnosis), treatment (surgery, mechanical ventilation), and outcome (length of stay and mortality).

Data collection and use of the Dutch Burn Repository R3 and its predecessors were conducted with approval of participating hospitals and the relevant medical ethical committees.

Information on burn related admissions in non-specialized burn care was derived from the National Hospital Discharge Register (NHDR). All primary burn related admissions were extracted, using the International Classification of Diseases (ICD-9) codes 940–949 from 131 Dutch hospital locations with 105 ED's in 2011. A selection was made of all primary burn related hospital admissions in non-specialized burn care excluding primary admissions in specialized burn care, to compare with the admission numbers in specialized burn care. Data from NHDR were not directly accessible and therefore information by 5 age groups, but no digital data, was obtained on demand from the Consumer Safety Institute, Amsterdam, the Netherlands.

2.3. Statistical analyses

Incidence density rates, the number of burn-related admissions in a Dutch burn centre in an age category in one year, divided by the total number of persons at risk in this age category in the Netherlands in the same year, were calculated. The denominator data refer to the population at July 1st of a specific year, using the mean of the population at January 1st that year and the population at January 1st of the following year. Incidence rates were calculated, using population data from Statistics Netherlands [17].

Subsequently, using direct standardization, age- and gender-adjusted rates were calculated to control for changes in the Dutch population related to age and gender. Data were categorized into 10 age/sex groups. Weighting the age- and gender-specific rates with the 2005 Dutch population, age- and gender-adjusted burn incidence rates per 100,000 persons years were obtained.
No gender specific NHDR data were available; thus comparison of admission rates between burn centre hospitals and general hospitals were based on age-standardized data (instead of age, gender standardized data). 95% Confidence intervals (95%CI) were calculated using Byar's method [18].
The incidence rate ratio (IRR) for male/female incidences and 95%CI were calculated using Poisson regression model, adjusted for age and admission year. To identify trends in incidence rates, Joinpoint regression model and permutation tests were performed, expressed in annual percentage of change and 95%CI [19]. Length of stay was calculated by the difference in days between admission and discharge (i.e. overnight stay). Kruskal–Wallis test was performed to test for trends in length of stay, TBSA and length of stay per % TBSA. Analysis of variance was performed to test for trends in time to first surgery. Differences between age groups were tested by x^2 test (aetiology, place of occurrence, TBSA, ICU stay (yes/no), surgery (yes/no) mortality and mode of discharge), Kruskal–Wallis test (median length of stay) and analysis of variance (time to first surgery).
Analyses were performed using Joinpoint Regression Programme, Version 3.5 [20] Joint point (regression and permutation test) and standard statistical programmes (SPSS v 19, PASW statistics 18 and Excel).

3. RESULTS

3.1. Trends in burn centre admissions

A total of 9031 patients had a burn-related primary admission in a Dutch burn centre in the Netherlands from 1995 to 2011. The mean annual number of admitted patients was 531 and increased from 430 in 1995 to 747 in 2011. The standardized incidence rates increased from 2.72 to 4.66 cases per 100,000 population (see Fig.1), with an annual increase of 2.7% (95%CI 1.9; 3.4).
Overall, males outnumbered the females in burn centre admissions (65.0% versus 35.0%), the standardized IRR was 1.86 (95%CI 1.74; 1.99). In men, standardized incidence rates increased from 3.36 to 6.13 per 100,000 men in 2011, with an annual increase of 3.3% (95%CI 2.4–4.1). In women, incidence rates increased from 2.10 to 3.22 per 100,000 women in 2011. Trend analysis indicated a change in trend in 2008 ($p < 0.05$).

