

Review Article

An overview of contact dermatitis: occupational factors and preventive strategies

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ABSTRACT

Contact dermatitis, encompassing both acute and chronic skin inflammation, arises from exposure to chemical or physical agents. This condition, which includes irritant contact dermatitis (ICD) and allergic contact dermatitis (ACD), represents 95% of occupational skin disorders. ICD, accounting for 80% of cases, results from a direct cytotoxic effect on skin cells due to irritants such as abrasives and cleaning agents. It manifests as burning, stinging, and various degrees of skin damage. Chronic ICD stems from repeated exposure to irritants like solvents, while acute cases can result from single exposures or ultraviolet-induced reactions. In contrast, ACD, which constitutes 20% of cases, develops due to an allergic reaction to specific substances after sensitization. Individuals in certain professions, including hairdressers and healthcare workers, are particularly at risk. Preventive strategies include educational programs, protective measures like barrier creams and gloves, and regulatory controls. Emerging treatments focus on antioxidants, chelators, and specialized formulations to manage symptoms and improve occupational health.

Keywords: Contact dermatitis, Occupational skin disorders, Preventive strategies

INTRODUCTION

Contact dermatitis refers to an acute or chronic inflammation of the skin triggered by exposure to chemical or physical agents. Symptoms may include itching, dry skin, redness, bumps, blisters, or swelling. While the rashes are not contagious or life-threatening, they can cause significant discomfort. Contact dermatitis constitutes 95% of all occupational skin disorders.¹

Contact dermatitis is categorized into two primary types based on the underlying pathophysiological mechanisms: irritant contact dermatitis (ICD) and allergic contact dermatitis (ACD).^{2,3} As the most common occupational skin disorder, ICD accounts for 80% of contact dermatitis cases. It can develop after a single exposure to an irritant or toxic agent (e.g., abrasives, cleaning agents, oxidizing, and reducing substances) and is marked by skin damage due to a direct, localized cytotoxic effect on skin cells. The

clinical symptoms of ICD include burning, stinging, and smarting, often appearing within seconds after exposure. Lesions can range from erythema to vesication, caustic burns with necrosis, and the development of fissures, accompanied by itching and pain. Notably, exposure to low-grade irritants may delay the onset of symptoms. Acute manifestations of ICD can occur after a single exposure to substances like chemicals or ultraviolet A-triggered phototoxic reactions, while chronic cases typically result from cumulative and repeated contact with irritants such as solvents, soap, and detergents. Approximately 20% of all contact dermatitis cases are attributed to ACD, which is characterized by an adverse inflammatory reaction of the skin triggered by an allergen. This condition occurs due to direct contact with a specific external allergen, to which the individual has been previously sensitized.⁴

The leading and most prevalent form of immunotoxicity in humans is ACD.^{5,6} It can affect individuals across all age groups, though it is uncommon in those over 70 years of age.⁷ The condition typically develops after repeated exposure to a sensitizing substance, with clinical manifestations often including severe itching, stinging, and pain. These symptoms are commonly accompanied by well-demarcated erythema and swelling.⁴

Individuals in certain professions, such as hairdressers, beauticians, and wellness professionals, are at greater risk of developing ACD due to frequent contact with various chemicals and potential allergens. The hands are the most common site where ACD lesions appear, given the constant exposure to irritants and allergens during work activities. Early and accurate diagnosis is crucial to ensure proper treatment and prevent the condition from worsening.⁸ The sensitization process varies depending on the strength of the allergen. Exposure to a strong sensitizer can lead to sensitization within approximately one week, whereas contact with a weaker allergen may require months or even years before sensitization and subsequent clinical symptoms emerge. Thus, recognizing the type of allergen and the frequency of exposure is essential in managing and preventing the development of ACD.⁴

METHODS

This study is based on a comprehensive literature search conducted on 09 September 2024, in the Medline and Cochrane databases, utilizing the medical subjects' headings (MeSH) and a combination of all available related terms, according to the database. To prevent missing any research, a manual search for publications was conducted through Google Scholar, using the reference lists of the previously listed papers as a starting point. We looked for valuable information in papers that discussed an overview of contact dermatitis including occupational factors and preventive strategies. There were no restrictions on date, language, participant age, or type of publication.

