Burns Open 7 (2023) 1–7

Contents lists available at ScienceDirect

Burns Open

journal homepage: www.sciencedirect.com/journal/burns-open

Changes in epidemiology and care strategies at the Norwegian National Burn Centre over 35 years (1986–2020)

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ARTICLE INFO

Keywords:
Burns
Epidemiology
Burn center admissions
Norway

ABSTRACT

Introduction: We evaluated trends in admissions, % TBSA (total body surface area) burnt, age, and outcomes over a 35-year period at the national burn centre in Norway.
Methods: Relevant data were extracted from the departmental quality registry covering all acute admissions for burns during 1986–2020.
Results: In 1986–2020 there were 2.889 admissions for burns (67.6 % males), with a 110 % increase in 2016–20 when compared to 1986–90. Admissions of children <2 years increased by 400 %. In 2011–20, 66.5 % of patients were transferred from other hospitals.
The median area injured declined markedly, from 16.5% TBSA in 1986–90 to 4.5% TBSA in 2016–20.
Changes in care included an increased focus on non-delayed referrals and transfers, an explicit intent to achieve early excision within 48 h, and a transition from a highly frequent to a less frequent dressing changes scheme. Mortality declined from 10.9 % to 3.0 %. In 2011–20 the mortality among actively treated patients was 2.4 %. For patients with Baux scores 80–119, mortality declined from 36.0 % (1991–2010) to 18.2 % (2011–20) ($P < 0.001$).
Discussion: Since 1986, more patients have been referred to the burn centre, many of younger ages and with more minor burns. Survival of patients with Baux scores 80–119 increased significantly.

1. Introduction

The Norwegian National Burn Centre (NBC) at Haukeland University Hospital in Bergen, opened in 1984, is the only national referral burn centre in Norway. The centre provides care for paediatric and adult burn patients from all over the country, with a catchment area of 5.367.580 people (2020) and an area of 323.808 km^2. More minor burns are handled in >30 different hospitals nationwide. Norway is long-stretched and scarcely populated with contrasting seasonal weather and environmental challenges, affecting referral policies.

The distance from Bergen to Northern Norway can be 1500 km (by air). Even from the more populous south-eastern parts of Norway a 500 km distance to Bergen and the topography (numerous fjords and steep mountains), necessitate that most transfers to Bergen are by air (ambulance helicopter or fixed-wing air ambulance service). Referral of patients with more minor burns is often accomplished by elective transfers on regular commercial passenger flights. Hospital care in Norway and patient transport, including ground and air ambulance services, are covered by the Government through the four Regional Health Thrusts.

Other burn centres in Europe reported gradual improvements in both availabilities of burn centres and reduced overall mortality over time [1–3]. Though centres in Central Europe have a very different geographical setting, improvements seem to reflect improved care over time, and thus should be transferrable to a Nordic environment. The general progress in medicine overall combined with more readily available medevac capacities, has led to increased expectations from all stakeholders in society and a demand for high-level acute burn care.

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https://doi.org/10.1016/j.burnso.2022.12.001
Received 21 September 2022; Received in revised form 7 November 2022; Accepted 6 December 2022
Available online 15 December 2022

At the NBC, patients are included in a Burn Centre Registry containing data from 1984 until today. This rare quality registry allows for time-period comparisons over >35 years, impact analysis of changes in care strategies over time, and international benchmarking. We previously published a report on the activity of the Burn centre from 1984 until 2004 [4]. Over the past decade, we have made considerable changes in care and referral criteria based on current standards of care [5,6].

Over the years, both personnel and care have changed numerous times. A detailed overview of all changes in care and the possible effects on patient outcomes is not within the scope of this study. However, a brief summary is needed.

