



Universiteit  
Leiden  
The Netherlands

## Epidemiology of burns

Dokter, Jan

### Citation

Dokter, J. (2016, December 20). *Epidemiology of burns*. Retrieved from <https://hdl.handle.net/1887/45227>

Version: Not Applicable (or Unknown)

License: [Licence agreement concerning inclusion of doctoral thesis in the Institutional Repository of the University of Leiden](#)

Downloaded from: <https://hdl.handle.net/1887/45227>

**Note:** To cite this publication please use the final published version (if applicable).

Cover Page



Universiteit Leiden



The handle <http://hdl.handle.net/1887/45227> holds various files of this Leiden University dissertation

**Author:** Dokter, Jan

**Title:** Epidemiology of burns

**Issue Date:** 2016-12-20

# Chapter 9

## **Summary and discussion**

Samenvatting en discussie



Epidemiology is the cornerstone of public health. It generates information for policy decisions and evidence-based practice by identifying risk factors for diseases and targets for epidemiological studies that are essential for improving health care. High research design and conduct are essential and results should be interpreted carefully.

The epidemiology of burns in the Netherlands has changed in recent decades, and many factors have contributed to this change. The increase in the elderly among the population because of aging in our society and the numbers of children from other ethnic and cultural groups due to immigration cause the age distribution in society to vary. Although burns happen especially at the extremes of age, the total number of patients with burns is still decreasing.

Public education campaigns, often initiated by the Dutch Burns Foundation and the spread of one-liners for prevention (“Eerst water, de rest komt later” or “Water first, the rest will come later”) and first aid measures play an important role in the awareness of burn dangers throughout the population.

Education by healthcare professionals improves care quality, the recognition of small and simple burn wounds, and the acknowledgement of more specialized care in case of severe burn wounds.

Cooperation between burn centers and referral hospitals also increases awareness of the need for adequate early resuscitation, stabilization, referral and admission to specialized hospitals.

Good primary treatment is of major importance for optimal outcomes.

Nationwide registration of burn patients gives insight into care outcomes and can highlight the tools that can allow for further improvement.

Adequate registration and measurement of care outcomes remains necessary and will further change the epidemiology of burns in the future.

The aim of this thesis is to acquire knowledge on the epidemiology, treatment and outcomes of specialized burn care in the Netherlands. The thesis is mainly based on historical data from the Rotterdam Burn Centre since 1986, combined with historical data from the burn centers in Groningen and Beverwijk from 1995 to 2009 and the common Dutch Burn Repository (DBR) R3, established in 2009.

This thesis is divided into three parts:

Part 1: epidemiology

Part 2: management

Part 3: outcome

## **PART ONE: EPIDEMIOLOGY**

### **Chapter 1** *Introduction and outline of the thesis*

Chapter 1 describes the development of specialized burn care in The Netherlands. It began with the emergence of the Dutch Burns Foundation to generate funds for research and was followed by the opening of three burn centers in non-academic hospitals in Beverwijk, Rotterdam and Groningen.

In the course of time, strengthened cooperation between these three centers resulted in the Association of Dutch Burn Centres (ADBC).

One of the great milestones of the ADBC was achieved with the development and implementation of a common uniform database, the Dutch Burn Repository (DBR R3) in 2009.

The current version of DBR R3 contains all essential information about patients who have been admitted to any of the three burn centers, their treatment and their outcomes. The database is adapted and expanded in close consultation with the users in such a way that the system is up to date with developments in burn care, allowing for better comparison with international databases.

Merging the historical databases of the three burn centers and the start of the DBR R3 enabled an overview of primary admissions in Dutch burn centers from 1995 to 2011 described in Chapter 2. In this study, data were also used from general hospitals, specifically from the National Hospital Discharge Register (NHDR).

Data from these registries underscore their importance for monitoring and improving the quality of care for these patients.

### **Chapter 2** *Epidemiology and trends in severe burns in the Netherlands [1]*

The annual number of patients admitted to the three Dutch burn centers increased from 430 in 1995 to 747 in 2011, an increase from 2.72 to 4.66 per 100,000 inhabitants. There was a trend towards admissions for less extensive burns and lengths of stay decreased over time as well. Overall burn center mortality decreased from 8% to 4%. This reduced mortality could of course be at least partly explained by the fact that more patients with less extensive burns were referred over time to the three centers. In children, the vast majority of patients (four in five) meet the referral criteria for burn centers, as shown by Vloemans et al [2], but children with less severe burns are also admitted to the centers.