DISCUSSION

The pathophysiology of ICD involves disruption of the epidermal barrier, with keratinocytes functioning as immune mediators. Exposure to harmful agents triggers the release of interleukin-1 alpha, leading to further cytokine release from dermal cells, which activates T cells and fibroblasts, causing inflammation.⁹ Keratinocytes also produce vascular endothelial growth factors, promoting angiogenesis and increasing vascular permeability. Fibroblasts contribute to the extracellular matrix and collagen formation, supporting dermal homeostasis and dendritic cell migration.¹⁰

In ACD, the pathophysiology consists of sensitization and elicitation phases, with initial allergen contact activating effector T cells, followed by re-exposure leading to symptoms within 24-72 hours.⁴

Clinical features

Chronic irritant dermatitis is the most common occupational contact dermatitis, primarily affecting the hands. It begins in the webs between fingers and spreads to the fingers, backs of the hands, and sometimes forearms, showing redness, infiltration, scaling, and fissuring. The palms and fingertips may also be affected, often with hyperkeratosis from mechanical pressure or friction. A nummular subtype on the backs of the hands may suggest microbial co-etiology. The volar wrist is typically unaffected, while vesicles are more common in allergic or atopic dermatitis. Acute irritant dermatitis can mimic allergic eczema but shows sharp demarcation and severe tissue damage, such as bullous edema and necrosis.¹¹ Chronic allergic contact eczema may resemble chronic irritant dermatitis and spread to other body regions. Occupational allergens include epoxy resins, preservatives, and plant components. Atopic hand eczema, marked by vesicles, may also affect the backs of hands and the volar wrist. Psoriasis vulgaris can be triggered by friction or heat (Koebner phenomenon).¹² Differential diagnoses include pustulosis palmoplantaris, mycosis, palmoplantar keratosis, lichen ruber, herpes simplex, photoallergic/phototoxic reactions, and seborrheic dermatitis.

Direct skin contact with substances such as liquids, pastes, solids, aerosols, gases, and vapours can lead to ICD (Table 1).¹³

Occupational contact dermatitis arises from the interaction of external factors, such as irritants or allergens, and internal predisposing factors, like atopy or sensitive skin. Acute irritant dermatitis, including chemical burns caused by strong alkaline or acidic substances, is commonly observed in occupational injuries. However, chronic irritant dermatitis, also known as "cumulative insult dermatitis" or "traumiterative dermatitis", is a contributory factor in 65–80% of occupational skin diseases.^{11,14,15} This form of dermatitis is a persistent eczematous condition

lasting longer than six weeks, where an allergic cause has been excluded through careful diagnostic procedures. It develops due to repeated exposure to irritants such as water, detergents, solvents, or irritant foods, which gradually damage the skin barrier. The time between exposures is often too short to allow the skin to fully recover, leading to cumulative damage. Additional factors, like mechanical pressure, friction, and environmental conditions such as temperature or humidity, may also contribute to the development of chronic irritant dermatitis.

Occupational skin diseases often have a complex origin and can emerge from a pre-existing chronic relapsing atopic eczema, which may be unrelated to workplace exposure ("two-phase" or "hybrid" eczema). In some cases, the condition progresses in a "three-phase" process, where chronic irritant dermatitis with ongoing inflammation and compromised skin barrier leads to allergic sensitization in subsequent stages.

In addition to irritant and allergic forms, occupational skin conditions may also result from type I hypersensitivity, such as latex-induced contact urticaria. This condition is often accompanied by mucosal symptoms and, in rare cases, can provoke severe anaphylactic reactions in highly sensitized individuals. Another occupational form of allergic contact dermatitis is protein contact dermatitis, a rare condition where type I sensitizations cause an eczematous reaction. Unlike typical contact dermatitis, which is triggered by low molecular haptens, protein contact dermatitis is induced by exposure to proteins such as plant proteins, fish, meat, seafood, flour, or enzymes. This condition is most prevalent in food-related professions, with a 1–4% occurrence among cooks, bakers, and fish processors.¹³

Occupational skin conditions are prevalent across various industries due to exposure to irritants and allergens. (Table 2) outlines common occupational groups and their specific exposure risks. Understanding these exposures is crucial for implementing effective preventive measures and reducing the incidence of skin-related issues in the workplace.

