Chapter 12

Problem of Burns in Children: Opportunities for Health Improvement

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Additional information is available at the end of the chapter

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Abstract

Burns are one of the most devastating types of trauma in medicine. Children under 5 years of age are a high-risk group to burns. The most common type is thermal burn caused by hot fluids (scald). Most childhood burns occur at home under parental supervision. These are preventable injuries. The chapter presents results of my studies about risk factors of burns in children and possibilities of health improvement. Simple changes in children's environment and increasing awareness of caregivers can lead to a decrease in the number of this type of injuries. Moreover, the first aid given to burnt children soon after the injury usually is not adequate (no cooling thermal burns and no analgesia). Health improvement can be obtained by reducing the number of burns, the correct first aid given after the injury, and the organization of specialized health-care centers and rehabilitation services for victims of burns.

Keywords: children, burns, scalds, thermal burns, trauma

1. Introduction

Burns are often called one of the most devastating types of trauma in medicine because their consequences have physical and mental dimensions.

Severe burns can cause death. Physical consequences of nonfatal burns include scars, contractures, and keloids. The victims suffer due to disfigurement and disability often leading to stigma and rejection by the society. Among mental consequences of burns are, for example, low self-esteem, depression, or anxiety.

Burns are type of trauma that can be caused by thermal energy, chemical agents, electricity, or radiation. According to the World Health Organization, burn is an injury to the skin or other

organic tissues primarily caused by heat or due to radiation, radioactivity, electricity, friction, or contact with chemicals.

According to Juan P. Barret, trauma can be defined as bodily injury severe enough to pose a threat to life, limbs, tissues, and organs, but burn injury is different, because unlike other traumas, it can be quantified as to the exact percentage of body injured and can be viewed as a paradigm of injury from which many lessons can be learned about critical illness involving multiple organ systems [1].

2. Epidemiology of burns

According to the statistics of the World Health Organization, 180,000 deaths every year are caused by burns [2]. Majority of them occur in low- and middle-income countries. It is estimated that almost two thirds occur in the African and South-East Asia regions. The highest fire-related mortality rates are in Southeast Asia, 11.6 deaths per 100,000 population per year; in the Eastern Mediterranean, 6.4 deaths per 100,000 population per year; and in Africa, 6.1 deaths per 100,000 population per year [3].

Among pediatric population the rate of deaths from burns is over seven times higher in low- and middle-income countries than in high-income countries. Lowest mortality rates due to burns in high-income countries are the successful result of preventive interventions of many kinds, such as promotion of the use of smoke detectors, the lowering of temperatures of hot water heaters, the installation of sprinkler systems, the promotion of flame-retardant children's sleepwear, and the development of safer buildings and household fuels [3].

The epidemiology of burns differs in different age groups and depends on sex [3]. For example, in low- and middle-income countries, fire-related burns are the sixth leading cause of death among 5–14-year-old victims and the eighth leading cause death among 15–29-year-old victims [3].

In low- and middle-income countries, women (especially young) are at higher risk of burns [3]. However in high-income countries, men are at higher risk of burns.

In pediatric population, it is estimated that worldwide approximately 1% of all children sustain a burn injury each year [4].

The results of our studies conducted in Lower Silesia (the region of Poland) among children with burns indicate that boys are at higher risk of burn injury [5, 6].

The analysis of mechanism of trauma revealed that the most common type of injury in children treated in ambulatory conditions by general practitioners (GP) and requiring hospitalization due to burns in Lower Silesia was thermal burns [5, 6]. The second reason for hospitalization and ambulatory treatment were chemical burns [5]. In the studied population, there were no cases of burns caused by radiation [5, 6].

Among the pediatric patients hospitalized due to thermal injury in Lower Silesia, 2010–2012, burns were usually located in the upper limbs [5]. Trunk and lower limbs were also frequently affected [5].

The detailed analysis of the thermal burns of upper limbs revealed that the hand and wrist were more often affected than forearm, arm, and shoulder. However, the detailed analysis of the thermal burns of lower limbs revealed that the injury affected more often the hip, tight, knee, and lower leg than ankle and feet [5].