Since the centre opened in 1984, early excision has been an expressed surgical strategy. However, the exact timing of excision surgery has been dependent on an array of other variables, including a considerable variation in the delay of transfers and the availability of operating theatres. Hence, in the previous decades, no explicit time limit for complete burn excision was stated in the centre's standard operating procedures (SOP). However, along with an increase in surgeon staffing over the last decade, there was also a change in care towards more explicit SOPs for the timing of early excision within 48 h post-burn. The renewed strategy also changed referral routines from the previous approach of mainly planned next-day transportations towards more urgent non-delayed patient transportations. Additionally, referral criteria were revised in 2015 to allow for increased availability of specialist care for burn patients from all over the country (Table 1). In the same period, the main wound care strategy changed from a hydrotherapy-based routine with moist dressings with silver sulfadiazine (SSD) cream as the standard of care, toward a non-hydrotherapy dressing routine with dry silver-based dressings. Due to a change in strategy the frequency of dressing changes dropped from the previous daily or every-second day dressing changes into twice a week. Further, the introduction of enzymatic debridement by NexoBrid® and increased focus on early extubation may also have expedited the care offered.

The present study was performed to analyse the effects of changes in referral strategy and care and to illustrate the changes in the centre's patient mix over 35 years. Potential improvement in survival for the patients with higher Baux scores (Baux scores 80–119) was also explicitly addressed.

Table 1
Previous and current criteria for referral; National Burn Centre, Haukeland University Hospital.

Referral criteria prior to 2015[1]	Referral criteria practiced from 2015[2]
Adults with >15 % TBSA injuries	Burns >10 % TBSA Full-thickness injuries >5 % TBSA
Children >2 years with >10 % TBSA injuries	Burns >5 % TBSA in children
Children <2 years	
Deeper injuries on hands/ genitals/face	Burns in special regions: • hands, face, feet, genitals, perineum, burns over large joints • circumferential burns on extremities or thorax
High voltage injuries	Electrical injuries Burns with inhalation injuries Chemical injuries Burns in multimorbid patients Burns in pregnancy Burns combined with multitrauma Burns in very young children or in very old and weak patients Burns with suspected maltreatment or neglect

[1] Source: (Institutional) Burn care manual (edition 2003).
[2] Adopted from the Emergency Management of Severe Burns (EMSB) Course Manual, 18th ed, 2016 [6] and the European Practice Guidelines for Burn Care, European Burns Association (2nd ed., 2013) [5].

2. Material and methods

A quality registry has been maintained for all admissions at the Burn centre at Haukeland University Hospital, Bergen, Norway, since the first patients were admitted in September 1984. This registry contains basic information on all patients admitted as inpatients for burns. Patients managed solely on an outpatient basis and elective patients for secondary reconstructive procedures are not included.

The quality registry was searched for all admissions for burns in the period 1986–2020. Due to inconsistency in data gathering and reporting in the initiation years 1984–85, the first 16 months were not included in the present study. Age, gender, admission year, home address, %TBSA, LOS (length-of-stay), and mortality were extracted. LOS was calculated as the day of discharge *minus* the day of admission.

Patients admitted to the burn centre for other conditions (like toxic epidermal necrolysis (TEN), staphylococcal scalded skin syndrome (SSSS), or extensive losses of skin (e.g., following necrotizing fasciitis)) were not included. Re-admissions (175 stays; total length-of-stay 830 hospital days) are documented in the quality registry but were not included in the present study.

2.1. Statistics

Data were initially stored in Excel 2010. Statistical analyses were performed in R version 4.1.1, and a P value <0.05 was considered statistically significant.

Changes over time in the number of patients, age, and %TBSA burnt were analyzed by polynomial Poisson regression. The degree of the polynomial model was selected using a model selection method, the lowest Akaike Information Criterion (AIC) [7] value, and the ANOVA test. If overdispersion was detected, a quasi-Poisson model would be fitted to the data to correct standard errors in the polynomial Poisson regression and resulting P values.

Differences in mortality proportions for burns of different sizes were compared by Fisher exact test or chi-square test, as appropriate. Prism version 5.0 (GraphPad Software, San Diego, CA, U.S.A.) was used for Fig. 4.

