

Occupational Contact Dermatitis: An Update



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Overall Purpose/Goal: To provide excellent reviews on key aspects of allergic disease to those who research, treat, or manage allergic disease.

Target Audience: Physicians and researchers within the field of allergic disease.

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List of Design Committee Members: Emily C. Milam, MD, Stacy Nassau, MD, Erin Banta, MD, Luz Fonacier, MD, and David E. Cohen, MD, MPH (authors); Michael Schatz, MD, MS (editor)

Learning objectives:

1. To highlight important differences between occupational irritant and allergic contact dermatitis.
2. To increase awareness of irritants and/or allergens unique to particular professions, and their common presentations.
3. To understand how to obtain a thorough occupational history and conduct a physical examination when evaluating for clues of the offending workplace exposure.
4. To recognize the role of workplace process change and irritant and/or allergen avoidance in the treatment of occupational contact dermatitis.

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Occupation contact dermatitis (CD) is a common inflammatory skin condition impacting every professional industry in the United States. It is associated with significant personal and professional distress, loss of revenue, and decreased productivity. Occupational CD is further subdivided into irritant CD and allergic CD. Frequently, workers may suffer from a combination of both types. Numerous workplace exposures are implicated, but there are several themes across professions, such as CD related to frequent handwashing and wet work. A detailed occupational history, physical examination, and patch testing can help to make the diagnosis. Treatment includes identification of the substance and avoidance, which often is quite challenging. © 2020 American Academy of Allergy, Asthma & Immunology (*J Allergy Clin Immunol Pract* 2020;8:3283-93)

Key words: Occupational contact dermatitis; Irritant contact dermatitis; Allergic contact dermatitis; Contact allergen; Atopic dermatitis; Patch testing; Allergy; Immunology

*Abbreviations used**ACD- Allergic contact dermatitis**CD- Contact dermatitis**ICD- Irritant contact dermatitis**MSDS- Material safety data sheet**NACDG- North American Contact Dermatitis Group**PCD- Protein contact dermatitis**PPD- Paraphenylenediamine**PPE- Personal protective equipment***INTRODUCTION**

Occupational skin disorders impact every industry in the United States and are among the most common types of occupational disease.¹ The prevalence rate of work-related dermatitis has been estimated between 10% and 17.6%, but the true prevalence may be higher because mild cases often go unreported.^{2,3} Contact dermatitis (CD) is by far the most common of the various occupational skin disorders, comprising nearly 90% to 95%.⁴ Other occupational dermatoses include occupational skin cancer, acne, infections, and skin changes due to mechanical injury, vibration, and/or repeated pressure. Many studies have shown that workers' quality of life is significantly affected by occupational dermatitis.⁵⁻⁹ The economic burden of occupational CD is enormous, from both direct losses (treatment, doctor visits) and indirect losses (decreased productivity at work, leaves of absence). In 2013, estimated total direct costs for CD approached \$1.5 billion in the United States.¹⁰ In this review, we will discuss CD in the occupational setting and common irritants and allergens. We will review common triggers for CD by occupation and our approach to diagnosis and treatment for this problematic disorder.

CD is an inflammatory skin disorder caused by allergens or irritants that come into direct contact with skin. CD is more likely to develop in the setting of a compromised skin barrier and occupations at high risk for CD include those with repeated exposure to water, solvents, caustic material (such as acids) as well as those with microtrauma. It can be acute, subacute, or chronic in nature depending on the allergen, irritant, frequency, and duration of exposure. Acute CD generally presents as pruritus, erythema, vesicles, and scaling of the skin, whereas chronic CD is characterized by lichenification, fissuring, excoriation, and hyperkeratosis.

CD can be further divided into allergic contact dermatitis (ACD) and irritant contact dermatitis (ICD). Frequently, workers may suffer from a combination of both types. ACD and ICD are often clinically indistinguishable, making diagnosis difficult. Occupational contact urticaria and protein contact dermatitis (PCD) will also be reviewed.