Most of patients under 18 years old treated by GP due to burns in Lower Silesia of children were under 2 years old [6]. Moreover, in the studied population, the percentage of children hospitalized due to burns in Lower Silesia in 2010 according to individual age groups in age group under 2 years old was 0.5%, in children from 3 to 6 years old was 0.12%, in children from 7 to 12 years old was 0.06%, in children from 13 to 15 years old was 0.07%, and in children from 16 to 18 years old was 0.06% [5]. Similarly in the studied population, percentage of children hospitalized due to burns in Lower Silesia in 2011 according to individual age groups in age group under 2 years old was 0.54%, in children from 3 to 6 years old was 0.13%, in children from 7 to 12 years old was 0.06%, in children from 13 to 15 years old was 0.07%, and in children from 16 to 18 years old was 0.08% [5].

The chemical injuries were less common in pediatric population of Lower Silesia in the analyzed period of time. However, it was noticed that this type of burns more frequently affects the upper gastrointestinal tract than thermal burns [5, 6].

The obtained results are coherent with other studies realized in Polish pediatric population [7].

3. Classifications of burns

There are many ways in which burn injury can be classified.

Apart from the mechanism of injury, usually four criteria are taken into account: depth of injury, percent of body surface area involved, location of the burn, and association with other injuries [4].

3.1. Etiologic factor of injury

According to the etiological factor (factor that caused the burn injury), we can distinguish thermal, electrical, and chemical injury and burns caused by radiation.

The most common types of burns in children are thermal burns. Thermal injuries are caused by heat. They can be the result of hot liquids (scalds), hot solids (contact burns), and flames (flame burns). In pediatric population, especially in children under 2 years old, the most common type of burns is scalds.

3.2. Location of injury

Anatomic location is important in triage decision [4]. Burns can affect all parts of the body: head, neck, trunk, upper and lower extremities, perineum, and upper anterior abdominal wall (**Figures 1–3**).

International Classification of the Disease (ICD) is used by physicians, nurses, health-care providers, and researchers to classify the diseases and other health-care problems. It facilitated the comparison of date between different regions and is widely used for epidemiological purposes.

Figure 1. The child with the thermal burn of the knee (partial thickness burn).

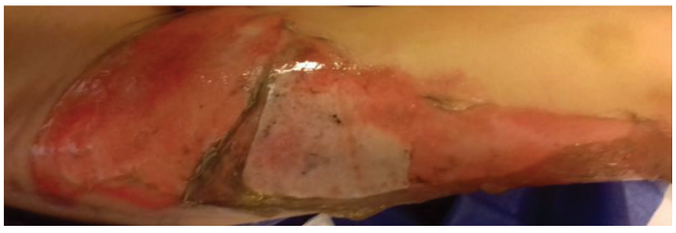

Figure 2. The child with the thermal burn of the lower extremity (partial thickness burn).

Figure 3. The child with the thermal burn (superficial) of the trunk caused by hot water (scald).

In the ICD-11 burns are divided into burns of external body surface, specified by site; burns of the eye or internal organs; and burns of multiple or unspecified body regions. In the ICD-10 the group of burns of external surface included burns and corrosions of all depth divided into burns and corrosions of head and neck (T20); burns and corrosions of trunk (T21); burns and corrosions of shoulder and upper limb, except the wrist and hand (T22); burns and corrosions of the wrist and hand (T23); burns and corrosions of the hip and lower limb, except the ankle and foot (T24); and burns and corrosions of the ankle and foot (T25) [8].

Burns involve also inhalation injuries. Inhalation injuries should be suspected in patients with facial burns, singed nasal hairs, and carbonaceous sputum [4].

The location is important in assessment of the risk of disability—the greatest is in the case of patients with affected face, eyes, feet, perineum, and hands [4].

3.3. Depth of burns

The skin is composed of two layers: epidermis and dermis. The epidermis is composed of stratified squamous epithelium, which acts as a barrier to infectious agents and also prevents fluid loss from the body [9].

As children's skin is thinner than adult's skin, exposure to the same agent will cause deeper burns in an infant compared to adults. For example, water at 60°C will cause a full-thickness burn in less than 1 s in an infant and 20 s in an adult [10].