In the Netherlands, the referral criteria for burn centers according to the Emergency Management of Severe Burns (EMSB) course are:

- Burns over 10% total body surface area (TBSA) in adults.
- Burns over 5% TBSA in children.
- Full-thickness burns over 5% TBSA.
- Burns at the extremes of age, children and the elderly.
- Burns in patients with preexisting medical disorders that could complicate management and prolong recovery or effect mortality.
- Any burn patient with associated trauma.
- Burns with associated inhalation injury.
- Circumferential burns of the limbs, neck or chest.
- Burns to special areas such as the face, hands, feet, perineum, genitals and major joints.
- Electrical burns.
- Chemical burns.

The introduction in the Netherlands of the Emergency Management of Severe Burns course in 1998, where lower-threshold consultation is encouraged, has contributed to earlier referral to burn centers. Many patients are transferred to tertiary care facilities because of a perceived lack of basic skills in assessing and caring for burn wounds in hospitals that are infrequently confronted with burn patients.

Recently, a working group of burn care professionals, general practitioners, ambulance personnel, emergency medicine physicians, pediatricians and trauma surgeons developed an evidence-based guideline on initial acute care and referral decisions [3]. This was done in close cooperation with the Dutch Burns Foundation, the Dutch Society for Burn Care (Nederlandse Vereniging voor Brandwonden Zorg), the ADBC and experts from the Dutch Institute for Healthcare Improvement (Centraal Begeleidings Orgaan (CBO)). This guideline aims to improve emergency care and to support treatment and decisions about referrals of burn patients. In case of questions or doubt, a burn center expert can always be consulted. In comparison with other countries, the Netherlands has a relatively low number of burn patients, which is likely related to the broad attention given to burn prevention in the country.

The incidence in children aged 0-4 years who were admitted to Dutch burn centers doubled from 10.26 per 100,000 inhabitants in 1995 to 22.96 per 100,000 in 2011 [4]. This marked increase in the number of pediatric admissions was also noted before by Vloemans et al [2], and it led to the retrospective epidemiological study described in Chapter 3.

**Chapter 3** *Epidemiology of children admitted to the Dutch burn centres. Changes in referral influence admittance rates at the centres*

In this publication, burn patients from 0 to 4 years were compared with patients age 5-17 during the two time periods 1995-1999 and 2000-2007.

From the first (1995-1999) to the second (2000-2007) period, the mean number of admissions to the Dutch burn centers increased from 113 to 163 per year for younger children and from 50 to 71 for older children, increases of 44.0 and 44.3%, respectively.

In patients over 18 years old, the annual mean number of admissions increased from 290 to 303, an increase of 4.3%. The proportion of children admitted to specialized burn centers rather than general hospitals increased over time from approximately 30% in 1995 to nearly 50% in 2007 in both age groups ( $p < 0.001$ ).

Nearly 50% of all children with burns between 0-4 years of age in the Netherlands were admitted to a specialized burn center.

In conclusion, there has been a shift in pediatric burn care towards a greater volume of admissions to burn centers particularly for young children with less severe burns. Together with the general tendency toward centralizing specialized healthcare, the introduction of the Emergency Management of Severe Burns course in 1998 could be a possible explanation because EMSB guidelines dictate stricter and generally accepted referral criteria.

The Netherlands is a small country with three burn centers. The merits of the two studies that were described in chapters 2 and 3 about epidemiology and registration is that they are nationwide and they cover 100% of admitted burn center patients. In other countries with larger numbers of burn centers, such as the UK, Australia and New Zealand, similar burn-center-based registries that include data on all patients, outcomes and quality of care, but nationwide participation is not always reached.

In the USA, the National Burn Repository (NBR, 2014) covers 96 of 123 US burn centers plus 4 centers in Canada and 2 in Sweden. [5]

The National Burn Repository summarizes and compares cases submitted by burn centers internationally and in the United States. The concept behind it is simple: through calls for data, burn centers send a standard set of data elements regarding their burn cases to a central repository. This central repository summarizes data quality, demographic and injury information, and outcomes to prepare various reports.

The American Burn Association (ABA) annually provides an NBR report of data that summarizes the clinical characteristics and courses of some of the annual burn treatment cases that were submitted to the NBR from specialized burn care facilities.

These cases constitute a convenient sample of burn patients who received specialized care; they do not represent a random sample of all patients who were presented to a hospital for burn treatment or who were admitted to burn centers. It is a large sample of patients from facilities that have a strong commitment to excellent burn care. The data include many of

the most challenging burn cases seen at specialized burn care facilities and reflect, in large part, the best possible outcomes of burn care at the beginning of the second decade of the 21st century.

Some shortcomings of our two studies have to be mentioned. First, data are lacking about outpatient treatment. In line with reduced lengths of stay (LOS), outpatient care has gained importance and is currently a crucial part of our specialized burn care. Data on these outpatient burn center activities would add to our knowledge on the full spectrum of specialized burn care. This is acknowledged by other groups as well [6]. In the Netherlands, the Dutch Burn Repository group has already designed a data collection scheme, but implementation has been postponed due to manpower constraints; electronic medical records do however include all necessary information. In the near future, we hope to extract these data and to be able to include them in our repository. Similar developments have been reported, for instance in the Burns Registry of Australia and New Zealand [6].