IRRITANT CONTACT DERMATITIS

ICD represents approximately 70% to 80% of the occupational skin disease burden.¹¹ ICD is a nonimmunologic consequence of a chemical or physical agent's direct cytotoxic effect on the skin. ICD may occur with first exposure because the adaptive immune response is not involved.¹² Both chemicals and physical/mechanical irritation of the skin contribute to damage of the epidermis and resultant activation of the innate immune system, via various proinflammatory cytokines and chemokines.¹³ There are innumerable potential irritants; in fact,



FIGURE 1. ICD of the hands in a construction worker, who was negative on patch testing.

almost any compound can cause irritation in sufficient concentration, in the right host, and under the right conditions. ICD is most commonly due to cumulative, chronic exposure to weak irritants such as soap and water.⁴ Stronger irritants (acids, bases, detergents) can lead to clinical symptoms immediately. Temperature extremes, repetitive and/or prolonged exposures, and exposures under occlusion mediate risk and severity of ICD. Environmental factors such as low ambient humidity and cold temperatures decrease the stratum corneum's water content, increasing irritants' permeability. Host factors, such as underlying atopic dermatitis, can also predispose to ICD—patients with atopic dermatitis have a 13.5 times greater risk of developing occupational CD.¹⁴

Symptoms of ICD are diverse, ranging from sensory disturbances without visible skin changes to severe chemical burns. Acute ICD can manifest as bright erythema, vesiculation, and erosions, often demarcated by the exposure's pattern of contact and occurring rapidly after first exposure. Chronic ICD manifests as duller erythema, profound xerosis, and lichenification (Figure 1). ICD can occasionally be difficult to distinguish from ACD because both share similar clinical findings and may coexist. In ICD, symptoms of stinging and burning are more typical than pruritus.

Certain occupations confer unique risks and distinct distributions of ICD. For example, agriculture workers and florists often demonstrate ICD from fertilizers, plants, and pesticides. Fiberglass dermatitis is a common ICD among construction workers, due to mechanical irritation from broken fragments of fiberglass fibers, which penetrate the stratum corneum, causing an eczematous or papular eruption.¹⁵

Wet work, frequent handwashing, and exposure to soaps and detergents are very common causes of occupational ICD, particularly among medical personnel, cleaners, and food service workers. Wet work is loosely defined as (1) immersion in water for more than 2 h/d, (2) frequent hand washing, more than 20 times/d, (3) use of hand sanitizer more than 20 times/working day, and (4) use of occlusive protective gear (such as gloves) more than 2 h/d or change of gear more than 20 times/d.^{4,16,17} Exposure to soaps and detergents is an important risk factor for developing ICD. The hands and forearms are most commonly affected, and there may be associated paronychia.