Baux scores were calculated as the sum of a patient's age *plus* %TBSA burnt [8].

2.2. Ethical approvals

The Regional Committee for Medical and Health Research Ethics, Western-Norway, reviewed and approved the study on December 15, 2020 (ref. no. 195566) and waived the need for informed consent.

3. Results

3.1. Patients

Over the 35 years 1986–2020 2.889 patients (67.6 % males) were admitted for burns at the NBC (Table 2). Patients were of all ages; the youngest was 14 days, and the oldest was 95.6 years. Six-hundred and ninety-eight patients (24.2 %) were children <2 years of age.

For the most recent decade (2011–20), there was a marked increase in the number of patients admitted (Table 2). In 2016–20 the number of patients more than doubled compared to in 1986–90 (Table 2, Fig. 1).

The most striking increase in the number of patients was for children <2 years (Fig. 2). Whereas in the period 1986–90, yearly ten children <2 years were admitted, the annual number of children <2 years increased over time, particularly in the most recent 15 years (Fig. 2). For the period 2016–20, the annual average had reached 39 children <2 years, almost four times as many as in 1986–90 (Fig. 2).

For children 2–14 years, 106 children were admitted in 2016–20 compared to 65 children in 1986–90. In a polynomial Poisson model (Fig. 2), this increase in number was statistically significant ($P < 0.05$).

Table 2
National Burn Centre, Haukeland University Hospital: number of patients, area injured, hospital days for burns, length-of-stay (LOS), and mortality for seven 5-year periods (1986–2020).

Time period	Patients (n)	Area injured, %TBSA, median (IQ)	Hospital days (n)	LOS (days), median (IQ)	Deaths (n)	Mortality (%)
1986–1990	331	16.5 (7.5; 33.0)	6725	14.0 (7.0; 27,0)	36	10.9
1991–1995	337	14.0 (7.0; 25.0)	6969	16.0 (6.0; 27.0)	48	14.2
1996–2000	276	15.0 (6.0; 27.0)	5208	13.0 (7.0; 23.0)	30	10.9
2001–2005	330	10.8 (4.5; 21.0)	5817	14.0 (4.0; 23.3)	27	8.2
2006–2010	384	11.5 (4.0; 24.0)	6830	13.0 (6.0; 24.0)	31	8.1
2011–2015	525	8.0 (3.0; 18.3)	9400	13.0 (4.0; 23.5)	33	6.3
2016–2020	706	4.5 (1.5; 10.0)	10.470	10.0 (3.0; 18.0)	21	3.0
Total population	2889		51.419		226	7.8

