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The aetiology of burns in developed countries: review of the literature

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This article reviews the literature on the incidence and aetiology of burn injuries. Burn injuries are among the most serious injuries man can incur. Although prevention of burn injuries has been given a good deal of attention in the past, it has never been subjected to a systematic approach which could result in a thorough knowledge of the incidence and the major risk factors and risk groups. The methodological limitations of the studies carried out in this field are striking. For instance, none of the studies of risk factors has used a control population for comparison. No figures are available on the total number of burn injury patients in the Netherlands. Estimates are derived from the situation in other countries, which yields an incidence of four per 1000 per year. Scalds are relatively common in the 0-4-year category. This is usually assumed to be caused by the stage of development of motor and cognitive skills, coupled with incorrect assumptions about these skills by parents. Men are found to be more often the victims of burns than women. Coffee and tea are assumed to be risk factors. The supposed risk factors and risk groups need to be investigated in a controlled epidemiological study, in order to allow establishment of preventive measures.

Introduction

Burn injuries have long been described in the literature as among the most serious injuries that may afflict a human being (Gross, 1864; Artz, 1979; Freck et al., 1979; Hermans and Olthuis, 1984). The main reason is that the severity and long-term effects of the injury are often considerable. This paper will discuss the incidence and nature of burns, as well as the circumstances under which burns occur. In addition, possible risk factors will be discussed. It is important to note that the literature referenced is primarily drawn from European, American and Australian studies. There is scant literature from non-Western countries to provide data for comparison so it is not possible to assess the roles that custom and culture play in patterns of burn injuries. Burn injuries are described in terms of 'depth' and 'extent'. The latter aspect is often measured by means of the 'rule of nines' (Wallace, 1951), in which the individual body areas represent a certain percentage of the total body surface area. This rule has to be adjusted in the case of children, as their bodily proportions are different. Roughly speaking, 'extensive burns' are all burns which affect more than 10 per cent of the body's surface (Hermans, 1982).

The depth of the burn is expressed in terms of first, second or third degree, or as superficial, partial skin thickness or full skin thickness. In addition to the extent and depth of the burn injury, the patient's age and the affected part of the body also determine the severity of the injury. Thus in very young (age 0-4 years) and elderly patients, burns are life threatening sooner than in the other age categories. Burns to the face, neck, hands and perineum are relatively serious, because skin shrinkage often occurs during the healing process, which may lead to contractures (Spijker et al., 1980).

In the literature, burn injuries are often categorized on the basis of the nature of the burn. The most common categories (Hermans and Spijker, 1977) are as follows:

- Scalds (caused by hot liquids).
- Flame burns.
- Flash burns (resulting from radiant heat in explosions).
- Contact burns (resulting from touching hot objects).
- Chemical burns.
- Electrical burns (resulting from electric current).
- Other causes, including radioactivity and irradiation.

Since chemical and electrical burns are too complex in nature (Huffstad and Klasen, 1975; Philips-Duphar, 1979), and often bear little resemblance to other types of burn injuries, these two types of burns will not be discussed here.

The depth of scalds is often very difficult to ascertain. In this type of burn injury, burns which are initially assumed to be second degree (partial skin loss) often turn out later to be third degree (full skin thickness). This may have consequences for treatment. Hence a reappraisal of the depth diagnosis after 12-24 h is essential in this type of burn injury (Broekhuizen, 1987). In scalds, it is also important to know the nature of the causative agent, since, for instance, hot water (with its high specific heat) tends to cause deeper burns than hot oil or fat. Flame and contact burns will generally be deep (Philips-Duphar, 1979; Van der Putten and Schouten, 1984). Flash burns are rarely discussed in the literature, probably because of their low incidence. A category receiving a good deal of attention lately is that of sunburn. In the above categorization of burn injuries by nature, these belong with the 'other causes'. Severe sunburn is comparable to superficial burn injuries (Bickers, 1982). Apparently, the number of sunburn cases is rising, as a result of the growing popularity of sunbathing in the West.

world. This rising incidence is attributed to the desire to acquire a tan as soon as possible, and to the increasing use of pharmaceuticals which can render the skin abnormally sensitive to solar radiation (van der Klauw, 1988). The depth of such sunburns is often 'only' first (superficial) or second degree (partial skin thickness).