A stable incidence rate for women was found up to 2008 (annual percentage of change 0.3; 95%CI -0.7; 13); from 2008 onwards an annual increase was observed (annual percentage of change 13.4; 95%CI -3.0; 24.9).
The incidence rates of severe burns were strongly correlated to age groups. Infants and children <5 years of age were the most frequently admitted age category in our centres. The incidence rate was 15.31 per 100,000 children in young children (0–4), compared to incidence rates between 2.00 (age 60 years and over) and 2.89 (20–39 years) per 100,000 in other age categories (see Fig.2)

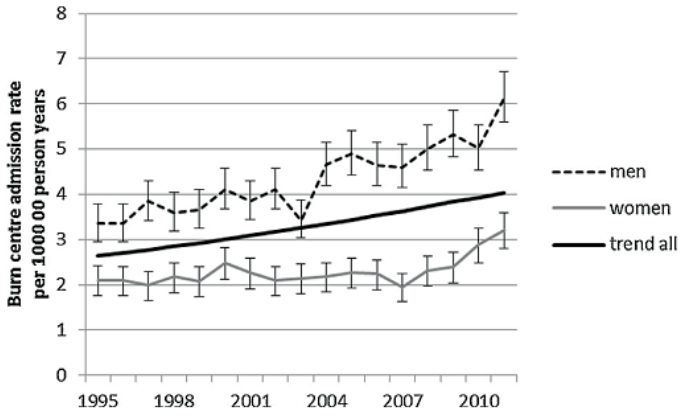

Fig. 1 – Trends in burn centre admissions, by gender (standardized incidence rates).

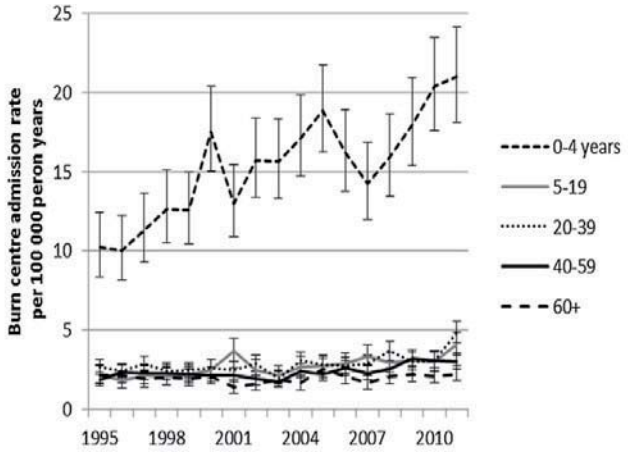

Fig. 2 – Trends in burn centre admissions, by age (standardized incidence rates).

Incidence rates in young children doubled in the study period, from to 10.26 in 1995 to 20.96 per 100,000 in 2011; with an average annual increase of 3.9% (95%CI 2.61; 5.2). Incidence rates in persons up to 59 increased as well, from 2.19 to 4.09 per 100,000 per year in children aged 5–19 (annual percentage of change 3.5%; 95%CI 1.9; 5.0) in young adults (20–39) from 2.69 to 4.85 per 100,000 per year (annual percentage of change 2.5%; 95%CI 0.8; 4.1) and in middle aged adults from 1.88 to 3.01(annual percentage of change 2.2%; 95%CI 0.9; 3.6). In older adults no change was observed (annual percentage of change 0.4; 95%CI - 1.2; 2.0).

3.2. Trends in burn-related hospital admissions

The total number of acute burn-related hospital admissions in the Netherlands varied between 1080 and 1340 admission a year. This included data from both general hospitals as well as specialized burn care. A peak was observed in 2001, after the Volendam fire disaster [21] (see Fig.3).

Overall burn related admission rates showed a mixed trend: after a significant downward trend up to 2008 (annual percentage of change -1.0; 95%CI -2.0; -0.1), a trend upwards was observed up to an incidence of 8.50 primary admissions per 100,000 persons years in 2011(annual percentage of change 7.3; 95%CI 2.2; 17.7).

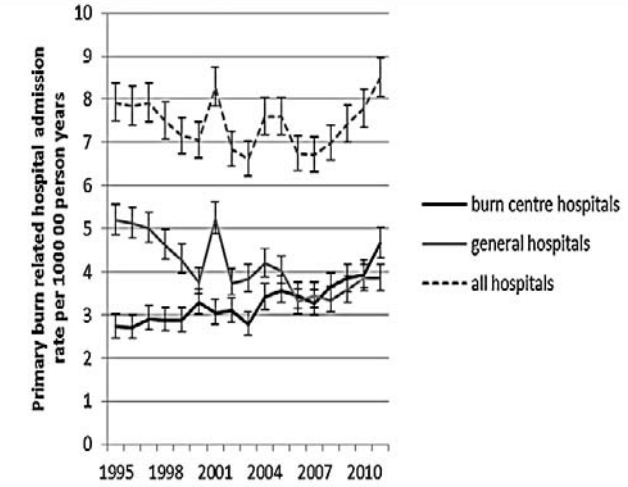

Fig. 3 – Trends in burn-related primary hospital admissions in specialized burn care versus general hospitals (standardized incidence rates).