Second, we did not have access to the digital NHDR data, and thus only limited analyses could be performed on the overall burn-related admissions in the Netherlands. A frequent problem in these datasets is the double counting of patients with an admission to a non-burn centre hospital first and referred to a burn centre afterwards. This problem will apply to the Dutch data as well, but only to a minority of patients; more than 80% of our patients at first are seen in emergency departments at non-burn center hospitals, but after first assessment and resuscitation, they are transferred immediately to burn centers for admission and further treatment because of the short distances to the specialized centers in our country. Thus, the delivered data were of good quality and sufficient for comparing trends in specialized burn care with trends in non-specialized care [7].

A third potential shortcoming is the content of the dataset. We included data such as age, sex, cause of burns, accident location, accident background, etc. into local databases and merged these into one database as much as possible. In the past, specific patient characteristics (e.g. co-morbidity and socioeconomic status) could not be addressed because these variables were absent or partly absent in the historical local databases. However, with the uniform Dutch Burn Repository R3 from 2009 onwards, a number of problems were overcome, and more detailed information became available. For instance, we now have indications of patients' socioeconomic status based on information their postal codes. In addition, information on comorbidity is systematically recorded.

The two studies show that young children especially are an important target group for prevention; the age group of 0-4 years is overrepresented in the patient population in the Dutch burn centers. The Dutch Burns Foundation pays special attention to this age group by means of lectures, special mass media prevention campaigns, in infant welfare centers and by publishing prevention measures on their website.

The fact that children are so frequently involved in burn injuries has implications for therapy, as well. Most of these injuries are scald burns, which require special wound care. This aspect is described in detail in Part 2 of Chapter 4.

A new challenge is evaluating the implementation of the recently developed Dutch guideline on initial care for burn patients in the acute phase [3]. With data from the HDR and the DBR R3, we can better monitor referral patterns, and additional data on burn care consultation will add to our knowledge on the needs of health care professionals outside of specialized burn care. As a result, we can direct prevention, monitor care quality and facilitate scientific research.

## **PART TWO: MANAGEMENT, WOUND CARE (A) AND BACTERIOLOGICAL SURVEILLANCE (B)**

### **a) Wound care**

An important milestone in burn treatment was adding silver to local wound care. In his 1968 article "Silver sulfadiazine--a new topical therapy for Pseudomonas in burns. Therapy of Pseudomonas infection in burns," in *Archives of Surgery* [8], C. L. Fox, Jr. describes for the first time the effect of silver sulphadiazine on reducing burn wound sepsis and mortality. Since then, silver sulfadiazine has been the first choice in treating burns and today it is still frequently used worldwide, especially in full-thickness burns [9].

With the introduction of this anti-bacterial cream with its broad antibacterial spectrum, which results in less wound infection and sepsis, it became possible for patients to survive major burns. Especially in full-thickness burns, it has proven its benefits, and in many treatment protocols, the use of silver sulphadiazine is clearly defined [10].

In practice, however, most burn injuries are a mixture of superficial and deeper lesions, especially in scalds in children. In addition, negative side effects of silver sulphadiazine were observed over time. In mixed partial-thickness burn wounds, it is our policy to wait and see which parts will heal spontaneously within 2 weeks and to wait for demarcation of deeper areas that require excision and grafting.

A number of studies showed that silver sulphadiazine inhibits the healing of partial-thickness burn wounds [11]. In the late eighties and early nineties, it became evident that the optimal environment for wound healing is between moist and dry [12]. Therefore, modern wound dressings that create this jelly environment are used more and more, and this prompted the study described in Chapter 4.

In this chapter, a retrospective study is described that compared the clinical outcomes of using silver sulphadiazine with those from the hydrofiber dressing Aquacel®, a modern

wound dressing that creates a jelly environment. The primary endpoint was the need for secondary surgical intervention, and secondary endpoints were length of stay and readmission for the same burn.

**Chapter 4** *Reduction in skin grafting after the introduction of hydrofiber dressings in partial-thickness burns: a comparison between a hydrofiber and silver sulphadiazine*[13]

The study population consisted of 804 children aged 0-4 years with scalds on up to 10% TBSA between January 1987 and January 2010. Of these 804 children, 502 were treated with silver sulphadiazine (Ag-SD) and 302 with the hydrofiber dressing (HFD).

In the total study period, 27.3% of 502 children who were treated with silver sulphadiazine underwent skin grafting, whereas in the group of 302 children who were treated with the hydrofiber, only 11.6% required operative treatment, a significant decrease in the number of operations.