TABLE I. Irritant and allergic exposures by occupation

Occupation	Irritants	Allergens
Agriculture workers	Artificial fertilizers, disinfectants, pesticides, cleaners, gasoline, diesel oil, plants/grains	<i>Toxicodendron</i> , <i>Compositae</i> , other plants, grains, fertilizers, pesticides, herbicides
Artists	Solvents, clay, plaster	Dyes, turpentine, pigments, colophony, resins
Automobile and aircraft industry workers	Solvents, cutting oils, paints, hand cleansers	Chromates, cobalt, nickel, rubber, acrylates, epoxy resins
Bakers and confectioners	Flour, detergents	Balsam of Peru, dyes, spices, preservatives, benzoyl peroxide, grains
Bartenders	Wet work, detergents	Citrus, metals
Bookbinders	Solvents, glues	Glues, resins, leathers
Butchers	Detergents, meat	Nickel, animal products
Cabinet makers and carpenters	Glues, detergents, thinners, solvents, wood preservatives	Colophony, varnishes, glues, stains, turpentine
Cleaners	Detergents, solvents, wet work	Rubber and rubber additives, biocides
Coal miners	Dust (coal, stone), wet conditions	Rubber and rubber additives
Construction workers	Cement	Potassium dichromate, metals, resins, rubber and rubber additives, acrylics, thiuram
Cooks and caterers	Detergents, vegetable juices, wet work	Foods, spices, rubber and rubber additives, nickel formaldehyde
Dentists and dental technicians	Detergents, hand cleansers, wet work	Rubber and rubber additives, acrylates, disinfectants, local anesthetics
Dry cleaners	Solvents	Rubber and rubber additives
Electricians	Soldering fluxes	Rubber and rubber additives, resins
Electroplaters	Acids, alkalis	Metals, epoxy resins
Floor layers	Solvents	Cement, resins, varnish, woods
Florists and gardeners	Manure, artificial fertilizers, pesticides, wet work	<i>Toxicodendron</i> , <i>Compositae</i> , other plants, fertilizers, pesticides, rubber
Hairdressers	Permanent wave solutions, shampoos, bleaching agents, wet work	PPD, other dyes, fragrance, metals, rubber and rubber additives, formaldehyde, ammonium persulfate, glyceryl monothioglycolate, preservatives, plant-derived extracts
Homemakers	Detergents, cleansers, foods, wet work	Rubber and rubber additives, disinfectants, biocides, foods, spices, nickel, chromate
Hospital workers	Detergents, disinfectants, foods, wet work	Latex, rubber and rubber additives, biocides (ie, formaldehyde and releasers), disinfectants (ie, quaternary ammonium compounds, glutaraldehyde), fragrance
Jewelers	Detergents, solvents	Metals, epoxy resins
Mechanics	Oils, greases, gasoline, diesel fuel, cleaners, solvents	Metals, biocides (especially formaldehyde releasers), rubber and rubber additives, petroleum products, emulsifiers, fragrances
Metal workers	Cutting oils, solvents, hand cleansers	Metals, metalworking fluids
Nurses	Disinfectants, detergents, wet work	Latex, rubber and rubber additives, biocides, disinfectants, quaternary ammonium compounds, formaldehyde and releasers, fragrance
Office workers	Paper products, solvents in cleaners, adhesives, and photocopiers/toner	Nickel, glues
Painters	Solvents, thinners, wallpaper adhesives, hand cleansers	Chloracetamide, resins, dyes, formaldehyde, turpentine, metals, epoxy resin, adhesives, paints
Photography industry workers	Solvents, wet work	Color developers, rubber and rubber additives, chromates
Plastics workers	Solvents, acids, styrene, oxidizing agents	Phenolic resins, polyurethanes, acrylics, plasticizers, hardeners
Printers	Solvents	Dyes, formaldehyde, glues, resins, acrylates, turpentine
Rubber workers	Solvents, talc, zinc stearate	Rubber and rubber additives, dyes, colophony

(continued)

TABLE I. (Continued)

Occupation	Irritants	Allergens
Shoemakers	Solvents	Dyes, rubber and rubber additives, glues, metals, leather, turpentine
Tannery workers	Acids, alkalis, reducing and oxidizing agents, wet work	Chromates, tanning agents, formaldehyde, dyes
Textile workers	Fibers, bleaching agents, solvents	Textile dyes, rubber and rubber additives, metals, formaldehyde
Veterinarians and slaughterhouse workers	Disinfectants, wet work, animal entrails and secretions	Rubber and rubber additives, disinfectants, animal products

Adapted with permission from Tovar and Leikin¹¹ and Cohen.¹⁸

Other common workplace irritants include (but are not limited to) particulate dusts, food products, cleaning agents, solvents, plastics, resins, degreasers, petroleum products and lubricants, metals, machine oils, coolants, inorganic and aliphatic acids, alkalis, heavy metal salts, aldehydes, alcohols, esters, proteins, hydrocarbons, and metallo-organic compounds (Table I). A detailed discussion of each is beyond the scope of this review.