Over the past few years, much progress has been made in the treatment of burn injuries. However, the specialized care given to seriously burned patients is time consuming and very expensive. Here too, prevention is better than cure. Effective prevention requires a thorough understanding of the major risk factors. Publications on this subject are scarce. Most papers discuss the medical treatment of burns, or describe the occurrence, nature or severity of the burns. However, studies of risk factors involving comparisons between groups of patients with burn injuries and control groups are not available, although the importance of this type of research in relation to the study of the aetiology of burn injuries is generally recognized (Knudson-Cooper, 1984).

Incidence

The incidence of burn injuries is clearly related to the severity of the burns. The incidence of (very) small burns can be said to amount to 100 per cent, but this figure is hardly interesting. Of greater importance are the data on more severe burn injuries, but here the problem of defining such severe burn injuries arises. The literature shows the use of three types of operationalization, which, respectively, define severe burn injuries as:

- Second degree (partial skin thickness) burns in which more than 15 per cent of the body surface area is affected (Spijker et al., 1980).
- Third degree (full skin thickness) burns in which more than 2 per cent of the body surface area is affected (Koller, 1987).
- All burns in which more than 10 per cent of the body surface area is affected (Hermans, 1982).

Incidence data based on these conceptual definitions are not available. However, burn injuries can also be described in terms of 'medical consumption', which allows a distinction between burn injuries treated by the general practitioner or by the specialist, on an inpatient or an outpatient basis, or in a specialized burn treatment centre. This distinction is made because of the great difference between all burn injuries and the subgroup of those who have been admitted to hospital. Incidence data based on medical consumption are available, although limited.

A study of 24 000 households in the Netherlands (van Montfoort et al., 1988) estimates the number of burn injury patients receiving medical treatment in the Netherlands each year at 45 000. It is assumed that about 31 000 of these patients are treated by the general practitioner. These assumptions result in an incidence rate of three per 1000 medically treated burn patients per year, of which two per 1000 patients are treated by a general practitioner per year.

Since the middle of 1983, the Dutch Home and Leisure Accident Surveillance System (PORS) has kept a record of the burn injuries treated at First Aid Stations or other in- or outpatient departments in hospitals. Among the 18 types of injuries recorded, burn injuries take about the tenth place, with a share of about 2 per cent (Privé Ongevallen Registratie System, 1985, 1986, 1987).

According to the Dutch National Medical Records

(LMR), over 4000 burn injury patients are hospitalized in the Netherlands each year. Of these patients, an average of 450 were admitted to the specialized burn injury treatment centres in 1984 and 1985, while this figure rose to 650 in 1986 (Stichting Consument en Veiligheid, 1987).

Some of the data on medically treated burn injuries inside and outside the Netherlands, taken from the literature, are given in *Table I*. For a number of reasons, the incidence figures in *Table I* cannot be easily compared with one another. The main reason is the use of various definitions for the severity of the burn injuries. The incidence rates from Denmark (Sørensen, 1976; Thomsen et al., 1978; Lyngdorf, 1986) are based on epidemiological studies on the total number of burn injuries recorded in Copenhagen in 1965, 1975 and 1983. Because of the fact that the registration system covered those treated in hospital as well as those treated by a general practitioner, it was possible to estimate the total number of burn injuries and to calculate the incidence of medically treated burns.