However, trend analyses for specialize burn care versus general hospitals showed uniform trends: a decrease in non-specialized burn care and an increase in specialized burn care admissions (annual percent of change -2.3; 95%CI -3.4; -1.3 and 2.7; 95%CI 1.9; 3.4, respectively (Fig.3). The proportion of burn-related hospital admissions in specialized burn care increased from 34% in 1995 to 55% in 2011.

3.3. Trends in burn centre aetiology

The most prevalent causes of burns in recent burn centre admissions were both scalds and flames; after a dominance of flame burns in the1990s (Fig.4). Fat burns were the third major aetiology in the past five years, accounting for 6.7% of the admissions in the past five years. Admission rates of scalds increased 4.9% annually (95%CI 3.5; 6.3); flame burns were stable (annual percent of change 0.8; 95%CI -0.4; 1.9). Admission rates of burns by hot fat/oil and chemical burns increased over time, to 6.7 and 4.1% of the admissions in the past five years with estimated annual increases of 5.3% (95%CI 2.8; -7.8) and 14.0% (95%CI 8.6; 19.7). Admission rates of contact burns were small and stable up to 2006, afterwards rose to a 5.3% of the admissions in the past five years, with an estimated annual increase of 24.7% (95% CI 7.2; 45.2).

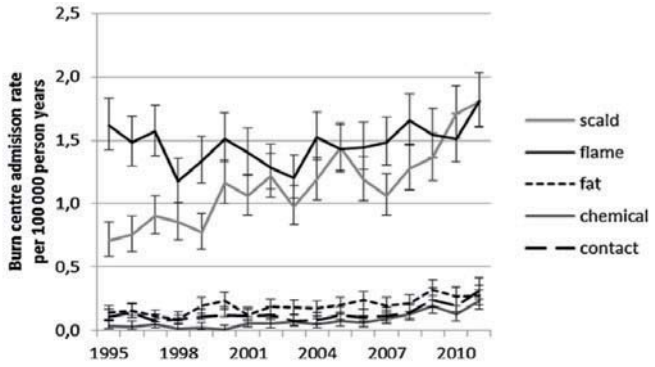

Fig. 4 – Trends in burn centre admissions, by aetiology (standardized incidence rates).

3.4. Trends in burn centre burn severity

Overall burn severity in admitted patients, as assessed by percentage TBSA, reduced over time; the median TBSA in admitted patients decreased from 8 to 4%.
Incidence rates of burns <10% TBSA increased, from 1.46 to 3.62 per 100,000 per year, with an annual increase of 5.1% (95%CI 4.2; 6.0) (Fig.5). In the past 5 years 80.0% of the patients

had a TBSA <10%. Incidence rate of moderate (TBSA ≥10%, <20%) and severe burns (TBSA ≥20%) reduced over time (annual percent of change -3.0; 95%CI -4.3; -1.80 and -3.5; 95%CI -4.6; -2.3, respectively), but seemed to stabilize in recent years.

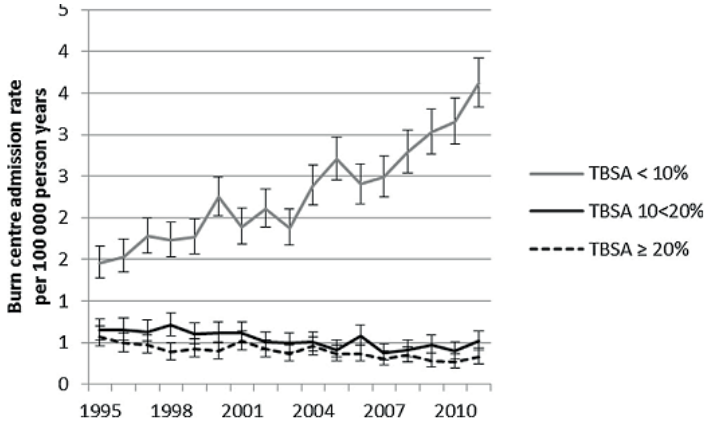

Fig. 5 – Trends in burn centre admissions, by TBSA (standardized incidence rates).