ALLERGIC CONTACT DERMATITIS

ACD is a type IV delayed-type hypersensitivity reaction that results from the activation of allergen-specific T cells. ACD involves both innate and adaptive immunity. Its initial phase, sensitization, is characterized by exposure to an allergen, often a low-molecular-weight hapten, that binds to an epidermal protein.¹⁹ This haptenized protein stimulates the release of inflammatory mediators, which contribute to activation of Langerhans cells, dermal dendritic cells, and endothelial cells,²⁰ though the relative importance and role of each of these cells continues to be investigated.^{21,22} The Langerhans and dermal dendritic cells take up and process the hapten-protein complex and migrate to regional lymph nodes where they prime hapten-specific T cells (T_H1, T_H2, T_H17, and regulatory T cells). These hapten-specific T cells then proliferate and circulate in the blood and return to the location of the initial injury. With reexposure, the elicitation phase occurs and T cells specific for the allergen are recruited to, or activated at, the site of contact, leading to an inflammatory cascade and resulting in eczematous inflammation of the skin.²³

Clinically, the sensitization and elicitation phases account for the latency that is often seen between exposure and the onset of symptoms in ACD. Often, with history, this can be helpful in distinguishing ACD from ICD, which is more often seen with early exposure. Although in appearance ACD resembles ICD, patients often present with pruritis as the main symptom rather than a secondary symptom, followed by burning or stinging. Lesions due to ACD also typically take longer to heal.²⁴

Some allergens are frequent triggers of ACD across professions. Often, environmental factors facilitate development and professions that involve wet work, temperature extremes, and repeated exposures are more likely to lead to ACD. Nickel is the most common contact allergen worldwide, and nickel allergy is seen in metalworkers, domestic cleaners, hairdressers/cosmetologists/barbers, machine operators, cashiers, food handlers, and health care workers.²⁵ Chromate and cobalt are other common occupational metal allergens.

Professions that require use of rubber or synthetic gloves, boots, or other protective gear are particularly susceptible to ACD due to rubber accelerators (health care workers, domestic cleaners, hairdressers, and food handlers). Occupations with frequent exposures to resins, epoxy hardeners, and acrylates can develop ICD, ACD, and contact urticaria to these triggers (construction workers, dental workers, textile workers, mechanics, and printers).²⁶

Sterilizers and biocides including antimicrobials and disinfectants are generally low-molecular-weight molecules that can permeate the cell surface of various microbes, and similarly penetrate the stratum corneum.²⁷ Occupations at risk of developing sensitization to these substances include health care workers, janitors, hairdressers, dental hygienists, and food handlers.

Fragrances, including essential oils and botanical extracts, are extremely common sensitizers. Terpene hydroperoxides, such as limonene and linalool, are “up and coming” fragrance allergens, which are prohaptenes that autoxidize on exposure to air.²⁸ Fragrances are ubiquitous, and particularly affect workers in the beauty industry and massage therapists.

Paraphenylenediamine (PPD) is a common allergen found in hair dyes, black henna tattoos, printer ink, rubber products, leather, and photographs. PPD penetrates the stratum corneum easily, and thus is a potent sensitizer, with at-risk occupations including hairdressers, textile workers, mechanics, and printers.

Formaldehyde and formaldehyde releasers, frequently used preservatives, are also common sensitizers. They are found in a myriad of products, including cosmetics, clothing, some paints and glues, embalming fluids, adhesives, and many more. Formaldehyde releasers include quaternium-15 (most common), bronopol, diazolidinyl urea, DMDM hydantoin, and imidazolidinyl urea. Patients sensitized to formaldehyde often have positive patch test reactions to formaldehyde releasers.²⁹ There is a large group of preservative systems that do not rely on formaldehyde for their mechanism of action, including methylisothiazolinone/methylchloroisothiazolinone, methyl-dibromoglutaronitrile, iodopropynyl butylcarbamate, and parabens. We are in the midst of a methylisothiazolinone-driven CD epidemic, with methylisothiazolinone found in many personal care products and industrial fluids. Methylisothiazolinone now dominates as the leading preservative contact allergen, and the second most prevalent positive patch test allergen in North America (after nickel).^{30,31} Occupations at risk for ACD due to preservatives include metalworkers, hairdressers, textile workers, massage therapists, and health care professionals.³²