Nevertheless, some cautious conclusions can be drawn from these data. The incidence of burn injuries is much higher among the 0-4-year category than among the other age categories. This corresponds with data from Dutch studies (e.g. Klasen, 1983; Rogmans, 1984). The explanation for this is often sought in the great urge for movement by children at this age, their lack of skill in walking and their lack of judgement (Klasen, 1983; Rogmans, 1984). In addition, parents often misjudge their children's developmental stage, which may also contribute to the high incidence of burn injuries (Rivara and Howard, 1982). The low incidence figure reported by Feck et al. (1979) can be attributed to the fact that they only include burn injuries which affect more than 10 per cent of the body surface area, i.e. only very severe burn injuries. All other investigators report incidence figures around three or four per 1000 per year.

Risk groups

Scalds are the most frequent type of burns (e.g. Klasen and Sauer, 1979; Glasheen et al., 1981; Libber and Stayton, 1984; Rogmans, 1984; Darko et al., 1986; Haberal et al., 1987). In children between the ages of 0 and 4 years scalds account for 50 per cent of all burn injuries (Thomas et al., 1984). For the other age categories the figure is lower. In their study of burns in children ($n=382$), Klasen and Sauer (1979) even found a percentage of scalds of 80 per cent in the 0-5 years category. They distinguish between various types of hot liquid (including bath water, coffee, tea, soup) and report that coffee and tea are the most frequent causes of burns. A later study (Klasen and ten Duis, 1986) of young children ($n=884$) showed a similar percentage of scalds (77 per cent), with a reduced share for coffee. A possible explanation for this could be the increased popularity of the automatic coffee-maker. This will be discussed in more detail below. Davies (1985) studied 1680 children with burn injuries, resulting for the 0-4-year age category in a percentage of scalds similar to that reported by Klasen (1979). In addition, Davies found a clear difference between boys and girls in this age category: boys are more often the victims of scalds than girls. Similar findings have been reported by other investigators (Glasheen et al., 1982; Libber and Stayton, 1984; MacKay-Rossignol et al., 1986). However, Davies (1985) also reports that in the 0-1-year category the percentage of scalds is about equal for boys and girls.

It is striking that the number of burn injuries among children between the ages of 5 and 14 years is so much lower

Table I. Incidence rates based on medical consumption

Author	Country	Year	Incidence (1000/yr)	Patients (no.)	Remarks
Thomsen et al.	DK	1978	4	2200	All types of burn injuries
Glasheen et al.	USA	1982	10.7	1552	Only scalds in children
Feck et al.	USA	1979	0.3	5791	Burn injuries more than 10% BSA
Lyngdorf	DK	1986	3	75	All types of burn injuries
Sørensen	DK	1976	3.5	2900	Burn injuries treated by a general practitioner
Montfoort et al.	NL	1988	3	24000	All types of burn injuries
Montfoort et al.	NL	1988	2	24000	Burn injuries treated by a general practitioner

than that in the 0-4-year category (Davies, 1985). Moreover, the former age category shows relatively more burns of other types than scalds, such as flame and contact burns. This has also been found by MacKay et al. (1979) in a study of age-specific burn injuries ($n = 2729$). This author reported that flame burns often occurred in boys between the ages of 10 and 14 years, very often as a result of explosions involving petrol. This type of burn occurred eight times more often in boys than in girls.

Flame burns are the most common type of thermal injury in persons of 60 years and over, and lethality is relatively high for these injuries (Anous and Heimbach, 1986). Ostrow et al. (1987) studied 327 burn injury patients over 65 years of age, and found that 51 per cent of all burn injuries in this group were flame burns, 19 per cent were scalds, and 18 per cent were contact burns. The remaining 12 per cent were electric, tar and other burns. The study showed that in this age category contact burns were more common in men.

In the 20-39-year age category the majority of burn injuries are apparently also flame burns (Boxma et al., 1984).

Circumstances

The circumstances which lead to burn injuries can best be discussed on the basis of the nature of the burn. Since burns by hot liquids and by fire are relatively more common than others, only scalds and flame burns will be discussed here.