3.5. Trends in burn centre treatment

The median length of stay decreased over time from 15 days in 1995 to 5 days in 2011 ($p < 0.001$). Both overall and in all specific age groups. The mean length of stay decreased from 23 to 11 days. The median length of stay per percent TBSA did change as well, from 1.7 days in 1995 to 1.0 day in 2011 (Kruskall–Wallis test, $p < 0.001$).

The mean time to first surgery was 14.7 days post burn (SD10.0). No trend was observed (ANOVA, $p = .427$).

3.6. Trends in burn centre mortality

Mortality rate in admitted patients was 4.1% (n = 371). The majority of the patients died after flame burns (85.8%) (Fig.6). This applied to all age categories except the young children (not shown). In these children mortality occurred both after scalds (n = 4) and flame burns (n = 4). Standardized mortality rates significantly decreased over time, in the total population with an annual percentage of change of -4.1% (95%CI -6.2; -2.0) (Fig.6) and in men and women separately (annual percentage of change -5.0%, 95% CI -7.9; -2.2 and -2.9(95%CI -5.8; -0.0).

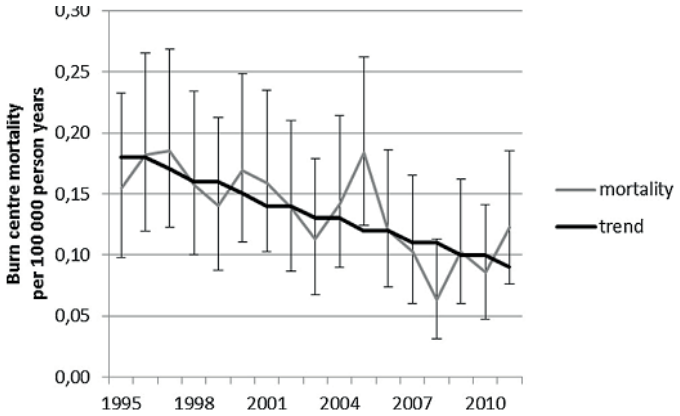

Fig. 6 – Trend in burn centre mortality (standardized mortality rates).

Standardized mortality rates in elderly patients (60+) significantly decreased over time, (annual percent of change -6.3% (95%CI -9.5; -3.0); but not in patients aged 40–59 (annual percentage of change -2.2%, 95%CI -6.4; 2.1). younger age categories were not analyzed because of small numbers of deceased patients.
Known risk factors for mortality: age, TBSA and inhalation injury remained stable over time. The overall mean Baux score of the deceased patients (age + TBSA) was 102 (SD 28) and the mean Revised Baux Score (RBS = age + TBSA + inhalation injury x 17) was 106 (SD 29).
Mortality often occurred in the first days after admission: 40.7% (n = 151) of the deceased patients died on the day of admission or the next day. This included patients receiving only palliative care because of the severity of the burn. The median LOS in deceased patients was 4 days.

3.7. Epidemiology of burn centre admissions by age

Important overall causes of burns resulting in a burn centre admission were flames (46.3%) and scald (35.7%). Scald was the predominant cause of burns in young children admitted to the burn centres (Table 2). In all other ages, flames were the most important cause for burn centre admission (>59.9%). Chemical burns were seen in the working-age population (4.3% in young adults, 4.6% in middle aged adults), contact burns were most prevalent in the elderly (8.5%).
The majority of accidents occurred in the house, especially in young children and in elderly. In children and adolescents (5–19) burns also occurred relatively often in the direct neighbourhood of the house (18.6%). In the working-age population almost one in five admissions was the result of an accident at work or in a business area.