In addition, a second major gain after the introduction of hydrofiber dressings was the reduction in hospital Length Of Stay (LOS). Before the introduction of HFD, the mean LOS was 12.4 days. When HFD was introduced, a change of policy in wound treatment was initiated, and Ag-SD was later replaced by a variety of wound dressings, allowing for less frequent dressing changes and therefore less need for long hospital stays.

This could explain the observation that in the period during which both Ag-SD and hydrofibers were used, LOS for Ag-SD treated patients showed a statistically significant decrease to 9.7 days. However, patients with burns treated with HFD were admitted for 7.5 days, a more significant decrease compared with Ag-SD-treated patients in the same time period.

Although this was a retrospective study, with all the limitations that entails, it gained strength due to the large number of patients. However, as a result of our study combined with other benefits such as decreased pain perception and increased patient comfort (based on fewer dressing changes) at lower total cost, currently hydrofiber dressings are the first choice in treating scald burns over up to 10% TBSA in our burn center [14,15].

The proverb "All roads lead to Rome" is especially true in the vast range of wound dressings for burns. It should be realized that the ideal wound dressing still does not exist. With one dressing, it will take 14 days for a superficial burn to heal, and with the other, it will take two weeks. In addition to time for wound healing, patient comfort, ease of use and cost also determine the choice of a dressing. Burns are dynamic wounds: superficial-looking wounds can deepen secondary to multiple causes such as inadequate cooling or infection. The best time to assess the depth of burns is after 48-72 hours, and currently, laser Doppler imaging (LDI) is much more reliable than clinical assessment by physicians or nurses [16]. To be able to make LDI scans 2 to 5 days after the burn, the HFD has to be removed first, which is not

always easy after two days because the fragile, just-repairing epithelium may be disrupted. Hydrofibers therefore remain on the wound for approximately 10 days, making interim assessment impossible. It is always possible that there are deeper parts after dressings are removed that sometimes have to be operated on, and this has to be discussed in the beginning of treatment with patients and/or parents.

### **b) Bacteriological surveillance**

Infection remains one of the major complications in the period following severe burns, facilitated by the defect skin and patients' innate immune responses.

We had the opportunity to merge the patient database of the Rotterdam Burn Centre, with mainly demographic data on causes and localizations of burns, with a very large database from the hospital's Department of Bacteriology, which contained all microbial cultures over a period of 24 years.

After a presentation at the 16<sup>th</sup> Congress of the International Society for Burn Injuries in 2012 in Edinburgh, there was a discussion of a preliminary survey of bacteriological cultures taken on admission [17], and the question was raised about the need for and value of standard culturing of burn patients on admission.

This was the impetus for the article described in chapter 5, where the first results are presented of merging these two extensive databases [7,18]. Herein, the rationale for taking bacteriological cultures on admission is discussed, including the frequency of colonization with potentially pathogenic microorganisms on admission and identifying the bacteria involved and their potential roles in later septic complications.

### **Chapter 5** *Bacteriological cultures on admission of the burn patient; to do or not to do, that's the question*[18]

In this study, 3271 patients were included who had primarily been admitted to the Rotterdam Burn Centre between January 1987 and August 2010 with complete bacteriological swabs from the nose, throat, perineum and burn wounds.

Resistant bacteria or micro-organisms that can impede wound healing and cause major infections are found in a minority of bacteriological specimens obtained on first presentation of patients with burn wounds. Methicillin-resistant *Staphylococcus aureus* (MRSA) was cultured in 0.4% (14/3271) of patients on admission; 12 out of these 14 patients (85.7%) were repatriated from abroad. Overall, 9.3% (12/129) of repatriated patients were colonized with MRSA. Multi-resistant *Acinetobacter* or *Pseudomonas* were detected in 0.3% of patients (11/3271 and 10/3271 respectively). Overall 18 of 129 patients (14%) who were repatriated from abroad had one or more resistant bacteria in cultures taken within the first 24 hours after admission to our burn center.

On admission, Lancefield group A  $\beta$ -hemolytic streptococci (HSA) were found in 3.6% of patients (117/3271), predominantly in children up to 10 years of age (81/1065 = 7.6%). These microorganisms were found mainly in the throat but also in the burn wounds.

HSA can cause failure in primary closure or loss of skin grafts and is the only microorganism for which systemic antibiotic treatment is begun as soon as possible after admission.

Consequences in terms of isolation and therapy are of great importance, justifying the rationale for systematic bacteriological surveillance on admission. Our study indicates that special attention to resistant bacteria is required for patients who are repatriated from abroad and for HSA contamination in younger children.