CONTACT URTICARIA AND PCD

Other skin diseases that can be triggered by contact in the work environment, but occur with lower frequency, include contact urticaria and PCD. Contact urticaria describes a wheal and flare type I hypersensitivity reaction that occurs because of contact between an allergen and the skin. The reaction can be immunologic or nonimmunologic.^{33,34} PCD, however, is eczematous in appearance and occurs after contact between the skin and typical proteins such as shrimp, fish, meat, or latex.³⁵

CD BY OCCUPATION

Farmers, agricultural workers, florists

Farmers, agricultural workers, gardeners, and florists have frequent exposures to plants and chemicals. ACD can develop secondary to the plants themselves or to pesticides and chemicals used in daily work.

Toxicodendron (literally, poisonous tree) dermatitis accounts for more cases of ACD than all other causes in the United States combined.³⁶ Toxicodendron are the most clinically relevant plants of the Anacardiaceae family, and include the notorious and ubiquitous poison ivy, poison oak, and poison sumac. Greater than 50% of the population in this country is thought to be sensitized to this group of plants.³⁶ The allergenic substance is urushiol, found in the oleoresin, which is located within the leaves, stems, seeds, and roots of many (but not all) Anacardiaceae plants. Dermatitis will develop only if the plant is damaged, allowing physical contact with the urushiol.³⁷ Other plants of the Anacardiaceae family contain allergens that cross-react with

Toxicodendron species, including the Japanese lacquer tree, Brazilian pepper tree, ginkgo tree, mango tree, and cashew nutshell.³⁸

The Compositae family includes a wide variety of plants, with sesquiterpene lactones acting as the primary allergenic substance. Plants in this family include ragweed, sagebrush, mugwort, chrysanthemum, yarrow, feverfew, chamomile, and pyrethrum among others.³⁹ The clinical presentation can be quite variable, from dermatitis on exposed skin areas, to generalized eruption, to an airborne-induced eruption.⁴⁰ Parthenium is a member of the Compositae family whose main allergen is parthenolide (a sesquiterpene lactone) and has been implicated in airborne CD.

In addition to plants, a wide variety of chemicals can cause dermatitis. The dithiocarbamates are a group of inexpensive yet effective fungicides that can induce sensitization.⁴¹ Maneb is a dithiocarbamate commonly used to prevent potato blight and other diseases that has been implicated in severe ACD reactions.^{42,43} Other common culprits include organophosphorous compounds, a large and diverse group of chemicals used as insecticides, fungicides, herbicides, and plant growth regulators.⁴⁴

Textile industry

Textile manufacturing workers prepare natural and synthetic fibers to spin into yarn that will be used in the creation of clothing, home textiles, and other industrial products. Workers are regularly exposed to various substances, such as raw textiles, dyes, finishing resins, preservatives, rubber accelerators, and metal tools. Cloth fibers themselves rarely cause ACD, but chemicals used to treat the cloth are common culprits.⁴⁵ A study of 72 textile workers presenting for evaluation of dermatitis found that 74% of the patients had dermatitis related to work exposures, with the most relevant allergens being textile dyes, textile finishes, and rubber allergens.⁴⁶ The hands are the most common location of dermatitis, and both ICD and ACD are common.⁴⁷

Dyes have been used to color clothing for thousands of years. Disperse dyes are used to color mixed and synthetic fabrics in particular. PPD is commonly used in textile and fur dyes. The prevalence of dye allergy has been reported to range from 15.9% to 72.7% in patients with pretesting clinical suspicion of dye allergy.⁴⁸ Disperse dyes are more common sensitizers than nondisperse dyes, with Disperse Blue 124 and Disperse Blue 106 as the most common in multiple studies.⁴⁹⁻⁵¹ Disperse dyes tend to cause a more acute, inflammatory dermatitis, whereas textile resins present more commonly as chronic dermatitis.³⁹