Preventive strategies

Education, legislation, and prevention

Currently ACD lacks a cure, with clinical manifestations arising upon re-exposure to the sensitizing chemical. Therefore, guidelines recommend eliminating exposure to triggers and developing preventive measures, including education, lifestyle modifications, and protective measures for hands and body.^{16,17} Interventions to alleviate ACD impact occur at three levels: primary, secondary, and tertiary prevention. Primary prevention aims to prevent disease onset and reduce new cases by eliminating, substituting, or reducing allergenic substances with less reactive alternatives.^{18,19} Secondary prevention involves

early detection, such as through health surveillance, enabling timely corrective actions. Tertiary prevention focuses on managing established disease effects.

A multidisciplinary approach integrating modern occupational medicine policies is essential. This approach includes providing information and training and implementing control measures through collaborative occupational health activities between employers and employees. Patient education, which includes verbal or written guidance and formal training, is crucial for identifying allergen exposure, recognizing early symptoms, and reinforcing safety measures. However, the effectiveness of these interventions can vary, with some showing limited impact.⁴

Preventive measures also include maintaining personal hygiene and using protective gear. Washing hands with mild soap and water or alcohol can remove allergens and irritants from the skin, while regularly cleaning protective clothing is beneficial.¹⁹ Personal protection, such as wearing gloves when handling irritants and allergens, is important, although occlusive gloves can exacerbate occupational allergic hand dermatitis. Replacing powdered natural rubber latex gloves with low-protein, non-powdered alternatives can reduce ACD symptoms and severity. Using boots, masks, and aprons further reduces exposure and protects the skin from sensitizers.^{16,20} If ACD persists despite eliminating the chemical agent, redeployment to areas with lower exposure and implementing exposure controls may improve or resolve the condition. Reducing wet work hours, a known risk factor, is also relevant. Additionally, motivation, administrative controls, and appropriate signage and labelling on containers and products are crucial.^{20,21}

Secondary prevention includes diagnosis and surveillance, while tertiary prevention covers treatment, management, and rehabilitation.⁴ Effective strategies rely on surveillance complemented by clinical epidemiological data to develop important regulations and legislation.²¹ New tools for identifying and characterizing skin-sensitizing chemicals and conducting effective risk assessments are now available. Regulatory authorities globally require chemical testing for ACD and appropriate hazard labelling to minimize exposures, while toxicologists identify skin sensitization potential and estimate human health risks.⁴

Creams, emollients, and moisturizers

A barrier cream is a topical preparation that forms a thin layer on the skin, helping to reduce direct contact with contaminants and facilitating their removal.¹⁷ An ideal barrier cream should completely block the allergen from contacting the skin, functioning similarly to a glove.²² Some barrier creams contain active ingredients that may trap or neutralize sensitizers and irritants.⁴ Despite extensive documentation of barrier creams' effectiveness in improving irritant hand dermatitis among hairdressers, many international experts remain skeptical about their

specific benefits.¹⁷ However, under experimental conditions, barrier creams have shown protective effects against acute irritation caused by solvents, and some studies indicate that moisturizers and skin barrier repair creams can significantly extend the disease-free interval.⁴ Repair creams have also been shown to improve skin condition in workers with damaged skin, and after-work creams can offer some protection against developing ICD.^{17,23} Additionally, controlled clinical trials have demonstrated a reduced incidence and prevalence of ACD with the use of soap substitutes and after-work creams, suggesting that these products should be encouraged and made available in the workplace.²⁴

Water-resistant barrier creams, which contain hydrophobic substances like silicone, protect against water-soluble acids, alkali, and dyes. In contrast, oil or solvent-resistant barrier creams protect against dust, oils, greases, and solvents, although their clinical effectiveness in preventing ACD remains controversial and lacks strong clinical support. Barrier creams should be applied to normal skin, as they may worsen dermatitis if used on inflamed skin. Among topical ingredients, quaternium-18-bentonite is effective in preventing urushiol-induced ACD, and diethylenetriamine pentaacetic acid can prevent nickel, chromium, and copper dermatitis. Conversely, pentoxifylline has been shown ineffective in preventing nickel allergy.⁴ Barrier creams are recommended for application before and during work, but the optimal frequency of use remains unclear. It is important to note that evidence supporting the clinical benefits of pre-work or barrier creams is limited, with only a few high-quality studies showing improvement in skin condition indicators.¹⁹

