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Review



# SKIN FEATURES IMPORTANT FOR THE OCCURRENCE OF CONTACT DERMATITIS IN HEALTHCARE WORKERS

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SUMMARY – The occurrence of skin lesions in healthcare workers is associated with a negative impact on important skin functions, including protection from mechanical injuries, sunlight, dehydration, and penetration of chemical substances or pathogenic microorganisms. In healthcare professionals, the most common occupational skin disease is contact dermatitis (CD), either irritant (ICD) or allergic (ACD), and typically on the hands. ICD accounts for about 80% of occupational CD, making it the most frequent cause. According to the literature, CD frequency is higher among healthcare professionals than other occupations, with critical occupational risk factors including contact with irritants and allergens at the workplace. Furthermore, ICD is a multifactorial disorder influenced by many constituent and environmental factors. Constituent factors include age, gender, body location, atopy, and genetic factors, while environmental factors include temperature, airflow, humidity, and occlusion. Commonly encountered irritants are water, detergents and surfactants, solvents, oxidizing agents, acids, and alkalis; however, use of protective gloves or equipment, hand-washing habits, use of cleansers and creams, active inflammatory skin diseases, and daily activities are also important for ICD onset. Additionally, ICD is known to predispose to ACD. Important risk factors for ACD development include occupation, age, history of atopic dermatitis, genetics, female gender, and fair skin phototype. In summary, numerous skin features and other occupation-related factors contribute to CD among healthcare practitioners. Given the high level of exposure to contact irritants/allergens in the healthcare setting, implementation of preventive measures is crucial for a safer work environment.

Key words: *Contact dermatitis; Healthcare workers; Irritant contact dermatitis; Allergic contact dermatitis; Hand eczema; Medical doctors; Dentists*

## Introduction

A variety of factors play a role in skin inflammation at the onset of contact dermatitis (CD), including its occurrence in healthcare workers. CD is known to be one of the most common inflammatory skin diseases to occur after contact with irritants and/or allergens. CD includes two types, irritant CD (non-allergic, toxic; ICD) and allergic CD (ACD), both of which can have a clinical course in either acute or chronic form[1,2]. ICD accounts for approximately 70%-80% of CD cases, while ACD is less common[3]. Furthermore, hands are the most common location of CD. In the general population, the frequency of hand eczema is about 4% and is more common in women than in men, however, this incidence is increased in health-

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care workers (it ranges from 0.6 to 6.7 *per* 10,000 person-years)[1-4].

## Methods

In this narrative review, we analyzed available data on the current knowledge and latest findings on the occurrence of CD in healthcare workers. Our methods included analysis of recent articles published in English available through the PubMed database and other prominent literature, including medical internet web pages/basis. Inclusion criteria for cited articles were coverage of the main topic that implicates findings on the ICD and ACD in healthcare workers (primarily including medical doctors and dentists) and articles that were published in the last 20 years with accentuation on those published in the last 5 years.

## Protective Functions of the Skin Important for the Occurrence of Contact Dermatitis in Healthcare Workers

Numerous skin functions (excretion, absorption, thermoregulation, immune activity, hormone and vitamin D synthesis) play a crucial role in protecting the body from mechanical injuries, sunlight, dehydration, loss of nutrients, and penetration of pathogenic microorganisms and chemical substances from the environment[1,3,5,6]. The integrity and preserved functionality of the epidermal barrier are essential in achieving these functions and are especially important for the occurrence of CD among healthcare workers who often are in contact with various substances[3,7]. The protective and defensive functions of the skin almost entirely belong to the epidermis, its surface layer (*stratum corneum*) and the hydrolipid layer on its surface. The structure of the epidermis and its layers are compared to a brick-and-cement model, i.e., corneocytes (the bricks) and the extracellular matrix (the cement) composed of various proteins (corneodesmosin, antimicrobial peptides) and lipids (glucosylceramides, cholesterol, phospholipids, sphingomyelin). The proteins and lipids of the extracellular matrix are synthesized and excreted into the intercellular space (combining with the membrane of the epidermal spinous layer of keratinocytes) by lamellar bodies, or so-called Odland bodies[5]. In addition, lamellar bodies contain enzymes such as proteases, anti-proteases, enzymes from the lipase group (phospholipase A, sphingomyelinase, steroid sulfatase, acid lipase) and enzymes from the glycoside group. These enzymes are crucial for the breakdown of excreted lipids and proteins into a less polarized mixture, composed of ceramides (50%), cholesterol (25%) and free fatty acids (15%), and promote a decline in the pH of the extracellular matrix and mild skin acidity[5,6,8].