In the Netherlands the incidence of resistant bacteria is relatively low, but misuse of antibiotics and other antimicrobials in humans and animals has led to the development of resistant bacteria: MRSA (Methicillin-resistant *Staphylococcus aureus*), VRE (Vancomycin-Resistant Enterococcus), Extended-Spectrum Beta-Lactamase (ESBL) producing bacteria and Carbapenemase-Producing Enterobacteriaceae (CPE).

Currently, five to ten percent of the Dutch population show colonization with ESBL-producing bacteria [19], and this worrying trend is caused by intensive use of antibiotics in various sectors. As a result of imports from abroad, contamination from livestock and infections in healthcare facilities and in households, it is likely that the increase in ESBL is unavoidable, indicating that bacteriological surveillance is no longer intended for burn patients only [19].

Apart from identifying microorganisms found on admission, we were interested in whether these bacteria were also responsible for later septic complications.

In 62.6% of 195 patients with later clinical signs of sepsis, *Staphylococcus epidermidis* was found in their blood cultures, indicating catheter-related sepsis.

*Pseudomonas* was cultured in 18.5% of later septic patients. In 0.9% of patients with later positive blood cultures, *Pseudomonas* was not present on admission; when found on admission, this microorganism was detected in 3.3% of patients with positive blood cultures, a significant difference. A similar trend was found for other gram-negative bacteria, but a predictive value could not be determined.

*Staphylococcus aureus* was found in 17.4% of patients with later clinical signs of sepsis. When it was not detected on admission, *Staphylococcus aureus* was found in the blood cultures of 0.9% of patients who later developed septic complications. In patients who had *Staphylococcus* initially, only 1.2% had later positive blood cultures for *Staphylococcus aureus*, a non-significant difference.

In conclusion, the results of bacteriological cultures taken on admission have very little predictive value for later septic complications. However, the rationale for culturing burn patients on admission is determined by the identification of bacteria that have consequences for isolation and therapy, for example, isolation in the presence of resistant microorganisms and the choice for early antibiotic therapy if Lancefield group A  $\beta$ -haemolytic streptococci are cultured.

Infections and sepsis are major complications that can lead to death. Thus, mortality prediction and information are the subjects of the third part of this thesis.

### **PART THREE: OUTCOME**

A variety of models have been developed for estimating the chances of surviving a burn injury. The most commonly used model is the Baux score. The Baux score is the sum of the total body surface area burned (TBSA) and the age of the patient [20]; it is a comparative indicator of burn severity, with a score over 140 considered unsurvivable. Because inhalation injury was recognized as an important contributor to mortality, Osler et al. developed a revised Baux score for predicting mortality in burn patients in an American population. It was found that inhalation injury resulted in an increase of approximately 17 points on the Baux score, which means that a patient with burns and an inhalation injury would have his revised Baux score calculated by TBSA burned + age of patient + 17 [21].

Chapter 6 describes a study that was performed to validate the revised Baux score with data from patients admitted to our burn center.

#### **Chapter 6** *External validation of the revised Baux score for predicting mortality in patients with acute burn injury[22]*

Prospectively collected data were analyzed for 4389 patients with an acute burn injury who were admitted to the burn center of the Maasstad Hospital in Rotterdam from 1987 to 2009, including sex, age, total involved body surface area, inhalation injury, mortality, and premorbid conditions. Logistic regression analysis was used to determine the relationships between mortality and possible contributing variables. The discriminative power of the revised Baux score was assessed by receiver operating characteristic curve analysis.

The mortality in the study group of 4389 patients was 6.5% (286/4389). In the group of non-survivors, 96 patients received tender loving care (TLC), and 190 had an intention to treat (ITT). Mortality in patients with ITT was 4.4% (190/4293).

Significant differences between survivors and non-survivors were found regarding age (median 25 vs 62.5 yrs), TBSA (5 vs 38%) and the presence of inhalation injury (7.2 vs 58%). As a result there were significant differences in Baux scores (33 vs 99) and revised Baux scores (33.5 vs 108).

Patients who did not survive had more comorbidities. This applied to the circulatory, gastrointestinal, urogenital, locomotor and endocrine tracts and the central nervous system (CNS). Age, total body surface area, and inhalation injury as well as premorbid circulatory and central nervous system conditions were significant independent predictors of in-hospital mortality.

The fact that CNS problems have predictive value for mortality could be explained by disorders such as neuropathy and CVA's that lead to decreased sensitivity and mobility, as well as by psychiatric disorders and suicide attempts, which frequently cause more serious burns.

Osler et al. believed that the revised Baux score performed the best in predicting mortality for patients between the ages of 20 and 80 years with TBSA values between 30% and 80% [21]. Contrary to this belief, in our study, the revised Baux score had high predictive value for mortality in the total population (area under the curve, 0.96; 95% confidence interval 0.95-0.97 vs. Osler's area under the curve of 0.81 with 95% confidence interval of 0.76-0.84). Differences in methodology could be responsible for the differences between our data and Osler's, such as different study periods and numbers of patients, the inclusion of all patients including patients with TLC, possible different diagnostics for inhalation injury and records of premorbid conditions.