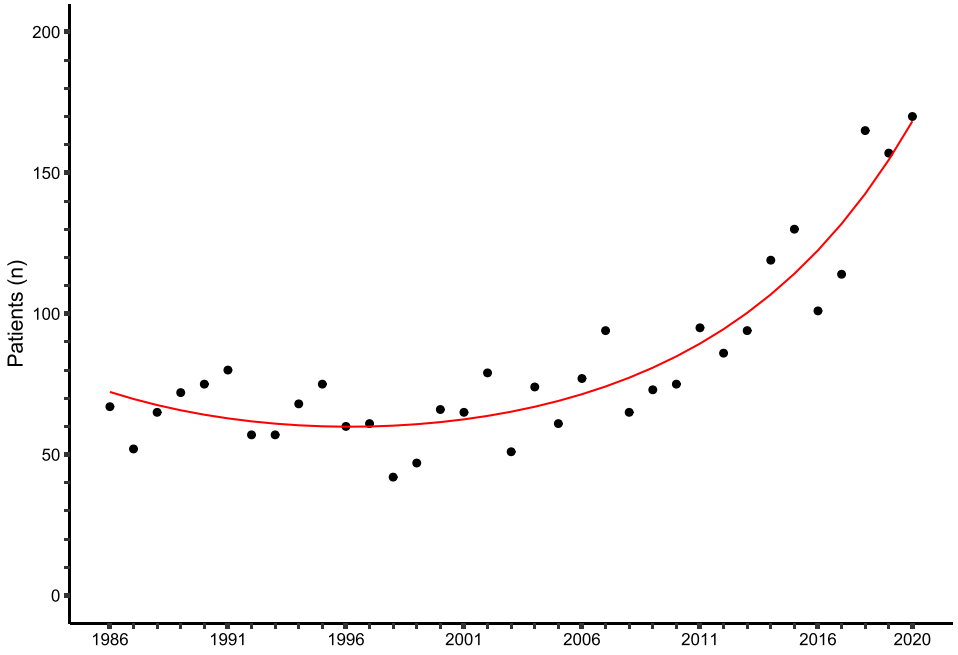

Fig. 1. Annual number of burn patients (1986–2020). This figure illustrates an increase in the number of burns admitted annually to the NBC. To better characterize this trend, a trend line (red line) was fitted to the data using regression analysis. The curve was estimated in a polynomial Poisson model; with the number of patients in each year as a dependent variable (Patients (n)) and years from 1986 to 2020 as an independent variable (year). The second-degree polynomial model (Patients (n) = exp (4.36301 + 1.48639 * year + 0.97948 * year^2) resulted in the best fit to the available data with AIC = 282.58. The increase in absolute numbers of patients was significant (all coefficients $P < 0.0001$).

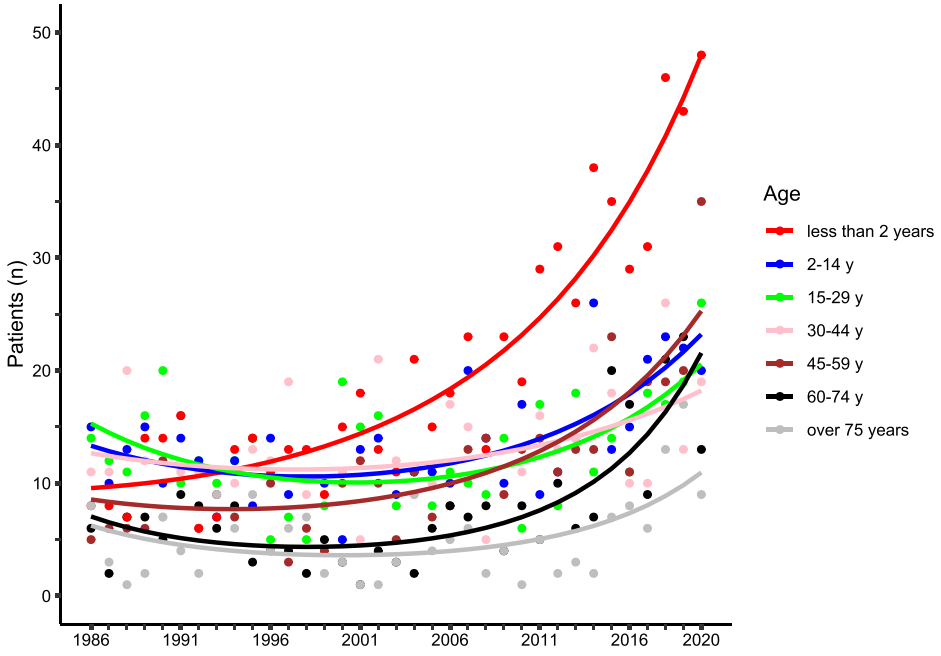

Fig. 2. Trends in the annual number of burn patients of different ages (1986–2020) with polynomial regression line.

The number of patients aged 45–59 years, 60–74 years, and above 75 years increased significantly with time (all age groups, $P < 0.05$) (Fig. 2).

The number of patients aged 75 years or more, remained relatively stable around 4–5 patients yearly (Fig. 2) until the 2016–20 period, when the number of patients above 75 years more than doubled (10–11 patients per year).