Resins used in the finishing processes of textile manufacture are common sensitizers. Formaldehyde resins are used to make fabrics more wrinkle-resistant (permanent press), to reduce the likelihood of shrinkage and to improve coloring by certain dyes. The initial formaldehyde resins used in the mid-20th century released much higher amounts of free formaldehyde than the versions today, and as such prevalence of CD to this allergen is thought to have decreased.⁵² When ACD to formaldehyde resins is suspected, patch testing allergens should include both aqueous formaldehyde and resin vehicles such as dimethylol dihydroxyethyleneurea. Similar to dye allergy, true prevalence of finishing resins is unknown and thought to be underreported.⁵³

Rubber and rubber accelerators found in the elastic of clothing (undergarments, socks, waistbands, shoes) can cause ACD. Most clothing does not contain latex, but rather synthetic rubber, which may still contain rubber accelerators.³⁹ Other common

TABLE II. The Mathias criteria of occupational causation of CD

Criterion	Yes	No	Don't know
1: Is the clinical appearance consistent with CD?	Eczematous morphologic or histologic findings <i>or</i> Adequate clinical description in history or medical records	Noneczematous morphologic or histologic findings	No dermatitis on clinical examination; inadequate clinical description in history or medical records <i>or</i> Noneczematous reaction sometimes mimicked by CD (eg, lichenoid eruptions)
2: Are there workplace exposures to potential cutaneous irritants or allergens?	Supported by toxicologic data or clinical experience	Not supported by toxicologic data or clinical experience	Toxicologic properties of the exposure not known
3: Is the anatomic distribution of dermatitis consistent with cutaneous exposure in relation to the job task?	Dermatitis is most severe on skin surfaces with maximal exposure (depends on physical form of irritant or allergen)	Dermatitis does not affect skin surfaces with greatest exposure	Dermatitis affects skin surfaces with maximal exposure but is more severe on other body areas (excluding eyelid, facial, genital skin) <i>or</i> Dermatitis spares skin surfaces with maximal exposure but affects eyelid, facial, or genital skin
4: Is the temporal relationship between exposure and onset consistent with CD?	First or increased exposure preceded onset or aggravation <i>and</i> Onset or aggravation within 6 mo of first or increased exposure	Onset or aggravation preceded the first exposure <i>or</i> Onset or aggravation occurred more than 3-4 d after last exposure (exception: initial allergic reaction)	Onset or aggravation occurred more than 6 mo after first or increased exposure
5: Are nonoccupational exposures excluded as probable causes?	Not likely on the basis of a thorough history or patch tests	Likely on the basis of a thorough history or patch tests	Inadequate history <i>or</i> Exposure to irritants or allergens both within and outside the workplace
6: Does dermatitis improve away from work exposure to the suspected irritant or allergen?	Improvement not a result of concomitant medical treatment (eg, intramuscular steroid) <i>and</i> Reexposure causes exacerbation	No improvement after more than 1 wk away from work exposure <i>and</i> No concomitant exposure to other allergens	Improvement coincides with medical treatment <i>or</i> Failure to improve may be attributed to other irritants or allergens <i>or</i> No improvement but away from work exposure <1 wk
7: Do patch or provocation tests identify a probable causal agent?	Positive reaction, with tests performed according to established guidelines <i>and</i> Exposure as occurred in the workplace	Negative reaction, with tests performed according to established guidelines <i>and</i> All potential workplace allergens tested	Tests not performed according to established guidelines <i>or</i> All potential workplace allergens or irritants not tested

Adapted with permission from Mathias.⁹⁶

allergens associated with rubber are PPD derivatives and 4-isopropylaminodiphenylamine, which act as antiozonants and antioxidants to delay environmental degradation. In the study of 72 patients in the textile industry previously mentioned, 14% were positive to rubber accelerators.⁴⁶