We concluded that the revised Baux score is a simple and accurate model for predicting mortality in patients with acute burn injuries in a burn centre setting.

Including premorbid conditions in the revised Baux formula is not recommended because relevant historical information is not always available at admission and because of the resulting increased complexity of the model.

Although the Baux score has proven to be a useful tool in itself, it still remains difficult for a treatment team to decide on the basis of a mathematical calculation whether to begin treatment with the aim of survival or to opt for comfort care.

Limitations of the Baux score include the fact that neither the distinction between superficial and full-thickness burns nor the influence of different etiologies, for example, high-voltage electrical burns that can cause limited skin lesions but extensive life-threatening internal damage, are taken into account.

Mortality and causes of death are described in Chapter 7 and Chapter 8.

### **Chapter 7** *Mortality and causes of death in a burn center*[23]

In this retrospective study, we described mortality and causes of death for 135 of 1946 patients who were admitted to the burn center of the Maasstad Hospital in Rotterdam (RBC) between 1996 and 2006.

The overall mortality rate, including patients who received tender loving care (n=41), was 6.9%; mortality in patients with an intention to treat (ITT) was 4.9% (94/1905). Mortality, being an important parameter for outcome and quality, was compared with data from the American National Burn Repository (NBR), which were derived from data from 70 burn centers in the USA from 1995 to 2005. In this database, overall mortality of patients who were comparable in demographics such as age and TBSA was 5.6%.

However, in the NBR, it is not clear if patients who received TLC were also included, and there is no clear uniformity about the definition and therefore incidence of inhalation injury. The NBR reports an incidence of inhalation injury in 6.5%, whereas the RBC diagnosed inhalation injury in 12.5% of patients. In the RBC, inhalation injury was considered to be present in cases of clinical signs of airway obstruction, the presence of soot in sputum, or confirmation by bronchoscopy. In the NBR, no strict criteria for the diagnosis inhalation injury are described. The differences between the NBR and the RBC illustrate the need for uniform criteria for the diagnosis of inhalation injury.

Chapter 8 deals with mortality and causes of death of burn patients admitted to the Burn Centres of Rotterdam and Beverwijk between 2006 and 2011, creating the possibility to compare mortality rates in different time periods.

### **Chapter 8** *Mortality and causes of death of Dutch burn patients during the period 2006-2011* [24]

In this period 88 out of 2730 patients died after sustaining a burn injury, an overall mortality of 3.2%. The mean age of these 88 patients was 63.5 years and the average TBSA burned was 42.1%. Most burn injuries (89.9%) were flame burns.

Patients who died were subdivided in three groups. These groups did not differ in age and gender distribution and there was no significant difference in the incidence of inhalation trauma.

The first group of 28 patients received no active curative treatment from the start because of the severity of their injuries without chance of survival. All 28 patients in the palliative Tender Loving Care group were above 16 years of age, had a significant higher TBSA burned (65.7%) and higher Baux scores (124.5) and Revised Baux scores (133.0).

In a second group of 29 patients active treatment was started initially, but discontinued later due to complications like MOF and severe hemodynamic and respiratory insufficiency.

Compared to the group who received TLC these patients had lower TBSA's burned, lower Baux scores and more co-morbidities like pre-existing heart and lung conditions. The mean survival time in this group was 10 days with a range of 3 to 78 days.

The third group of 31 patients received active therapy until death, mean 19 days after injury (range 2 to 109 days).

Co-morbidities were more frequently present in the patients who primarily received active curative care.

In table 1 we combined results of the two studies from Chapter 7 and 8.

<b>Table 1. Results from studies on mortality after burn injuries</b>			
	<b>Bloemsma 1996-2006</b>	<b>Dokter 2006-2011</b>	<b>NBR*ref 1995-2005</b>
	Number of patients	1946	2730
	Mean age (yrs)	28.6	28.1
	Mean TBSA (%)	10.9	8.0
	Overall mortality (%)	6.9	3.2
TLC**	Number of patients	41/1946 (2.1%)	28/2730 (1.0%)
	Mean age (yrs)	61.1	58.8
	Mean TBSA (%)	62.3	65.7
	Inhalation injury (%)	95.1	50.0
	Mortality	100%	100%
ITT***	Number of patients	1905/1946(97.9%)	2702/2730(98.9%)
	Mean age (yrs)	27.9	28.1
	Mean TBSA (%)	9.7	8.0
	Inhalation injury (%)	10.7	40.0
	Mortality	94/1905(4.9%)	60/2702 (2.2%)

\* = National Burn Repository, \*\* = Tender Loving Care, \*\*\* = Intention To Treat

The 3 publications deal with significant differences of numbers of patients in different time periods. Mean ages and TBSA's burned were comparable. Most striking is the lower overall mortality of 3.2% in 2006 to 2011 compared to 6.9% in the period 1996 to 2006. The number of patients where no active therapy was given from the start is low, ranging from 2.1 to 1.0%. The percentage of inhalation injuries in the TLC group of Bloemsma (95.1%) was twice as much as in Dokter's publication (50%), with equal TBSA's burned and ages resulting in higher Baux scores.