The slightly acidic skin surface interacts with the superficial bacterial flora (microflora) that helps protect the skin from infections (bacteria, fungi and viruses), unique to each individual. The pH of the epidermis, starting from the surface, is reduced through several epidermal corneocyte layers and then rises slightly, in other words, the pH gradient is not linear but sigmoid, which is important for controlling the enzymatic activity involved in cellular metabolism and restoration. The steepest change in pH is found in the middle and lower epidermis, where pH-dependent enzymes are most active[5,8]. The pH of the surface hydrolipid layer is between 4.5 and 5.5; as such this layer is also called an 'acidic skin cloak' or an 'acidic leather robe'. This delicate pH balance may be affected by exposure to irritants that disturb the microflora or skin enzymes important for barrier renewal, all of which contribute to the development of CD[5]. The hydrolipid layer consists of lipid and water components and adds to the skin protection from harmful external influences, acting like wall plaster. The lipid component is created by the sebaceous glands and keratinocytes, while the water component consists of secretions of sweat glands and water released by keratinocytes to the very surface of the skin. These components are united by a natural emulsifier and scattered throughout the skin surface to keep it soft. Within the intercellular spaces, along with lipids and proteins, there are natural hydrating factors (natural moisturizing factor, NMF) that bind and attract water. NMF, specifically, is a mixture of amino acids (40%), pyrrolidone-carboxylic acid (12%), lactic acid (12%), urea (7%), urocanic acid (3%), ions (18%; $Na^+$, $Ca^{2+}$, $Mg^{2-}$, $PO_4^{3-}$, $Cl^-$), carbohydrates, NH3, peptides, and glucosamine (8%). It stems from the protein filaggrin (FLG), rich in histidine found in keratohyalin granules. At relative humidity <85%, FLG is hydrolyzed into free amino acids (histidine, glutamine and arginine), which are then metabolized into the osmotic active substances important for the regulation of corneal hydration, making up NMF[5,9].

The transepidermal water loss (TEWL) is yet another important diagnostic parameter of the skin[10,11].

According to one study, TEWL could be an indicator of an individual's sensitivity to the ACD development and an indicator of early skin damage, especially hand skin, which is often associated with occupational exposure to irritants[10]. TEWL measurement is often combined with measuring of the skin pH to give further insight into the skin condition. Various factors such as gender, age and body location can also impact TEWL and skin pH, and may be important for the occurrence of CD among healthcare workers. Currently, there is no consensus on the impact of race/ethnicity or gender on TEWL. Generally, TEWL values are significantly higher in darker skin types than in fair skin types, although not all studies find significant differences between races[11]. Data on the impact of age and body location on TEWL values are more consistent. TEWL is largely age-independent. In regard to body regions, TEWL is closely related to the anatomic skin area on which it is measured, as a result of variations in the skin structure on different parts of the body and their exposure to environmental conditions. Thus, the highest TEWL values are proven on the palms, which may contribute to the onset or persistence of hand CD among healthcare workers.

As for skin pH, there have been differences noted by race and genetic inheritance (i.e., dark skin types generally have a lower skin pH than fair skin types). Gender is considered to have no significant effect on skin pH, although one study noted slightly higher skin pH in women compared to men[6]. By age, skin pH is mostly constant in the 18-60 age group in most anatomic sites, although conflicting data can be found in the literature[12]. While there is some variation based on individual and environmental parameters, TEWL and skin pH assessment are useful in the evaluation of the protective skin function and detection of early skin changes.