At the emergency department, it is difficult to describe the thickness of burn injury because the appearance of burn wound evolves during first 24–48 h [9].

Usually in one pediatric patient, we observe burns of different depth.

According to depth of the skin affected, burns can be divided into superficial, partial-thickness, and full-thickness burns [9].

Superficial burns involve only the epidermal layer; the skin is erythematosus.

In partial-thickness burns, the whole epidermis and part of the dermis are affected. Most of authors distinguish superficial partial-thickness burns and deep partial-thickness burns. In the superficial partial-thickness burns, the papillary layer of the dermis is affected, and the erythema of the skin and blistering are observed. In the deep partial-thickness burns, the reticular layer of the dermis is affected, and the skin looks paler and has a speckled appearance due to thrombosis of superficial vessels. The deep partial-thickness burns are less painful than the superficial partial-thickness burns.

In the full-thickness burns, the epidermis and dermis with epidermal appendages are affected [9]. This type of burns is usually the result of flame, prolonged contact with hot objects, and hot oil [9].

In some old literatures, the classification involves first, second, third, and fourth degrees. The first degree corresponds with the superficial burns. The second degree A corresponds with the superficial partial-thickness burns; the second degree B corresponds with the deep partial-thickness burns. The third degree corresponds with the full-thickness burns. The fourth degree burns involve full depth of the skin and underlying fascia, muscles, or even bones [4].

3.4. Surface of burns

The extension of burn injury is expressed as percentage of total body surface area. There are several methods used to count the surface of burn.

In the teenagers and adults, the extent of the skin involved is estimated on the basis of "rule of nines." That means the surface of each upper extremity is 9% of total body surface area, each lower extremity is 18% of total body surface area, the anterior part of the trunk is 18% of the total body surface area, the posterior surface of the trunk is 18% of the total body surface area, the head is 9% of the total body surface area, and the perineum is 1% of the total body surface area [4]. There is a modified rule of nines for infants and children (**Figure 4**).

According to "rule of palm," the inner surface of the patient's palm is approximately 1% of total body surface area.

In younger children the Lund and Bowder charts are used to estimate the extension of burn wound [4].

According to extent of body surface involved, ICD-10 classified burns into burns involving less than 10% of body surface (T31.0), burns involving 10–19% of body surface (T31.1), burns involving 20–29% of body surface (T31.2), burns involving 30–39% of body surface (T31.3), burns involving 40–49% of body surface (T31.4), burns involving 50–59% of body surface (T31.5), burns involving 60–69% of body surface (T31.6), burns involving 70–79% of body surface (T31.7), burns involving 80–89% of body surface (T31.8), and burns involving 90% or more of body surface (T31.9) [8].

The extension of burn injury plays a crucial role in the process of decision-making about hospitalization of the patient. It is also important to count the amount of intravenous fluids that should be given to the patient.