In the ITT group comparable ages and TBSA's burned combined with a higher incidence of inhalation injuries of 40.0% in Dokter's publication would result in higher Revised Baux scores with worse prognosis, but mortality decreased from 4.9% to 2.2%.

The second goal of the studies was an analysis of causes of death following burn injury. To compare mortality rates, uniform classification of causes of death is also necessary; in the NBR, these data are lacking.

Multisystem organ failure (MOF) was the leading cause of death in 64.9% of patients (61/94) in the first study and 38.3% (23/60) in the second. Nearly all of these patients showed signs of systemic inflammatory response syndrome (SIRS). In the first study an infectious source in terms of proven or highly suspected sepsis was present in 45.9% of patients who died from MOF.

Preventing and treating MOF and better managing infection and SIRS might further decrease mortality, which has already improved with the institution of burn centers, advances in critical care, fluid resuscitation, operative approaches and techniques, insights in metabolism and the use of topical and systemic antibiotic agents.

The decreased mortality in burn patients in recent decades can be explained best by the decrease in mean TBSAs of admitted patients from 9.4% to 7.5% over the years 2006-2009 e.g.. Another explanation could be a changing referral pattern, especially in children as a result of the introduction of the Emergency Management of Severe Burns course in the Netherlands and ongoing improvement of burn care, prevention and educational programs. From the database of our own burn center in Rotterdam, we see that the mean age of patients with an ITT who died increased slightly over in time. The mean TBSA in these patients remained approximately the same, as shown in figure 1.

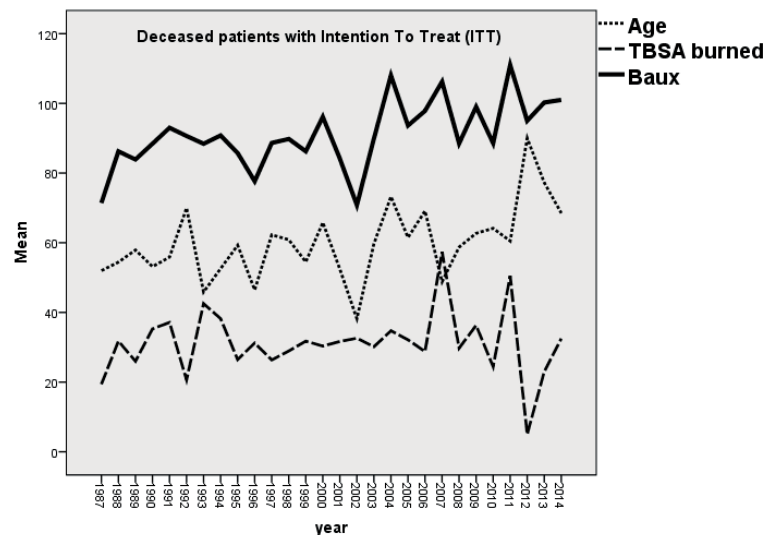


Figure 1. Deceased patients with Intention To Treat (ITT)

Mortality is one of the main markers for quality of burn care, but it appears that the limits for achieving burn survival have been reached and that other outcome measures after surviving severe burns have become increasingly important. Long-term outcome measures such as quality of life measures, exercise tolerance and return to pre-burn activities are now becoming of equal importance as the numbers of burn survivors increase.