Another important factor that is not often mentioned in skin homeostasis and skin barrier maintenance is psychological stress, commonly recorded among healthcare workers. Thus, psychological and physical stressors stimulate neuroendocrine responses that can affect multiple aspects of skin physiology, including the skin barrier, all important for CD[13]. It should be noted that skin structures (epidermal and dermal) produce different hormones (e.g., cortisol) and have receptors for many hormones (e.g., cortisol, corticotropin-releasing hormone, adrenocorticotropic hormone)[14-16]. Previous research has established that glucocorticoids reduce lipid production and thus hinder production and excretion of lamellar bodies. Thus, epidermal production of lamellar membranes is weakened and so is the epidermal barrier function. The epidermis also contains free nerve endings that connect the skin to the peripheral nervous system. During times of stress, neuropeptides are released from these endings (e.g., substance P and vasoactive intestinal peptide), affecting keratinocyte mitotic activities. Similarly, nerve endings themselves can directly affect the activity of Langerhans cells (LC) and thus contribute to the stress-induced onset or exacerbation of skin diseases, including occurrence of CD in healthcare workers[17].

**Irritant Contact Dermatitis**

Irritant contact dermatitis is a localized, inflammatory, non-allergic skin response to several different chemical or physical factors. This multifactorial disorder is influenced by the physical and chemical properties of irritants, host sensitivity factors, and environmental factors. It results from the direct cytotoxic effect of irritants and, unlike ACD, it is not immune-mediated[18]. Irritants are chemical or physical agents that, when in contact with the skin, can disturb the skin integrity if applied long enough and in sufficient concentration.

Common chemical irritants include water and so-called wet work, detergents and surfactants, solvents, oxidizing agents, acids, and alkalis; all these factors may participate and contribute to common CD occurrence in healthcare workers. Since water is hypotonic, it acts as a cytotoxic agent on eroded skin. Prolonged contact with water on intact skin causes corneal swelling, disruption of intercellular lipids, and an increased skin permeability and sensitivity to irritants. Wet work is defined as prolonged skin exposure to liquids or wearing occlusive gloves for more than two hours a day or washing or disinfecting hands more than 20 times a day. Occupations involving wet work include handling and preparing food, occupations related to healthcare, cleaning, and hairdressing (Fig. 1). Detergents used for household and industry cleaning remove lipids and hygroscopic substances on the epidermal surface, denature proteins, and damage cell membranes. Similarly, solvents remove lipids and hygroscopic substances and damage cell membranes. Their ability to irritate depends on their chemical structure; aromatic solvents

*Fig. 1. An example of allergic contact dermatitis on the hand of a healthcare worker.*

(e.g., benzene or toluene) are particularly strong irritants, even stronger than alcohol or ketones (e.g., acetone). Oxidizing agents such as sodium hypochlorite or benzoyl peroxide have a cytotoxic effect. Strong acids cause protein clotting and cell necrosis, while alkaline solutions saponify surface lipids, dissolve water-retaining substances, break cross-rotated keratin bonds, and cause cell swelling. Strong alkaline substances include soaps, ammonia, potassium and sodium hydroxide, cement, and chalk. The irritating potential of a substance depends on its chemical properties (e.g., acid dissociation constant, ionization status, molecular mass or liposolubility) and duration of contact with the skin or mucous membranes[19]. High concentrations of irritating chemical substances trigger strong skin reactions in almost all individuals, while mild irritants can only trigger an inflammatory response in sensitive individuals or after repeated or prolonged contact[20]. Furthermore, various chemical substances can act synergistically in causing dermatitis, e.g., combined exposure to solvents and detergents, and may also be recorded among healthcare workers[21].

Apart from chemical irritants, there are physical irritants such as metal tools, wood, glass-reinforced plastic, plant parts (e.g., thorns, spines), paper, dust, and soil[22,23]. Chronic microtrauma or friction can damage the epidermis, disrupt the epidermal barrier, and promote the release of pre-synthesized cytokines in keratinocytes. Physical irritants can act synergistically with chemical irritants (such as detergents or water), causing serious disruption of the epidermal barrier[24].