Most young children were admitted with small burns (TBSA <10%, 81.8%). Severe burns (TBSA ≥20%) were rare in young children (3.3%), compared to adults and elderly (>11.9%) (see Table 2).

Table 2 – Burn characteristics of burn centre admissions, by age: 1995–2011 (*n* = 9031).

	Patients		TBSA		Aetiology		Site of occurrence		
	Total	Annual	<10%	≥20%	Scalds	Flame	In house	Around house	Business (area)
	n	*n*	*n* = 2028 (%)	*n* = 81 (%)	*n* = 3111 (%)	*n* = 4035 (%)	*n* = 4478 (%)	*n* = 1357 (%)	*n* = 707 (%)
Age (yr)									
0–4	2534	149	81.8	3.3	84.5	5.4	76.5	14.9	0.4
5–19	1356	80	73.6	11.9	23.8	59.9	41.9	23.4	2.7
20–39	2220	131	65.2	16.4	12.3	64.0	38.1	16.0	18.6
40–59	1855	109	65.7	16.8	14.2	63.8	44.8	15.1	17.0
60+	1065	63	62.9	18.5	19.5	60.2	65.8	15.0	2.0
All ages	9031	531	70.9	12.4	35.7	46.3	54.5	16.5	8.6

Missing values: age (*n* = 1), aetiology (*n* = 319), site of occurrence (*n* = 815), burn size (*n* = 186). *p*-Value aetiology, site of occurrence, TBSA: <0.001.

Some seasonal variation in admission rates was detected ($p < 0.001$). Admission rates were highest in summer months and around the end of the year festivities (data not shown).
Length of stay increased by age, as did the prevalence of surgery. Intensive care was highly prevalent in the young age groups, up to 39.3% in young children (0–4), often comprising the monitoring of IV fluids resuscitation. The timing of surgery did not differ between age groups, with a mean of 14.7 days after the accident (SD 10.0, see Table 3).
Survival was strongly related to the age of the patient and was lowest in patients of 60 years

Table 3 – Treatment characteristics in burn centre admissions, by age: 1995–2011.

Age (yr)	Patients	Length of stay, days		Intensive care	Surgery	Timing of surgery, days post burn	
	n	Median	Mean (SD)	(%)	(%)	*n*	Mean (SD)
0–4	2534	6.0	9.6 (10.8)	39.3	27.6	582	13.9 (7.3)
5–19	1356	8.0	15.8 (22.6)	35.5	46.9	530	15.3 (10.4)
20–39	2220	9.0	17.4 (26.5)	14.3	45.4	843	14.8 (10.1)
40–59	1855	12.0	20.1 (25.3)	15.4	56.5	868	14.8 (10.7)
60+	1065	17.0	23.8 (25.3)	19.2	60.7	557	14.6 (10.9)
All ages	9031	9.0	16.3 (22.6)	25.3	44.7	3380	14.7 (10.0)

Missing values: LOS (*n* = 18), IC (*n* = 195), surgery y/n (*n* = 3), timing of surgery (*n* = 655 of 4035 patients with surgery). *p*-Value LOS, IC, surgery $p < 0.001$ timing of surgery $p = 0.21$.

and over. Most patients were discharged home. With increasing age patients were more frequently discharged to other hospitals and nursing homes. A small proportion of patients was discharged to centres for mental health care and rehabilitation centres (see Table 4).

Table 4 – Mortality and discharge in burn centre admissions, by age: 1995–2011.

Age (yr)	Patients	Mortality	Mode of discharge				
	n	*n* = 371 (%)	Home *n* = 7247 (%)	Hospital *n* = 249 (%)	Nursing home *n* = 133 (%)	Rehabilitation *n* = 101 (%)	Mental health care *n* = 180 (%)
0–4	2534	0.3	97.8	1.5	0.0	0.1	0.0
5–19	1356	0.7	95.3	1.4	0.0	1.6	0.4
20–39	2220	2.9	87.0	3.0	0.2	1.7	3.6
40–59	1855	4.7	80.4	4.4	1.5	2.1	4.6
60+	1065	18.8	58.5	6.1	10.5	0.8	2.1
All ages	9031	4.1	86.6	3.0	1.6	1.2	2.2

Missing value: mode of discharge (*n* = 662). *p*-Value mortality, mode of discharge: <0.001.