Moisturizers and emollients, either alone or in combination with barrier creams, can provide a significant protective effect for the primary prevention of skin disease, both in the short and long term. Moisturizers enhance the hydration of the stratum corneum using humectants like glycerine, urea, sorbitol, and pyrrolidone carboxylic acid, along with emollients such as petrolatum, lanolin, mineral oil, silicone, and waxes. They are useful for regenerative skincare during and after work and should be applied regularly, especially after hand washing and at home, to support the skin's regenerative processes.⁴ Despite their protective role, some emollients may inadvertently act as carriers for chemicals, as certain ingredients can function as haptens, preservatives (e.g., imidazolidinyl urea,

formaldehyde, methylisothiazolinone), fragrances, emulsifiers, or humectants.^{25,26} Therefore, primary care practitioners should be mindful of the excipients in emollients, which might trigger new rashes or worsen existing conditions. Barrier creams combined with gloves and adequate moisturizers are widely recommended as key personal protective measures in professions at risk. However, research on the use of gloves to prevent occupational contact dermatitis is limited, and observed benefits were often part of a broader prevention strategy.¹⁷

Antioxidant, chelator, and quencher-based topical formulations

The field of ACD is evolving with new chemicals, resurging allergens, and changing industrial practices. A multi-layered approach to treatment is crucial, focusing on controlling reactive oxygen species (ROS), modulating inflammatory mechanisms, and regulating T cells. Advances in understanding ACD pathomechanisms could lead to combination therapies and targeted treatments. Emerging research into biomarkers and technologies like genomic and proteomic profiling may uncover new signalling pathways, refining our understanding and improving allergen identification.²⁷

The disruption of the epidermal barrier and activation of inflammatory pathways in both irritant and allergic contact dermatitis are significantly influenced by ROS. Antioxidants such as ascorbic acid and α -tocopherol have shown potential in reducing reactions to allergens like limonene-2-hydroperoxide, although their effectiveness varies. Ascorbic acid has been shown to reduce allergic reactions to hair dye, while NAC and glutathione block inflammatory signalling. Flavonoids like luteolin and quercetin also exhibit antioxidant and anti-inflammatory properties.⁴

Metal-chelators like ethylenediaminetetraacetic acid (EDTA) have been explored for ACD prevention. EDTA creams reduced reactions to nickel sulphate in patch tests.²⁸ A 10% diethylenetriaminepentaacetic acid (DTPA) emulsion showed reduced patch test reactions in metal-sensitized patients.²² Products like NIK-L-BLOK® and Skintifique's barrier creams aim to protect against allergens by capturing free ions and pollutants.²⁹ Bariéderm is also in trials to assess its efficacy for hand dermatitis. These advancements suggest a promising future for topical formulations in managing ACD.⁴

Table 1: A list of irritants that can lead to hand eczema.¹³

Chemical irritants	Physical irritants	Other irritants
Acids (including those from fruits)	Mechanical	Water
Alkaline substances	Friction	Cold climate
Cement and lime	Pressure	Low relative humidity
Cooling lubricants	Heat	
Oil-based products, such as cutting oils	Dust	
Organic solvents (e.g., benzene, acetone)	Occlusion (e.g., gloves)	

Continued.

Chemical irritants	Physical irritants	Other irritants
Detergents	Mineral and glass fibres, sand, UV radiation, ionizing radiation, wool	

Table 2: Occupational exposures and associated skin risks.¹³

Occupation	Exposure risks
Health occupations	Irritants: wet work, disinfectants, soaps, detergents. Allergens: dyes, shampoos, wave liquids, bleaches
Florists, gardeners, and plant growers	Irritants: plants, fertilizers, pesticides, manure
Plastic industry workers	Irritants: solvents, acids, epoxy resins
Painters and varnishers	Irritants: solvents, paints, removers, organic tin, hand cleansers, glues, epoxy resins, gloves
Construction industry	Irritants: paints, preservatives, glue, cement, acids
Metal workers, mechanics, and galvanizers	Irritants: cooling fluids, lubricants, detergents, solvents, antifreeze, battery acid
Food professions	Irritants: wet work, soaps, detergents, food substances (juices, spices, fish, meat, dressings, acids)
Dentists and dental technicians	Irritants: solvents, paints, epoxy resins
Other occupations	Irritants: soldering fluxes, adhesives, acrylic monomer

CONCLUSION

Contact dermatitis, encompassing irritant and allergic types, remains a significant occupational health issue. Effective management requires a multi-faceted approach, including prevention through education, protective measures, and timely intervention. Advances in barrier creams and topical treatments show promise, but further research is needed to refine preventive and therapeutic strategies for better protection and management of this prevalent condition.

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