Concerning the pathogenesis, ICD may develop through multiple mechanisms (some of which have not been fully explained), e.g., damage to the epidermal barrier and keratinocyte cell membranes, cytotoxic effect of irritants on keratinocytes, release of keratinocyte cytokines, and activation of innate immunity[25,26]. Initial ICD development occurs through damage to the epidermal barrier by skin occlusion or by influence of chemical or physical irritants, resulting in higher skin permeability and TEWL, and lower natural hydrating factor[27]. In experimental animal and human models, acute epidermal barrier disruption due to exposure to superficially active substances (e.g., sodium lauryl sulfate) stimulates keratinocytes to release cytokines, e.g., interleukins (IL)-1α, IL-1β, IL-6 and tumor necrosis factor-alpha (TNF-α)[28]. In doing so, IL-1α and TNF-α act as primary signals for the release of pro-inflammatory chemokines that attract mononuclear and polymorphonuclear cells to the site of injury[28,29]. In addition, TNF-α stimulates the expression of intercellular adhesion molecule 1 (ICAM-1) on keratinocytes, which promotes the infiltration of leukocytes into the epidermis. According to recent research on acute CD, CD44 participates in transendothelial transition of inflammatory cells, as well as maintaining the cell barrier[30]. In response to exposure to irritants, a release of anti-inflammatory cytokines such as IL-10 and IL-1 receptor antagonists (IL-1RA) occurs, which may be involved in the regression of the inflammatory process[31]. So, the pathogenesis of ICD is very complex.

Unlike the acute ICD form, the pathogenesis of chronic ICD is not well studied. According to one hypothesis, chronic exposure to mild irritants or so-called wet work reduces the inflammatory skin response and stimulates cell proliferation and differentiation. A comparison of cytokine levels in normal skin *versus* chronically irritated skin (repeatedly exposed to sodium lauryl sulfate) revealed that chronically irritated skin contained higher levels of IL-1α, TNF-α and IL-1RA than non-irritated skin[31,32]. Tolerance to chronic irritant exposure has also been observed in some peo-

ple; this adaptation to repeated irritating exposures is called the 'hardening phenomenon'. The mechanism underlying this phenomenon is not known, but it is believed to include changes in skin morphology (e.g., acanthosis and hyperkeratosis), corneal lipid composition, barrier permeability, and expressiveness of inflammatory mediators[33].

Development of ICD is influenced by many constituent and environmental factors, which is important to keep in mind for timely recognition and preventive measures for healthcare workers. Constituent factors influencing ICD include age, gender, body location, atopy, and genetic factors.

When studying skin reactivity by age, reaction to irritants was noted to be highest in infants and decreased with age; lower reactivity to irritants was observed in people over 65 years compared to those under 30 years of age. By gender, the prevalence of ICD is generally higher in women than in men, especially on hands. This higher risk in women is thought to be related to increased exposure to detergents in households and workplaces, and so-called wet work, and not to actual sex differences in skin sensitivity. However, the prognosis and cure rate are similar in both genders[4]. When studying specific body locations, the response to irritants varies according to area, reflecting differences in the epidermal thickness and epidermal barrier function. A greater propensity for chemical irritation is noted on the face, dorsum of the hands, and interdigital skin compared to the palms, soles or back[19].