As for scalds, tea and coffee are regarded as the most important causes (Klasen, 1980; Rogmans, 1984). Typical circumstances under which such scalds occur include that of children getting hold of an object filled with hot liquid, which is standing on the stove or the kitchen worktop. Another common situation is that of children pulling down a hot liquid container with the tablecloth (Klasen, 1980). In his study of scalds among Brisbane children, Philips et al. (1986) showed that very young children (aged 0-2 years) incur relatively more scalds from overturned cups or mugs, while slightly older children (aged 2-6 years) receive burn injuries relatively more often as a result of hot water from baths, showers or taps. Davies (1985) also mentions hot water from baths, showers or taps as a major cause of burns. Among the 1036 young children with burn injuries he studied, 49 per cent received their injuries from this source. Burn injuries caused by hot water from baths or taps appear to be far less frequent in the Netherlands than in the UK. This difference has been explained by the greater popularity of mixer taps in the Netherlands (Klasen, 1980). Most scalds occur in the home. In the kitchen, most accidents occur during cooking or while making tea or coffee. In his study in

Copenhagen, Sørensen et al. (1977) found that nearly all scalding accidents occurred in the kitchen. Davies (1985) mentions children at play, who push each other under the shower or into a bath, as the prime cause of scalds. Rogmans (1984) mentions that in the Netherlands the course of events of scalding accidents in bathrooms is not always clear. The impression is that children often injudiciously turn on the hot water tap by themselves.

As for flame burns, a number of common circumstances can also be found in the literature. Byrom et al. (1984) regard liquids (particularly petrol and paraffin) catching fire as the most common situation in which flame burns occur. This cause is also mentioned by Klasen (1980), but in his study of 316 burn injury patients with ages up to 14 years, playing with fire was found to be a more common situation leading to flame burns. In particular during the summer months, a relatively large number of flame burns result from exploding butane gas containers. Saxby and Shakespeare (1985) described 47 burn injury patients admitted to the Wessex Burn Injury Treatment Centre as a result of exploding butane gas containers. Of these accidents, 18 were the result of failure to observe the instructions on the container. In the Netherlands too, exploding gas containers cause many burn injuries each year (Boxma et al., 1984). Finally, it has been found that many flame burns are caused by textile fabrics catching fire. Rogmans and Braams (1983) subdivide these products into clothing fabrics (clothes, cleaning cloths, rags) and furnishing fabrics (bedclothes, carpeting, curtains and upholstery). Clothing fabrics are most often set on fire by contact with gas stoves, electric lights and matches, while furnishing fabrics catch fire particularly from electrical appliances, gas stoves, burning cigarettes and matches.

It should also be borne in mind that in some instances of burn injuries in young children, there are indications of maltreatment. In particular burn injuries with an 'abnormal pattern', where often only certain parts of limbs are burned, may indicate deliberate infliction, especially if the burn injuries narrowly fail to be serious enough to warrant admission to hospital (Lung et al., 1977).

Risk factors

The proposed risk factors can be classified into demographic factors, situational and personal characteristics, and products, and they will be discussed in that order below.

Demographic factors

Strictly speaking, conclusions about risk factors can only be drawn if the presence of such factors in persons with burn

injuries is compared with that in persons from a control group without burn injuries. As was mentioned above, the need for this type of research is generally accepted, but the existing literature on the subject of burn injuries shows no studies actually using this type of research. Hence this section of the paper will discuss a number of possible risk factors that are assumed to be related to the occurrence of burn injuries, although there is no solid empirical evidence for this. As was described above, burn injuries occur more often in young children (aged 0–4 years). This is often attributed to the development of motor and cognitive skills, and to an incorrect opinion on the part of the parents about these skills. Sex differences have been discussed above. On the whole, boys aged 0–14 years are found to suffer more frequent burn injuries than girls. de Leeuw (1988) seeks to explain this difference in terms of acquired or encouraged 'masculine' or 'feminine' role behaviour.