3.2. Area injured

For the entire period studied, 462 patients (16 %) had injuries ≥30 % TBSA. Most patients had more moderately extensive injuries; 1436 of 2889 patients (49.7 %) admitted had injuries <10 % TBSA. The median %TBSA decreased markedly over time (Table 2).

The changes in the numbers of patients with burns of different sizes are illustrated in Fig. 3. The curves were estimated in a polynomial Poisson model, with the number of patients in a year as a dependent variable and the area injured as an independent variable.

Between 2011 and 2020 there was a pronounced increase in the number of patients with burns <5 % TBSA ($P < 0.0001$) and in injuries with 5–9 % TBSA ($P < 0.001$) (Fig. 3). Still, the number of patients with more extensive burns remained quite stable, though with a trend towards slightly reduced numbers for burns 30–49 % TBSA and ≥50 % TBSA (both groups $P < 0.05$) (Fig. 3).

3.3. Length of stays

In the recent decade (2011–20) the number of hospital days spent on acute burn care increased by 57 % compared to for 1986–2010 (Table 2).

Many patients had fairly brief stays in the latest 5-year period (2016–20). In 2016–20 the median length-of-stay (LOS) was ten days, and the 25-percentile for LOS was just 3.0 days (Table 2).

3.4. LOS / %TBSA

The ratio between LOS and area injured (%TBSA) has been interpreted as an indicator of the efficacy of burn care. LOS/%TBSA for the larger burns, intermediate burns and more minor burns for 2874 patients admitted in 1986–2020 are presented in Table 3.

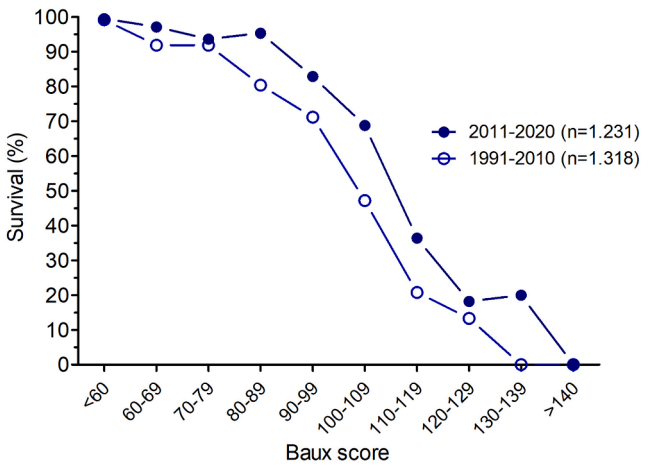

Fig. 4. Survival relative to Baux score (sum of age *plus* %TBSA) for patients admitted in 2011–20 compared to those admitted in 1991–2010. Numbers in parentheses are the total number of patients admitted in the two time periods.

3.5. Patients referred from other hospitals

Data for patient residence were available for patients admitted in 2011–20. Patients living outside Hordaland County (population 524.495 (2019)) represent patients transferred to the NBC from hospitals in other regions of the country (potential catchment area some 4.5 million people).

Table 3
Length-of-stay (LOS) relative to area injured (%TBSA).

		LOS (days) / %TBSA		
%TBSA	Patients (n)	Mean	SD	Median
20–100	779	0.91	0.70	0.82
10–19	672	1.37	0.93	1.18
0–9	1423	4.29	10.89	2.00