4. DISCUSSION

This study characterized the epidemiology and trends of severe burns in the Netherlands, over a 17-year time period. The Dutch Burn Repository and its predecessors were used to create a nationwide dataset comprising all burn centre admissions in our country. Data on 9031 patients admitted in the study period showed an increasing incidence rate of burn-related burn centre admissions, with a decreasing TBSA and decreasing in-burn centre mortality. Data on burn related general hospital admissions showed a decreased incidence rate in non-specialized burn care. In specialized burn care, type of burn, treatment and outcome characteristics varied with specific age categories.

Incidence rates of burn centre admissions increased over time from 2.9 in 1995 to 4.6 per 100,000 person years in 2011. The 1995 data are similar to the incidence rate of 2.9, based on early data from the three Dutch burn centres [8]. International incidence rates of burn centre admissions are hardly reported. Al Shaqsi etal. reported higher burn unit incidence rates, with 7.05 patients per 100,000 in the national burn unit of Oman [22]. Most incidence rates on burns reflect overall hospital admission rates, derived from national hospital discharge registers. Our study showed an incidence rate of primary admissions of 8.5 per 100,000 inhabitants in 2011. This number varies in Europe between 2 and 29 per 100,000 inhabitants [12], in Australia 36 per 100,000 has been reported [23]. In the Netherlands, an overall hospital admission rate, including readmissions of 11 burn related admissions per 100,000 inhabitants was observed in 2010 [24].

Burn centre admissions rates increased over time. These increasing incidences were based on increases in the younger age categories (up to 39 years of age), especially in the youngest children. However, overall burn related hospitals admissions rates (including burn centre admissions) seem to be stable in the Netherlands over the past decade [24].

In a systematic review a declining incidence rate of severe burns needing hospitalization

was described [12]. Several studies reported declining burn-related hospital admission rates, both in low and middle-income countries [14], as well as in high-income countries [25].

Vloemans et al. analyzed the Dutch paediatric burn centre admissions in 1995–2007 and suggested a changing referral pattern in paediatric burns in the Netherlands. The proportion of children admitted to specialized burn centres, rather than general hospitals, increased over time from about 30% in 1995 to almost 50% in 2007 [10]. As shown in our data, this trend continued and applied to most age categories.

The reduction in length of stay over time is in line with described trends in burn care in developed countries [5,23,26,27] and can be explained by the higher admission rates of smaller burns, the use of new treatment techniques [28] and the expanding outpatient facilities in Dutch burn care.

It can be concluded that more and more burn patients are referred to specialized burn care, for assessment and/or treatment. This is in line with the guidelines for the Emergency Management of Severe Burns (EMSB), introduced in the Netherlands in 1998 [10,16]. Referral was now advised in children with 5% TBSA or more (instead of 10% before) and also in case of chemical and contact burns. In addition, there is a trend towards further specialization of health care in general in our country, also because of limited travel distances. The trend towards a growing specialized burn care has been described in other countries as well [29,30]. Vercruysse (USA) et al. suggest that many patients are transferred towards tertiary care facilities because of a lack of basic skills in the assessment and care of burn wounds at community and rural hospitals.

Burn centre mortality rates declined over time. This decline cannot be explained by the lower injury severity of admitted patients; Baux scores were stable over time. Thus, the lower mortality rate is probably the result of improved burn care, including improved resuscitation protocols and intensive

care. Peck described a decline across the world in mortality due to fire and flames [13]. Declines in burn related mortality have been described in several hospital based studies [5,31] and burn centre based studies [26], but not in all studies [1]. Burn centre mortality is only a small part of burn related mortality. In the Netherlands, approximately 75 persons die of burns annually, according to data from fire department statistics [32] and mortality statistics. These patients generally die at the scene of the accident or before they reach specialized burn care.

A seasonal variation was also described by others: studies from several countries in North America, Europe and Asia [3,33–36] describe a peak in summer months. We noticed an additional peak in the winter months December and January, possibly related to the end of year festivities including fireworks and the more frequent use of fireplaces and highly flammable fuels in table cookers.