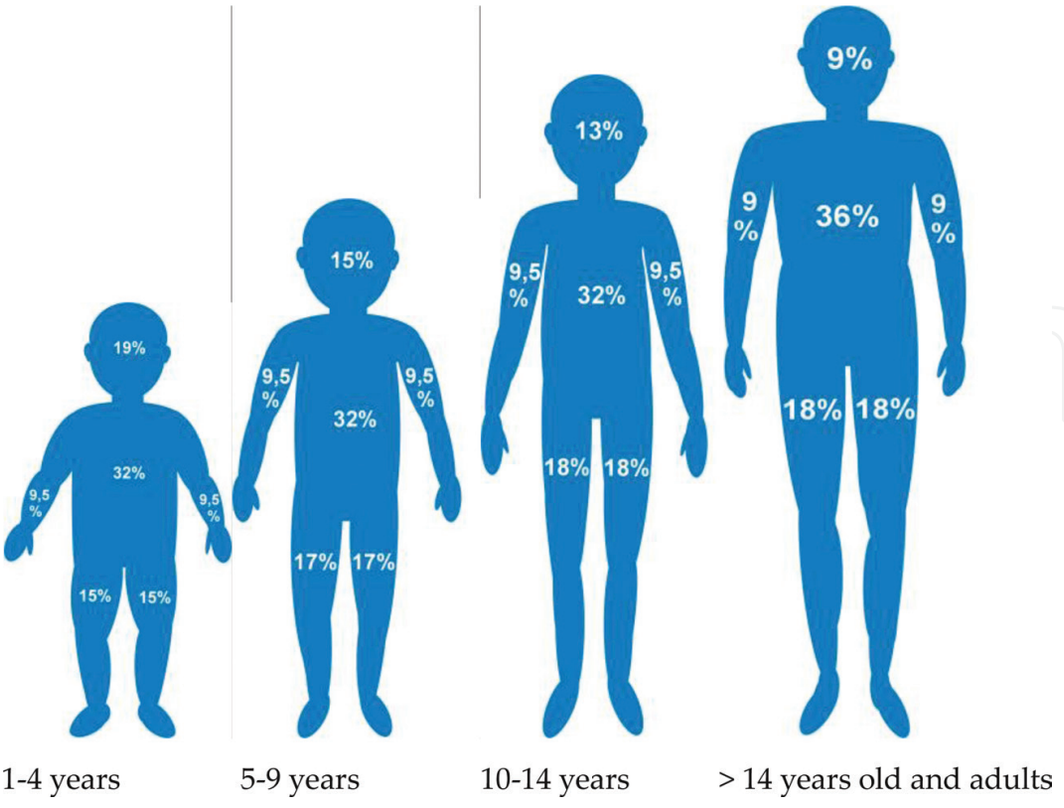

Figure 4. Modified rule of nines in children in different age groups.

3.5. Jackson's zones of injury

According to Jackson it is possible to classify thermal burns into three zones of injury: the inner, the intermediate, and the outer zone. The inner zone is the zone of coagulative necrosis. The intermediate zone is the zone of stasis, while the outer zone is the zone of hyperemia [11].

4. Pathophysiological effects of burn injury

Pathophysiological effects of burn injury can be divided into local and systemic [11].

The local effects include release of inflammatory mediators from the capillary walls, white blood cells, and platelets. These inflammatory mediators result in vasodilatation and increased vessel permeability that leads to fluid loss from the circulation into the interstitial space [11].

Systemic effects occur in extended burns (usually in those that burned surface area exceeds 20% of total body surface area) and include hypovolemia, immunosuppression, catabolism, loss of the protective function of the gut, and pulmonary edema [11].

A major burn injury leads to fluid and electrolyte imbalance with systemic intravascular losses of water, sodium, albumin, and red blood cells. If the intravascular volume is not rapidly restored, the shock develops [1]. Moreover, burns can lead to malnutrition and organ dysfunction due to metabolic disturbances (hypermetabolism and muscle catabolism) [1].

5. Causes of burns

The burns according to the cause of the injury can be divided into accidental and nonaccidental.

Most of burns in children are caused by the accident [12].

There are several features that can make a health-care provider to suspect nonaccidental injury.

Among them is delay in seeking medical help by parents. It is very important to write down all the details of mechanism of the injury provided by caregivers, because sometimes caregivers change the history of trauma with time. The non-accidental injury is suspected when the mechanism of injury given by parents is not coherent with the burn wound found in child and also when the history of trauma is not consistent with the developmental stage of the child. In older children the abnormal behavior, such as avoiding eye contact, can be observed.

Characteristic for nonaccidental burns are burn wound caused by cigarettes. Also the so-called glove or sock burns are typical for nonaccidental injury. In many children with nonaccidental burns, additional sings of trauma can be found, for example, bruises, fractures, etc.

According to Adronicus et al., there were no differences between the groups in age or mortality between children with accidental and nonaccidental burn injuries. The authors found that in the group of children with nonaccidental injuries, burns involving both hands or both legs

were more common; these patients were more likely to require skin grafting and treatment in the intensive care unit [12]. Moreover the abused/neglected children were more likely to come from single parent families [12].

6. First aid in burns

The appropriate first aid after burn injury is very important in reduction of burn depth, which means that it influences the requirement for surgical treatment, can shorten the hospitalization time, and results in better esthetic scar.