Among other CD-related factors, atopy is also an important predisposing factor. Atopy, defined as a condition of genetic predisposition for development of IgE-mediated allergic diseases [(such as allergic rhinitis, asthma and atopic dermatitis (AD)], is an independent risk factor for developing occupational ICD. For example, people with AD have been observed to manifest chronically impaired epidermal barrier function, which increases their susceptibility to irritants[34,35]. Atopic workers exposed to skin irritants have a three times higher risk of developing occupational ICD than exposed non-atopic workers[36]. According to a study conducted in patients with occupational skin diseases (OSDs) and ICD, 64% of ICD patients reported a personal or family history of AD or had typical AD symptoms[37]. Studies in twins have shown that genetic factors are also associated with atopy (e.g., cytokine gene polymorphism) and a propensity for ICD[38]. Null mutations in the *FLG* gene have been found to be associated with the development of allergic disorders, mainly AD[39]. In addition, there is evidence that *FLG* gene mutation increases the risk of developing allergic sensitization, allergic rhinitis, and AD-related asthma[40-42]. Additionally, people with a low threshold for the irritating effects of sodium lauryl sulfate and benzalconium chloride have a high prevalence of TNF-α gene polymorphism, which is associated with its increased production[43,44]. In a study examining the genetic basis of susceptibility to irritants in healthcare professionals, nine polymorphisms of individual nucleotides were identified (single nucleotide polymorphism, SNP) in the seven genes involved in skin inflammation and homeostasis: rs2268387, rs16934132 and rs2284685 in the *ACACB* gene, rs1179251 in the *IL-22* gene, rs2227564 in the *PLAU* gene, rs6593202 in the *EGFR* gene, rs308439 in the *FGF2* gene, rs10868231 in the *NTRK2* gene, and rs1347424 in the *NTRK3* gene[45]. Just as genetic predisposition is important for developing CD, it is also important for the development of OSDs. Environmental factors, such as temperature, airflow, humidity, and occlusion also affect the skin response to irritants[46]. High temperatures and airflow reduce the epidermal barrier function and increase the penetration of irritants, while low temperatures and low humidity increase TEWL and skin sensitivity to irritants[47,48]. Increased skin moisture (e.g., sweating due to prolonged wearing of gloves) can also disrupt the epidermal barrier and intensify the inflammatory response to chemical or mechanical irritants[24].

Diagnosis of ICD is mainly based on clinical findings of localized dermatitis in patients with a history of exposure to chemical or physical irritants, which all are important for timely recognition of ICD in healthcare workers. Skin examination and precise history data are key to making the correct diagnosis. Complete skin examination is needed to assess the extent of skin involvement and concomitant skin disorders. In most cases, the affected lesions occur on areas such as the arms, face, and neck. However, irritants can also be transferred to other areas through contaminated hands or clothing. Important aspects to consider in patient history include daily activities such as occupations and hobbies; types of substances or machines used at the workplace; working environment (temperature, humidity, dust); use of protective gloves or equipment; wet work (including the use of occlusive gloves for

more than two hours in continuity); hand-washing habits; use of cleansers and creams to protect the skin; accidental exposure to irritants; and existence of AD, atopic respiratory disease or other inflammatory skin disease[49].

Additional clinical signs/symptoms that are beneficial to the diagnosis of ICD include the onset of symptoms within minutes to several hours from exposure; pain, burning sensation, prickling, or discomfort that goes beyond itching; shiny/smooth, dried or burned looking skin; peeling, hyperkeratosis or vesicular lesions[49,50]. However, an important diagnostic tool is the patch test which is performed in most patients to rule out possible ACD. In some cases, skin biopsy is also required to exclude other dermatoses. Additionally, there are other methods for measuring skin irritation (e.g., measuring TEWL, erythema intensity and corneal hydration), but these are not routinely used in clinical practice.