## REFERENCES

1. Dokter J, Vloemans AF, Beerthuizen GI, van der Vlies CH, Boxma H, Breederveld R, Tuinebreijer WE, Middelkoop E, van Baar ME; Dutch Burn Repository Group. Epidemiology and trends in severe burns in the Netherlands. *Burns*. 2014 Nov;40(7):1406-14. Epub 2014 Apr 2
2. Vloemans AF, Dokter J, van Baar ME, Nijhuis I, Beerthuizen GI, Nieuwenhuis MK, Kuijper EC, Middelkoop EM. Epidemiology of children admitted to the Dutch burn centres. Changes in referral influence admittance rates in burn centres. *Burns*. 2011 Nov;37(7):1161-7. Epub 2011 Jul 2
3. Eerste opvang van brandwondpatiënten in de acute fase (1ste 24 uur) van verbranding en verwijzing naar een brandwondencentrum. Nederlandse Brandwonden Stichting, Nederlandse Vereniging voor Brandwondenzorg, Vereniging Samenwerkende Brandwondencentra Nederland 2014 ISBN: 978-90-809861-3-8 Richtlijnontwikkeling
4. Statistics Netherlands. Population; sex, age and marital status; 2012, Available from URL: <http://www.statline.cbs.nl> [accessed 04.09.12].
5. <http://www.ameriburn.org>
6. Gabbe BJ, Watterson DM, Singer Y, Darton A. Outpatient presentations to burn centers: data from the Burns Registry of Australia and New Zealand outpatient pilot project. *Burns*. 2015 May;41(3):446-53.
7. Database Burn Centre Maasstad Hospital, Rotterdam, The Netherlands
8. Fox CL Jr. Silver sulfadiazine--a new topical therapy for Pseudomonas in burns. Therapy of Pseudomonas infection in burns. *Arch Surg*. 1968 Feb;96(2):184-8.
9. Fox CL Jr. Silver sulfadiazine for control of burn wound infections. *Int Surg*. 1975 May;60(5):275-7
10. Cech M. Management of patients with burns in the Zuiderziekenhuis, 1974-1976. *Ned Tijdschr Geneeskd*. 1978 Jan 28;122(4):114-9.
11. Wasiak J, Cleland H, Campbell F, Spinks A. Dressings for superficial and partial thickness burns. *Cochrane Database Syst Rev*. 2013 Mar 28;3:.
12. Jonkman M.F. Epidermal wound healing between moist and dry. Thesis. University of Groningen, Groningen; 1989.
13. Dokter J, Boxma H, Oen IM, van Baar ME, van der Vlies CH. Reduction in skin grafting after the introduction of hydrofiber dressings in partial thickness burns: a comparison between a hydrofiber and silver sulphadiazine. *Burns*. 2013 Feb;39(1):130-5. Epub 2012 Apr 4.
14. Yarboro. A comparative study of the dressings silver sulfadiazine and Aquacel Ag in the management of superficial partial-thickness burns. *Adv Skin Wound Care*. 2013 Jun;26(6):259-62.
15. Muangman P<sup>1</sup>, Pundee C, Opananon S, Muangman S. A prospective, randomized trial of silver containing hydrofiber dressing versus 1% silver sulfadiazine for the treatment of partial thickness burns. *Int Wound J*. 2010 Aug;7(4):271-6.
16. Monstrey SM, Hoeksema H, Baker RD, Jeng J, Spence RS, Wilson D, et al. Burn wound healing time assessed by laser Doppler imaging. Part 2: validation of a dedicated colour code for image interpretation. *Burns* 2011; 37(2): 249-256.
17. Jan Dokter, Wim Hendriks, Kees v.d.Vlies, Margriet van Baar, Nele Brusselaers. Do patient and burn characteristics influence surveillance cultures taken at admission 16<sup>th</sup> congress International Society for Burn Injuries (ISBI). 2012 International Conference Centre Edinburgh (Schotland). <http://app.emobilise.com.au/files/programs/22/abstracts/13924.pdf>
18. J.Dokter, N.Brusselaers, W.D.H.Hendriks, H.Boxma. Bacteriological cultures on admission of the burn patient; to do or not to do, that's the question. *Burns*. 2016 Mar;42(2):421-7.
19. Heleen Croonen. De ongehinderde opmars van ESBL. *Medisch Contact* Nr.20 -20 mei 2010, 910-913.

20. Baux S. Contribution à l'Etude du traitement local des brulures thermiques et endues. Paris, France: These; 1961.
21. Osler T, Gance LG, Hosmer DW. Estimates of the probability of death after burn injuries: extending and updating the Baux score. *J Trauma*.2010;68:690Y697.
22. Dokter J, Meijjs J, Oen IM, van Baar ME, van der Vlies CH, Boxma H. External validation of the revised Baux score for the prediction of mortality in patients with acute burn injury. *J Trauma Acute Care Surg*. 2014 Mar;76(3):840-5.
23. Bloemsma GC, Dokter J, Boxma H, Oen IM. Mortality and causes of death in a burn centre. *Burns*. 2008 Dec;34(8):1103-7.
24. J. Dokter, M. Felix, P. Krijnen, J.F.P.M. Vloemans, M.E van Baar, W.E. Tuinebreijer, R.S. Breederveld, The Dutch Burn Repository Group. Mortality and causes of death of Dutch burn patients during the period 2006-2011. *Burns*, Volume 41, Issue 2, March 2015, Pages 235-240
25. Pereira C, Murphy K, Herndon D. Outcome measures in burn care. Is mortality dead? *Burns*. 2004 Dec;30(8):761-71.