According to WHO, the person who gives the first aid to the burned child should stop the burning process by removing clothing and irrigating the burns; extinguishing flames by allowing the patient to roll on the ground, or by applying a blanket, or by using water or other fire-extinguishing liquids; use cool running water to reduce the temperature of the burn; in chemical burns, remove or dilute the chemical agent by irrigating with large volumes of water; and wrap the patient in a clean cloth or sheet and transport to the nearest appropriate facility for medical care [2].

WHO also pays attention on the actions that the person who gives the first aid to the burned child should not do; for example, do not start first aid before ensuring your own safety (switch off electrical current, wear gloves for chemicals, etc.); do not apply paste, oil, haldi (turmeric), or raw cotton to the burn; do not apply ice because it deepens the injury; avoid prolonged cooling with water because it will lead to hypothermia; do not open blisters until topical antimicrobials can be applied, such as by a health-care provider; do not apply any material directly to the wound as it might become infected; and avoid application of topical medication until the patient has been placed under appropriate medical care [2].

The person who gives first aid to the child after the burn injury is usually the person that was present during the accident—in most of cases—the parent. Unfortunately, the own results indicate that parents do not provide first aid to burned children correctly. The most common mistakes were no cooling the burn wound and no analgesics used [13].

The aim of prehospital care is stabilizing ABCDEs (airway, breathing, circulation, disabilities, and environment control), preventing ongoing burn injury and provision of analgesia, covering area involved, and rapid transfer to emergency department [9].

It is worth to underline that also first aid provided by medical stuff in the place of the injury is not correct. The situation seems surprising, because in Poland young doctors are trained in first aid (including first aid in burns) during studies.

Nessler et al. conducted the pilot study (the anonymous questionnaire) among young doctors in Malopolska region (Poland) to evaluate the knowledge of burn first aid, because many patients admitted to burn centers in Poland receive inadequate treatment just after burn injury. The questionnaire verified the respondents' knowledge about appropriate first aid provided several minutes after burn trauma and included questions about possibilities of actions after

burn trauma in cases of burned patients. The obtained results were alarming, which revealed that the knowledge of burn first aid among young doctors is not satisfactory—none of the respondents answered correctly to all the questions. Only in 75% respondents knew that burn wound require cooling with running water, whereas only 25% respondents knew how to react after chemical injury [14].

It seems that more attention should be paid on education of caregivers of small children and medical stuff about first aid in burns.

7. Treatment of burns

Care for burned pediatric patient is a challenge for medical and paramedical staff. Treatment of burns is multidisciplinary. According to Juan P. Barret and David N. Herndon, in the burn team, apart from surgeons who specialize in the treatment of burns (general, pediatric, and plastic surgeons), should work also nurses (experienced with care for burned patients), intensive care professionals, scrub and anesthesia nurses, case managers (acute and reconstructive), anesthesiologists, respiratory therapists, rehabilitation therapists, dietitians, psychosocial experts, social workers, volunteers, microbiologists, research personnel, quality control personnel, and workers of support services [1].

The triage decision is based on the extent of burn, body surface area involved, type of burn, associated injuries, any complicating medical or social problems, and availability of ambulatory management [4].

In addition to what has been mentioned above, the criteria that are taken into account to decide if the patient requires hospitalization or referral to the center of burns are anatomic location of the injury and age of the patient.

The most important aspect in pediatric population is age—all the children younger than 1 year old should be hospitalized. Moreover all patients with third-degree burns should be treated in the hospital. Apart from depth of the injury, also extension of burn is taken into account. Hospitalization should be considered in children from families with lower socioeconomic status. Pediatric patients with burns on the face, hands, feet, genitalia, perineum, and joints; all patients with inhalation injuries and electrical or chemical burns; and also patients with associated injury should be hospitalized. Moreover, each patient with suspected nonaccidental injury should be admitted to the hospital. In Poland children with burns are hospitalized in departments of pediatric surgery (with personnel educated about care of burnt patients) or burn centers (children with major burns).