Patient profiles in burn care were strongly correlated to age groups. For instance, in young children scalds were most prevalent, frequently caused by an accident in house, which resulted in relatively small burns. Extensive burns, over 20% TBSA, were hardly prevalent in young children. Older patients most often suffered from flame burns, after accidents in the house (40%) or at work (18%), which generally resulted in burns of max. 10% TBSA (>60%) but sometimes also in extensive burns (16–19% of the elderly patients). Similar findings are reported by other burn centres in Europe or North America. Future in-depth studies on the epidemiology of specific age groups are planned to reveal detailed information for prevention and quality control.

Mean time to surgery in the Netherlands was 15 days post burn in the past decades, no significant trend was observed. This reflects the current treatment strategy in Dutch burn centres; mixed partial to full thickness wounds are conservatively treated for 10–14 days, followed by excision and split skin auto grafting of the remaining non healed areas [37]. The optimal timing of excision and grafting is subject of ongoing debate [38]. In a recent meta-analysis early excision ranged from <24 h to <144 h post burn [39]. This review of six randomized, controlled trials compared early excision of burns with wound dressing and grafting after eschar separation and found a trend towards a reduction in mortality with early excision and a significant reduction in the length of hospitalization. However, in patients who underwent early excision, blood-transfusion was increased. There was no consistent evidence of reduced sepsis or a better cosmetic or functional outcome with early excision. In the near future a Cochrane review will address this topic [40].

The merit of our Dutch Burn Repository is in the nationwide character and the 100% coverage of burn centre patients. In other countries with larger numbers of burn centres, like the UK, Australia and New Zealand, similar burn centre based registrations have been developed, including data on all patients, outcome and quality of care, but nationwide participation is not always reached [41]. In the USA, the National Burn Repository (NBR) covers 91 of 123 US burn centres, plus 5 centres from Canada and Sweden. In the NBR, burn centre deliver data from convenience samples of patients, not necessary all patients [27].

Some shortcomings of our study have to be mentioned. Data are lacking on outpatient treatments. Data on these outpatient activities of burn centres would add to our knowledge on the whole spectrum of specialized burn care. We aim to include these data into the Dutch Burn Repository R3 in the near future. Next, specific patient characteristics (e.g. comorbidity, socio-economic status) cannot be discussed, since these variables were absent in the historical databases. However, with the uniform database from 2009 onwards several problems are overcome and more detailed information is available. As a result we can direct prevention, monitor quality of care and facilitate scientific research. Finally, we did not have the digital NHDR data, and thus only limited analyses could be done on the overall burn related admissions in the Netherlands. A frequent problem in these data sets is the

double counting of patients with an admission in the first hospital and in the subsequent burn centre. This problem will apply to the Dutch data, but only to a small minority. The majority of our patients are first seen on EDs of general hospitals. However, they are transferred immediately to a burn centre for admission and further treatment because of the short distances to specialized burn care in our country. Thus the delivered data was of good quality and sufficient to compare trends in specialized burn care to trends in non-specialized burn care.

In conclusion, this study gives a unique overview of specialized Dutch burn care in the past 17 years. Data on 9031 patients show a shift in burn centre utilization, with increasing incidence rates of burn-related burn centre admissions, a decreasing incidence rate of burn related admissions in general hospitals, a decreasing burn severity in burn centres and decreasing in-burn centre mortality rates. Patients with burns needing hospital admission are more and more referred to specialized burn care, rather than general hospitals. These data are important for prevention and adequate establishment of the burn care facilities capacity.

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Conflict of interest statement

The authors declare that they have no conflict of interest.

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Appendix A

The 'Dutch Burn Repository Group' consists of:

- Burn Centre Beverwijk: EC Kuijper, FRH Tempelman, AFPM
- Vloemans, PPM van Zuijlen.
- Burn Centre Rotterdam: A van Es, H Hofland, J Dokter.
- Burn Centre Groningen: J Eshuis, J Hiddingh, S ScholtenJaegers.
- Association of Dutch Burn Centres: ME van Baar, E Middelkoop, MK Nieuwenhuis, A Novin, M Novin.

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