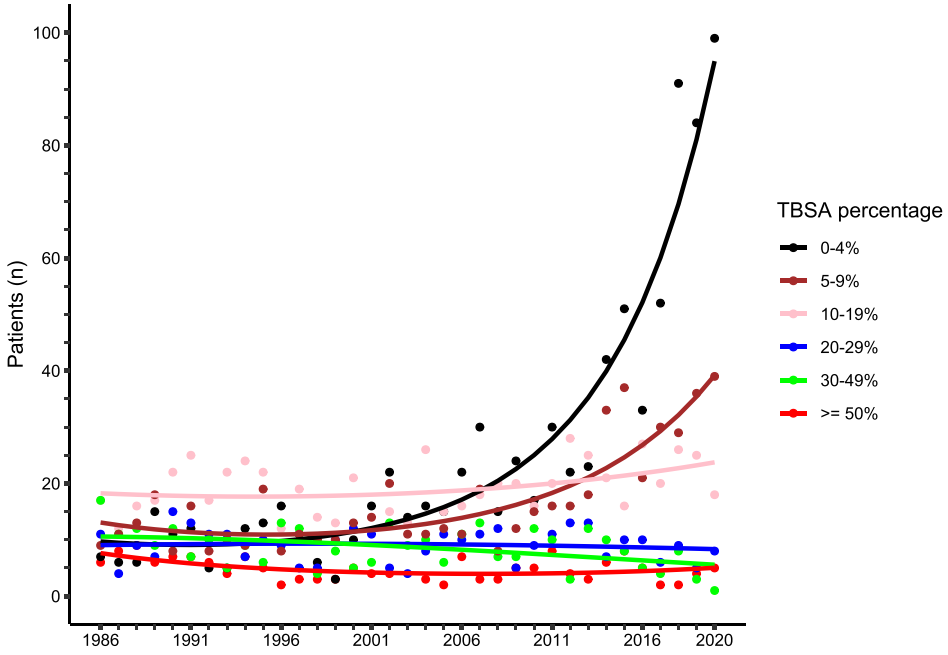

Fig. 3. Trends in the annual number of patients with burns of different sizes (1986–2020) with polynomial regression lines.

Hence, 818 of the 1231 patients admitted in 2011–20 (66.5 %) were burn patients transferred from other hospitals. Even for burns <5 % TBSA, almost half of the patients are presently patients referred from other hospitals.

The 818 patients transferred from other hospitals in 2011–20 required 16.273 out of totally 20.014 hospitals days at the Burn centre in this period (81.3 %).

3.6. Mortality

Mortality has declined in more recent years. In the most recent 2016–20 period, overall mortality was 3.0 % (Table 4). For the period 2001–2020, information was available as to whether deaths occurred in actively treated patients or following an early decision (usually within 1–2 days after arrival) to switch to comfort care in patients assessed as not having a realistic hope for survival. If the 2011–20 period is compared to the preceding 2001–10 period, the number of comfort care patients in both periods was identical (n = 24) whereas in 2011–20, there were marginally more deaths despite active therapy (n = 30) (Table 4). The mortality of actively treated patients in 2011–20 was just 2.4 % (Table 4).

Mortality for burns of different sizes is shown in Table 5. The number of more extensive burns is limited, with just 165 burns ≥50 % TBSA over the 35-year period. There was lower mortality in the last 5-year period ($p < 0.0001$) if burns of all sizes were compared as one group. However, the higher proportion of minor burns (<10 % TBSA) in the latter period makes this statistical difference clinically less relevant. Still, for pooled data for all areas with 10–100 % TBSA there was a specific trend (n.s.) towards lower mortality in 2016–2020 compared to 1986–2015 ($p = 0.05167$).

3.7. Survival relative to Baux score

Baux score (the sum of a patient's age *plus* the area of skin injured (% TBSA)) [8] may still be relevant in describing outcome after burn injury. In Fig. 4, the mortality for patients with different Baux scores in the most recent decade (2011–20) is compared to in the preceding 20 years (1991–2010).

Only 421 patients out of 2549 patients (16.5 %) in 1991–2020 had a Baux score ≥80. However, mortality for patients with Baux scores in the range 80–119 was significantly lower ($P < 0.001$) for patients admitted 2011–20 (mortality 18.2 %) than for those admitted 1991–2010 (mortality 36.0 %) (Fig. 4). Fourteen patients with Baux scores >110 survived; the survivor with the highest Baux score had a Baux score of 133.