**Allergic Contact Dermatitis**

Allergic contact dermatitis is recognized as a skin reaction appearing 24 to 48 hours after repeated contact with an allergen, i.e., a substance to which the skin has been sensitized to before (however, sometimes rarely lesions can manifest at the first encounter). According to one study, the most common allergens confirmed by positive patch tests include metals, fragrances, topical antibiotics, preservatives, chemical substances used in hair care products, topical corticosteroids, adhesives, plastics, and rubber[51]. Important risk factors for ACD development include occupation (with healthcare professionals, chemical workers, beauticians and hairdressers, machinists and construction workers facing the greatest risk); age (ACD incidence increases with age, likely due to repetitive and long-term exposure to contact allergens, but also due to comorbidities such as venous ulcerations or hypostatic dermatitis that are more common in adulthood); AD (with mixed results); ICD; genetics (polymorphisms of genes involved in different stages); gender (women develop ACD more often than men, possibly due to hormonal status); and skin phototype (no unanimous attitude, but generally darker skin types have a better epidermal barrier and therefore lower permeability to allergens)[49,52,53]. Unlike ICD, data on the impact of atopy on the occurrence and course of ACD are contradictory. While some studies found a link between atopy and ACD, other studies did not establish a clear association[54-56]. Furthermore, while some studies pointed to atopy as a predictor of a worse ACD prognosis, other studies suggest that the existence of a severe form of atopic disease may even protect from developing ACD[56].

Pathophysiologically, ACD is a cellular-mediated reaction of a delayed-type hypersensitivity (type IV reaction according to Coombs and Gell). The initial event is the infiltration of haptens, substances of a low molecular mass (<500 Daltons) that can penetrate the epidermis. Although they are not immunogenic and cannot activate the immune system on their own, they bind by covalent bonds to epidermal proteins creating a complete antigen that can activate the immune system. There are two stages in ACD development; the first stage includes sensitization (afferent phase), while the second stage is elicitation (efferent phase)[57]. Thus, haptens penetrate through the epidermis and bind to proteins, after which they are recognized by antigen-presenting cells, primarily dendritic cells such as epidermal LCs. With the help of the major histocompatibility complex (MHC) I and II molecules, LCs present the allergens on their cell membrane surfaces and migrate them to the regional lymph nodes where they are shown to the naïve (idle) T lymphocytes which, in turn, leads to their differentiation into the effector and memory T lymphocytes. The activated lymphocytes begin to express receptors for IL-2, thus becoming susceptible to this interleukin, and stimulating clonal expansion of lymphocytes, i.e., the formation of hapten-specific lymphocytes, ready for response to the same substance. The sensitized T lymphocytes then migrate back to the epidermis. This stage is usually asymptomatic and lasts for 10-15 days. The elicitation phase begins after re-contact with the allergen, when memory CD4+ T lymphocytes are activated. This is followed by the release of cytokines (IL-1, IL-2, IFN γ) and activation of CD8+ T lymphocytes, macrophages, and other effectors and mediators of inflammation, which promote an inflammatory reaction and keratinocyte cytolysis, with consequential epidermal damage[1-3]. Thus, new studies are gradually providing increasing insight into the pathogenesis of ACD.

Allergic contact dermatitis can be diagnosed on the basis of the clinical picture, a history of exposure to a potential allergen, patch testing to standard allergens and possible testing to additional allergens (compounds frequently used by the patient), blood tests

and/or histopathologic analysis (to exclude other dermatoses), and assessment of skin lesions after empirical therapy and avoidance of the suspected allergens[49]. So, for healthcare workers with CD it is very useful to examine the possible contact allergens (by patch tests) to reveal/support the diagnosis of ACD.

**Prominent Features of Contact Dermatitis in Healthcare Professionals**

The most common OSDs are ICD and ACD, which commonly appear on the hands, including CD in healthcare workers. The most important occupational risk factor is contact with irritants (most often contact with water) and allergens at the workplace[58]. As such, ICD accounts for about 80% of the cases of occupational CD, making ICD, specifically on the hands, the most common OSD. The risk of developing occupational ICD is highest among those exposed to the so-called wet work, such as food handlers, healthcare professionals, mechanical workers, cleaners, and housewives[4,19]. According to the literature, CD frequency is notably higher among healthcare professionals such as midwives (67%), dentists (64%), nurses (51%) and medical doctors (41%) compared to other occupations (mechanics, welders and metallurgy workers, food workers, cleaners, textile workers, hair stylists and cosmetologists)[59]. In a Danish study conducted in 1504 subjects of different occupations with diagnosed occupational CD, 26% worked in the healthcare sector (nurses/medical technicians, assistant nurses, medical doctors, physiotherapists, veterinarians, radiologists, midwives, dentists, and occupational therapists)[60]. Furthermore, 78% of them had ICD and 10% had ACD. Unfortunately, a slight increase in occupational CDs was found over time, despite prevention programs[60].