On the basis of his study of risk factors in 1552 persons admitted into the Virginia Burn Injuries Center with severe burn injuries over a period of 21 months, Glasheen et al. (1982) concluded that, in general, men run a higher risk of burn injuries than women. In addition, this author claims that the non-white population runs a higher risk of severe burn injury than the white population.

Situational and personal characteristics

Noyes et al. (1979) demonstrated a positive correlation between stressful life-events and the occurrence of burn injuries. Of the 67 burn injury patients admitted to the Iowa City Burn Injury Center in 1978, about half were found to have a long history of physical and psychological disorders. Physical disorders included arteriosclerosis, hypertension and diabetes mellitus. Psychological disorders included alcoholism and anxiety neuroses. Such complaints were found to be related to stressful events such as divorce or loss of employment, occurring during the year preceding the accident at which they suffered their burn injuries. The study led to the identification of two groups of persons who have an increased risk of burn injuries—elderly women with physical complaints, and persons belonging to the lower socioeconomic classes who have psychological problems. Again, the study could be criticized for not using a control group.

In a study similar to that by Noyes (i.e. without a control group), Libber and Stayton (1984) examined about 100 children aged 0–16 years, who had been admitted to the Baltimore Burn Injury Centre. They concluded that boys aged 1–2 years, who are the youngest in a large, single-parent family, and who belong to the lower socioeconomic classes, run an increased risk of burn injuries. Knudson-Cooper (1984) adds to the list of risk groups those children of school age who have many problems adapting to school and who are hyperactive.

Products

As was discussed above, coffee and tea are often involved in accidents leading to burn injuries in children aged 0–4 years. Because of this, Sørensen (1976) started a campaign for the prevention of burn injuries as a result of overturned coffee filters, by marketing two safer coffee filters. The share of 'overturned coffee filters' in the cause of burn injuries then fell from 45 per cent in 1971 to 32 per cent in 1974. Whether this decrease can be attributed to the new coffee filters was not investigated any further. The drop may also have been caused (Klasen and ten Duis, 1986) by the increased use of automatic coffee-makers.

The role of coffee and tea as risk factors for burn injuries is frequently discussed in the literature. In addition, less

common risk factors are also regularly reported. Some of these factors will be briefly discussed here. An example is inflammable nightwear for children, which is often involved in accidents leading to burn injuries. Moreover, children often wear such nightwear when they are not actually in bed, which increases the risk of burns. Unlike other European countries, Dutch law has not yet banned easily inflammable textiles for clothing. Around New Year's Eve, many burn injuries are caused by fireworks. Furthermore, many young children in Denmark are reported to suffer burns when they put old, or broken, bakelite electric power plugs into their mouths (Fogh-Andersen and Sørensen, 1984). Other products presenting risk factors include barbecue grills, candles and electric kettles. However, these factors appear to be of minor importance compared to coffee and tea.

Discussion

Despite the number of published studies of risk factors for burn injuries, hardly any controlled epidemiological research is available which would allow sound conclusions about particular risk factors. The course of events leading to burn injuries in, for example, young children is frequently investigated, but parents whose children did not suffer burn injuries are never interviewed. Most studies of burn injuries focus on the nature and severity of the burns. In addition, a number of factors (particularly in the case of scalds in children) are described as risk factors (e.g. coffee and tea). However again, all of these studies were carried out without a control group. Nevertheless, recommendations for intervention are frequently made on the basis of such non-controlled studies. It is essential, therefore, that carefully planned epidemiological studies, using an adequate control group, are undertaken. It will also be necessary to make a more complete estimate of the incidence of burn injuries, in order to establish the full extent of the problem. As soon as risk factors have been identified, it should be established which factors can be changed or influenced, and what methods would be most effective in bringing about the desired change in behaviour. In so far as the factors identified are mainly related to behaviour, health education would appear to be an important method. Should most of the factors identified turn out to be not directly related to behaviour, legal measures and regulations may be more effective. Eventually, evaluative studies will have to show whether influencing the risk factors actually leads to a decrease in the number of burn injuries.

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