4. Discussion

A 110 % increase was found in the number of burn patients admitted to the Norwegian National Burn Centre when the last period, 2016–20, was compared to the first, 1986–90 (Table 2). During this period, the Norwegian population increased by 29.1 % (population: 5.367.580 in 2020; 4.159.187 in 1986 [9]). Even if correcting for an increased population, the acute admissions to the burn centre for 2016–20 increased by 65 % compared to 1986–90.

Table 4
Outcome (deaths despite active therapy, comfort care, and discharged alive): the decades 2011–20 compared to 2001–10.

	2001–2010	2011–2020
Deaths despite active therapy	26	30
Deaths following comfort care	24	24
Discharged alive	664	1.177
Total mortality	7.0 %	4.4 %
Mortality excluding comfort care cases	3.6 %	2.4 %

Table 5
Mortality relative to burn size in the most recent five-year period compared to in the preceding three decades.

	1986–2015		2016–2020	
Area injured	Patients (n)	Mortality (%)	Patients (n)	Mortality (%)
90–100 %	11	81.8	2	100
80–89 %	26	88.5	3	100
70–79 %	28	60.7	0	–
60–69 %	30	60.0	4	25.0
50–59 %	51	27.5	10	20.0
40–49 %	103	24.3	8	25.0
30–39 %	174	16.1	12	8.3
20–29 %	279	11.5	38	13.2
10–19 %	556	3.8	116	1.7
0–9 %	925	1.1	513	0.6
Total population	2183	9.0	706	1.6

4.1. Changing practice for referrals and care

The present study shows a doubling of burn patients receiving care at the NBC. This change reflects an adjustment of the referral criteria (Table 1) and a change in attitude toward referrals of patients with minor injuries. It is recognized that even less extensive burns may lead to significant functional challenges in the future, although these injuries per se may often be far from life-threatening [10]. In previous years burns <10 % TBSA were more often treated at the primary hospital close to home. Presently, more patients are referred to the NBC. The change is partly due to the active change in referral criteria (Table 1) but might also be part of a general trend towards more centralized medical care.

Similar trends were also observed in the Netherlands were paediatric admissions at the three Dutch burn centres increased by 44 % in 2000–07 compared to in 1995–99. In contrast, the number of paediatric burn admissions in other hospitals in the Netherlands decreased [11]. In the Netherlands, the annual number of burn centre admissions (all ages) increased by some 70 % from 1995 to 2011, whereas there was a concurrent 25 % reduction in the number of burn-related admissions in general hospitals [2].

Ensuring the availability of specialized burn care to all patients in Norway is challenged by geography and is highly dependent on medevac capacities. Outpatient care is seldom practical for patients residing in another part of the country. In transitioning towards more acute transfers, burn surgeon availability for initial decision-making in referrals has been part of the centre's strategy. Initial care and fluid resuscitation are based on %TBSA and depth assessments [12]. The need for early referrals is motivated by recent findings of diverging burn assessments between primary hospitals and burn centres [13], as well as the shortened ICU stays and reduced time on mechanical ventilation which can be achieved by early excision [14]. Therefore, focusing on a non-delay of even long-distance transfers to burn centre will allow for better initial care affecting outcomes for patients [14]. The increased number of transfers of minor burns in children and the elderly might be criticised in terms of the utilization of resources. However, these changes have brought the availability and standards of burn care in our country closer to reported standards in other European countries [1]. Thus, the changing demographics of burns in the NBC could be interpreted as an indicator of a well-balanced availability of care rather than an increased burden on specialized care.

The transition from a wound care strategy based on hydrotherapy and highly frequent dressing changes with SSD towards a system with less frequent dressing changes with silver dressings without hydrotherapy represented a significant shift in care. This change in care was also initiated based on problems with multiresistant bacterial strains at the NBC [15] and reported strategies for mitigation of such problems elsewhere [16]. Although any direct interpretation of this and other observed changes in care strategies is compromised by its retrospective nature and lack of control, this major shift in care is worth noting when

interpreting the data.

The changes in care strategies included an increased focus on non-delayed referrals and transfers, an explicit surgical plan to achieve early excision within 48 h, and a transition from a highly frequent to a less frequent dressing change scheme.