It is possible to classify burn injury according to the severity into minor, moderate, and major [1]. Patients with moderate and major burns require hospital treatment. Minor burns are burns covering less than 15% total body surface area in adults and less than 10% total body surface area in children; less than 3% total body surface area is full-thickness burn; they do not involve the head, feet, hands, or perineum [1]. Moderate burns are burns covering 15–25% total body surface area in adults and 10–15% total body surface area in children,

full-thickness burns 3–10% total body surface area, and superficial partial-thickness burns of the head, hands, feet, or perineum [1]. Each case of suspected child abuse is classified as moderate burn [1]. Moreover, in this group, all patients have burn injury and concomitant trauma, significant preexisting disease, and extreme age (neonate and infants). Major burns cover more than 25% total body surface area in adults and more than 15% total body surface area in children [1]. In this group are full-thickness burns of more than 10% total body surface area, deep burns of the head, hands, feet, and perineum, inhalation injuries, chemical burns, and electrical burns [1].

Initial treatment follows the ABCDEs of resuscitation. The aim is to stabilize the airway, breathing, and circulation [9].

Airway management should also include assessment for the presence of airway or inhalation injury [4]. In the cases of suspected airway burns, early intubation can be considered [9]. Children with stridor due to upper airway compromise also require urgent intubation [9]. Potential indications for ventilation are excessive burns that cover over 60–70% of total body surface area, full-thickness circumferential chest burns, and severe inhalation lung injury causing pulmonary edema and hypoxemia [9].

All children with burns over 20% of total body surface area should have intravenous access (peripheral access through non-burnt skin is preferred) [9]. Fluid resuscitation rates should be calculated using the time of burn, patient's body mass, and the surface of burn with the use, for example, of Parkland formula [9]. To determine the adequacy of fluid replacement, monitoring of urinary output is useful [9]. Some patients require nasogastric tube. Important issue in care of burned patient is analgesia.

The treatment of burns can be conservative and operative. Fortunately, most of children do not require surgical treatment, which is reserved for patients with deep (third degree) burns. Conservative treatment is indicated in children with superficial, partial-thickness burns.

Among the most often realized surgical procedures are escharotomy (rare), excision of the dead tissue, and skin grafting [1]. Escharotomy is indicated in patients with circumferential burns on the chest or limbs. The aim of escharotomy is to release the constrictive eschar. The burned skin should be released by incisions with electrocautery within the lines of escharotomy. Early excision of necrotic tissues and grafting is indicated in patients with full-thickness burns. In Poland burn wounds are covered with autografts (donor site is usually tight, less often scalp or back). Skin grafts can be split-skin grafts and full-thickness skin grafts. Most pediatric patients require split-skin grafts. Full-thickness skin grafts can be necessary in specific areas, such as the face (lips, eyelids, nose), hand/fingers, toes, and genitalia. In cases of extensive burns, it is possible to use meshed skin grafts.

Burn wound dressings play crucial role in the care for patient with burns. Burn dressing should protect the burn wound from further harm, such as desiccation, mechanical trauma, and infection. Moreover, they can facilitate the process of healing and relief pain [10]. The current literature is still inconclusive with regard to the gold standard burn dressing for the pediatric population [15]. In Poland burn wound is usually treated with silver sulfadiazine. However, it is commonly known that the ideal dressing for children should alleviate pain, decrease length of hospital stay, and minimize the risk of complications [15].

8. Consequences of burns

The consequences of burns are mostly related with the loss of skin functions. The skin is the largest organ in the body and plays a crucial role in regulating body's temperature by preventing heat loss to the environment. It also prevents water loss from the body and acts as a barrier to infective organisms [9].

It is important to underline the fact that children have a greater ratio of surface area to volume of the body, increased metabolic rate, increased heat loss (less fat and shivering), and increased evaporative water loss [10].