According to epidemiological data obtained on dental professionals, the rate of occupational CD is very common, particularly on the hands[6]. Additionally, Leggat *et al*. report that the prevalence of occupational CD in dental workers varies between 15% and 33%[61]. According to a Japanese study by Minamoto *et al*. conducted in 528 dental staff, 46.4% of them reported the occurrence of chronic hand eczema during their lifetime[62]. On the other hand, according to a recent Croatian study conducted in 506 dentists, 30% of them reported professionally-induced skin problems, which was by one third less than the former study, however, twice as many as noted by Kurpiewska *et al*.[59,63]. In another Croatian survey of 444 dental students and dental professionals, 56.1% of the subjects noticed undesirable skin reactions associated with work, primarily (96%) on the skin of the hands and fingers[64].

As noted by available studies on skin lesions related to healthcare occupations (Table 1), it is evident that research on CD has not been extensive. In addition, the research methodologies of these studies differ significantly, therefore, it is difficult to compare their results. Various etiologic factors stand out in the development of CD in healthcare professionals; for example, the occurrence of chronic hand eczema in dental professionals is associated with the presence of AD, asthma and/or allergic rhinitis, dry skin, shorter office seniority, and frequent hand washing[62]. Dental workers with AD are more prone to ICD due to epidermal barrier disruption and due to the harmful effects of their activities during work. Also, as stated previously, development of ICD predisposes to the appearance of ACD[3,65]. Rubber, acrylic and latex are the most common allergens encountered by dental professionals[62,66]. Although skin lesions in healthcare professionals are often attributed to allergy to latex gloves, research has established that only a few of them are actually allergic to latex[67,68]. Ample research (Carøe *et al*., Cahill *et al*. and Prodi *et al*.) suggests that healthcare work is a significant risk factor for ICD, although one study (Malik *et al*.) in healthcare professionals found hand dermatitis (ICD 98%, ACD 2%) in only 4% of the workers[60-71]. Lastly, literature on skin lesions in hospital staff has reported a significant association between CD and exposure to latex, AD, and surgical work.

**Conclusion**

Numerous innate skin features and external factors play a role in the occurrence of ICD and ACD among healthcare workers. The development and course of occupational CD is influenced by constitutional factors, as well as environmental factors, and typically is a result of multiple variables; however, the exact mechanisms underlying the development of acute and chronic CD are not well described. A high level of exposure to contact irritants and allergens can lead to the development of occupational ICD and ACD. Based on this knowledge, preventive measures (routine screening for possible CD, use of protective gloves and other personal protective equipment, appropriate recognition and timely

*Table 1. Studies on contact dermatitis in healthcare professionals in the literature*