4.2. Incidence of burns

The overall trend in high-income countries is a reduction of extensive burns, although the total incidence of burns in the society might be more stable [3]. Data on burns admitted to all hospitals in Norway (based on data from the Norwegian Patient Registry) have been reported for the years 1992, 1999, 2007 and 2012 [17]. The 620 burn patients admitted to hospital in Norway in 2012 (number corrected for interhospital transfers and readmissions) corresponded to an incidence of 12.4 burns admitted to hospital/100.000 inhabitants/year [17]. For the years 1992–2012, the trend in Norway was a 20 % reduction in admission numbers by 2012 relative to in the preceding two decades [17]. Similar trends towards a decline in number of extensive burns have been described in many high-income countries [3], including Holland [2] and Sweden [18]. The trend in Norway seems similar, and the increased number of burns treated in the NBC relies on changes in the demographics of burns transferred to more specialized care.

4.3. Future demographic challenges

For 2020–2040 predicted changes in the Norwegian population based on population projections from Statistics Norway [19] are striking. Whereas in the next two decades, the number of children below two years of age in the population is expected to remain relatively stable, the number of elderlies will increase markedly. From 2020 until 2040, the group aged 67–79 is expected to increase by 37 %; for those aged 80 (or more), a 113 % increase is predicted. In the present study, for 2016–20, the number of burn patients above 60 years increased by 180 % compared to 1986–90 (Fig. 2). These projected increases in the Norwegian population above 60 years will further increase the load on burn centre care for far more elderly patients. These trends might also in the nearer future strain the capacity. Additionally, increased longevity and a healthier elderly population could challenge the approach to end-of-life decisions in the future.

4.4. Mortality

Changes in mortality expressed as a percentage of all patients treated may be less relevant if the fractions of younger patients and of patients with less extensive injuries increase significantly over time. On the other hand, attempts of active therapy are now offered to some marginal patients that will later be converted to comfort care if complications and severe organ failures develop. Resultingly, mortality in the "active therapy group" appears to increase, not as an effect of a worse outcome, but rather resulting from a more liberal attitude towards initially offering some patients an attempt at full active care. Still, for 2011–2020 the overall mortality was 4.4 %, reduced to 2.4 % if comfort care patients were excluded (Table 4).

Pompermaier et al [20] found that adding comorbidity to their model for mortality did not improve predictions. In this material specific data on inhalation injury were not available. Hence Baux score [8] was chosen as the preferred reporting for mortality. There are other models for mortality predictions in burn care, with the revised Baux (rBaux) score as the possibly best known [21]. The rBaux score includes inhalation injury as an added variable for mortality [21]. However, a clinical diagnosis of inhalation injury may be uncertain, and diagnostic bronchoscopy reports may not be available in all relevant cases.

Compared to previous periods, the mortality for all patients with Baux scores 80–119 declined significantly in 2011–2020 (Fig. 4). These results indicate a better prognosis in recent years for patients with extensive burns, often also combined with higher age. However, we cannot readily extrapolate the results to patients with Baux scores $\geq$120 since there were only 45 patients in this category and the number of survivors was too low to allow for meaningful statistical analysis. Nevertheless, the results represent a notable improvement in care over time, with the latest outcomes in line with expected outcomes in the literature [1,2].

The longitudinal data strengthens the present study, rendering the indicated improvements less likely to result from transient changes.

5. Conclusions

1. In the recent decade, the yearly number of patients transferred to the Norwegian National Burn Centre almost doubled compared to in the period 1986–90.
2. The largest increase in number of patients was found among toddlers with scalds.
3. The median %TBSA has decreased due to the increased availability of specialized burn care by accepting more transfers with less extensive burns.
4. Changes in care strategies have included an increased focus on non-delayed referrals and transfers, early excision within 48 h, and a transition from a highly frequent to a less frequent dressing changes scheme.
5. Survival for patients with severe injuries has increased substantially in the past decade.

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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