Possible complications of burns include variety of problems, for example, sepsis, hypovolemia, hypothermia, carbon monoxide poisoning, cyanide poisoning, gastric ulcers, cardiac dysfunction, hypermetabolic state, renal failure, transient antidiuresis, and anemia [4]. Another possible complication is laryngeal edema that can be treated with endotracheal intubation and tracheostomy [4]. Moreover, due to edema, compartment syndrome can develop, which means that the patient requires escharotomy [4]. Escharotomy technique involves making longitudinal incisions in segments with inelastic circumferential burns, usually of full thickness [1]. Possible contractures should be treated with physical therapy. Due to the risk of psychological trauma, it is important to provide to burn patients psychological rehabilitation [4]. The possible complications from respiratory system include pulmonary infiltrates, pulmonary edema, pneumonia, and bronchospasm [4]. Inhalation injuries may result in bronchospasm, airway inflammation, and impaired pulmonary function [4]. Moreover, they can result in difficulties in eating and drinking [4].

Among long-term consequences of burns in children are physical scarring and emotional impact of disfiguring burns [4].

9. Risk factors of burns in children: social, economic, and environmental issues related with burns in children

The risk of burn is the highest in children under 2 years old and in boys [5, 6]. Most of burns occur at home, when the child is under the supervision of parent. Appropriate supervision seems even more important than safe environment in prevention of burns in children [16].

Most of burns in children less than 2 years old occur when their mother or father is in the same room. The researchers found that family characteristics play a crucial role in increasing the likelihood of the injury. Lower maternal education, young age of mother and unemployment, and lone parenthood are identified risk factors of burns in children [17].

It is worth to underline that economic situation of the family is also important, because differences in the income result in differences in living conditions. The home environment plays an important role in the risk of burn injury among children.

Among effective strategies that reduce number of flame burns in pediatric population are installation of smoke alarms and smoke detectors [16].

According to the WHO, the possible modifications of the environment that can reduce the number of thermal injuries among children are improved heating and lighting equipment at homes [16].

The own review of the studies about environmental risk factors of burns in children indicates that effective strategy in prevention of scalds in pediatric population is lowering the temperature in the water heaters [17]. Moreover, several studies identified the lack of hot water supply in the household as a risk factor of scalds in children [17].

The arrangement of the apartment that decreases the likelihood of childhood injury includes limited access to the cooking area (and hot fluids). The own review of the studies about environmental risk factors of burns in children indicates that most burn accidents occur in the kitchen [17]. Kitchen without door was found to increase risk of burn injury [17]. The WHO also pays attention to the arrangement of the apartment and separation of cooking area from living area [16].

10. Opportunities for health improvement

Burns are preventable, so prevention strategies should address the hazards for specific burn injuries, education for vulnerable populations and training of communities in first aid. According to the European Report on Child Injury Prevention, there are many cost-effective strategies to prevent burns in children, for example, combination of approaches—involving legislation, engineering, environmental modification, and education [16].

Simple changes in the children's environment and increasing awareness of caregivers can lead to decrease in the number of this type of injuries.

11. Conclusions

To sum up, burns are injuries that affect approximately 1% of all children per year. Their consequences can have physical and mental dimension. Serious burns can lead to death.

Most of these injuries are preventable. Simple changes in the children's environment and increasing awareness of caregivers can lead to decrease in the number of burns in children. Moreover, the first aid given to burn children soon after the injury usually is not adequate (no cooling thermal burns and no analgesia). It is important to underline that also medical staff is not always well educated in providing first aid to burned patients.

Thus, education (medical stuff, paramedical stuff, and caregivers) about first aid in burns and increasing awareness of caregivers about the unsafe behaviors (such as leaving the mug with hot tea at the edge of the table, where the child can easily reach), avoiding the situations that puts child at risk of burn, seems to be one of the most important parts of prevention.

Moreover, legislation interventions such as laws to enforce smoke detectors, smoke alarms installation, or regulation of hot water at homes are promising strategies to reduce the number of burned children.

Health improvement can be also obtained by reducing number of pediatric patients with burns, correct first aid given after the injury, and organization of specialized health-care centers and rehabilitation services for victims of burns.

Conflict of interest

I confirm there are no conflicts of interest.

Acronyms and abbreviations

ABCDE	airway, breathing, circulation, disabilities, and environment control
ICD	The International Classification of Diseases
TBSA	total body surface area
WHO	World Health Organization

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