| Research | Subjects, N | Methods | Results |
|---|---|---|---|
| Malik, *et al*. 2015 Occup Med (Lond)[69] | 2000 HCWs | Hospital registry of health professionals | - Hand dermatitis in 4%; (ICD 98%, ACD 2%) |
| Prodi, *et al*. 2016 Occup Med (Lond)[68] | 2672 HCWs | PT | - Significant association between CD and healthcare work, hand/forearm dermatitis, and sensitization to formaldehyde and p-phenylenediamine |
| Kocak, *et al*. 2014 Cutan Ocul Toxicol[70] | 461 Dental healthcare professionals | Survey, PT (n=65) | - CD in 43%.<br>- Positive allergic reactions: European standard series 20%; dental series 10.8%<br>- The most common allergens: nickel sulfate (12.3%), acrylates (6.1%) and para-tertiary-butylphenol-formaldehyde resin (4.6%) |
| Minamoto, *et al*. 2016 Contact Dermatitis[62] | 528 Dental workers | Survey, PT | - 46.4% reported a lifetime history of chronic hand eczema |
| Vodanović, *et al*. 2016 Acta Stomatol Croat[63] | 506 Dental health professionals | Survey | - 29.3% reported work-related skin problems |
| Japundžić, *et al*. 2018 Acta Stomatol Croat[64] | 444 Dental professionals | Survey | - 56.1% reported work-related skin lesions (96% hands and fingers) |
| Kurpiewska, *et al*. 2011 Int J Occup saf Ergon[59] | 581 Professionals of different occupations | Survey | - The highest incidence of CD was in healthcare professionals: midwives (67%), dentists (64%), nurses (51%) and physicians (41%) |
| Carøe, *et al*. 2014 Contact Dermatitis[60] | 1504 Professionals of different occupations | Data from National Board of Industrial Injuries in Denmark | - 70% with occupational ICD (26% of all were healthcare professionals) |
| Cahill, *et al*. 2016 Australas J Dermatol[71] | 2894 Professionals of different occupations | Data from hospital register | - 75% had OSDs (ICD 44%, ACD 33%)<br>- Healthcare professionals were third in frequency among the occupations surveyed |

HCWs = healthcare workers; PT = patch test; ICD = irritant contact dermatitis; ACD = allergic contact dermatitis; OSD = occupational skin disease

diagnosis of CD, involvement of dermatologist and/or occupational medicine specialist, when necessary, etc.) should be put in place to prevent development of CD in healthcare workers at the workplace.

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Sažetak

## ZNAČAJKE KOŽE VAŽNE ZA POJAVU KONTAKTNOG DERMATITISA U ZDRAVSTVENIH DJELATNIKA

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Pojava kožnih promjena u zdravstvenih radnika povezana je s negativnim utjecajem rada na važne funkcije kože, uključujući zaštitu od mehaničkih ozljeda, sunčeve svjetlosti, dehidracije i prodora kemijskih tvari ili patogenih mikroorganizama. U zdravstvenih radnika najčešća profesionalna bolest kože je kontaktni dermatitis (CD), iritativni kontaktni dermatitis (ICD) i alergijski kontaktni dermatitis (ACD), koji se javljaju najčešće na šakama. Pritom ICD čini oko 80% profesionalnog CD-a, što ga čini njegovim najčešćim oblikom. Prema literaturi, učestalost CD-a veća je u zdravstvenih radnika nego kod ostalih zanimanja, gdje je kontakt s iritansima i alergenima na radnom mjestu ključni profesionalni čimbenik rizika. Nadalje, ICD je multifaktorski poremećaj na koji utječu mnogi konstitucijski i okolišni čimbenici. Konstitucijski čimbenici uključuju dob, spol, mjesto na tijelu, atopiju i genetske čimbenike, dok čimbenici okoliša uključuju temperaturu, protok zraka, vlažnost i okluziju. Iritansi koji se često susreću su voda, deterdženti i surfaktanti, otapala, oksidirajuće tvari, kiseline i lužine; međutim, upotreba zaštitnih rukavica ili opreme, navike pranja ruku, uporaba sredstava za čišćenje i kreme, aktivne upalne bolesti kože i svakodnevne aktivnosti također su važne za pojavu ICD-a. Uz to, poznato je da ICD predisponira osobu za pojavu ACD-a. Važni čimbenici rizika za razvoj ACD-a uključuju zanimanje, dob, anamnezu atopijskog dermatitisa, genetiku, ženski spol i fototip svijetle kože. Ukratko, brojne značajke kože i drugi čimbenici povezani sa zanimanjem doprinose nastanku CD-a u zdravstvenih djelatnika. S obzirom na visoku razinu izloženosti kontaktnim iritansima/alergenima u zdravstvu, provedba preventivnih mjera presudna je za sigurnije radno okruženje.

Ključne riječi: *Kontaktni dermatitis; Zdravstveni djelatnici; Iritativni kontaktni dermatitis; Alergijski kontaktni dermatitis; Ekcem šaka; Doktori medicine; Stomatolozi*