Metals, particularly nickel, are a common source of CD in the textile industry likely owing to tools such as scissors and sewing machines. An increased incidence of cobalt sensitization has also been noted in textile and leather workers.⁵⁴

Construction workers and machinists

Workers in the construction industry have recurrent exposure to cement, which can cause both irritant dermatitis (from alkaline components) and allergic dermatitis (most commonly from chromium).⁵⁵ In recent years, initiatives to reduce the amount of chromium in cement have led to a decreasing incidence of sensitization.⁵⁶ The prognosis of cement-induced chromate allergy tends to be poor; workers often have persistent dermatitis despite changing professions.⁵⁷ Other common sensitizers in construction workers are epoxy resin (which is found in electrical insulation, coatings, and adhesives), rubber accelerators found in gloves and other protective gear, and other metals such as cobalt and nickel.

Machinists operate machine tools to produce metal parts. A significant proportion of machinist CD is irritant in nature, but metalworking fluids that are used to cool and lubricate machines are well-known causes of ACD. Metalworking fluids contain a multitude of additives that may cause ACD, including biocides (especially formaldehyde releasers and isothiazolinones), fragrances, and emulsifiers.³⁹ Metalworking fluids that are entirely oil (insoluble fluids) tend not to cause ACD, whereas soluble fluids (oil mixed with water) usually have additives and consequently can cause sensitization.⁵⁸ Metals (nickel, cobalt, chromium) unsurprisingly are common sensitizers in this industry as well.⁵⁹

Health care personnel

The health care industry is one of the largest workforces, composed of physicians, dentists, nurses, paramedics, laboratory technicians, and clerical and support staff, among others. Health care personnel practice frequent handwashing and are repeatedly exposed to chemicals found in personal protective equipment (PPE), surgical tools, disinfectants, and preservatives. The reported prevalence of hand dermatitis among health care workers has ranged from 17% to 70%.⁶⁰ In a Danish registry-based cohort of 388 health care workers, 78% had reported an occupational ICD and 10% an occupational ACD.⁶¹

PPE confer great risk of CD among health care workers. Historically, gloves containing latex were associated with a high prevalence of allergy and sensitization, affecting upwards of 27% of skin prick tested cohorts.^{24,62}

Latex sensitization has declined over time, as latex-containing gloves have largely been replaced by synthetic rubber gloves, though rubber accelerators used in the production of these gloves are a frequent cause of CD in the health care industry.⁶³ Rubber accelerators most commonly affecting health care personnel include carba mix, thiuram mix, mercaptobenzothiazole and its derivatives, and increasingly 1,3-diphenylguanidine.^{24,64,65} Sensitization to thiuram mix, for example, has affected 5% to 12% of health care workers,⁶⁶ though rates appear to be decreasing.⁶⁵ Vinyl and other accelerator-free gloves are available alternatives.⁶⁶

Other culprit allergens among health care workers include surface and instrument sterilizers such as glutaraldehyde, Glyoxal, and quaternary ammonium compounds such as benzalkonium chloride; biocides such as formaldehyde and its releasers; the vaccine preservative thiomersal (though typically deemed an irrelevant allergen); and medications such as bacitracin.^{24,63,67,68} Dental workers are additionally susceptible to acrylates, used as hardening agents in dental implants and dentures.⁶⁹ More recently reported allergens have included colophony, a component in adhesive plasters, bandages, and hydrocolloid dressings.^{65,68}

The ongoing COVID-19 pandemic has led to a surge in PPE use, and with this a reported rise in adverse skin reactions among health care workers. An increase in related ICD and ACD is expected, but not yet characterized.^{70,71}

Beauty industry

The beauty industry workforce, including hairdressers, nail technicians, makeup artists, and aestheticians, has frequent and repeated exposure to irritants and potential allergens found in their professional tools and products. These exposures, in combination with frequent wet work, predispose them to occupational ICD and ACD, preferentially affecting the hands, face (especially the eyelids), and scalp.⁷²

As with food service and health care workers, frequent glove use predisposes beauty industry professionals to latex allergies and sensitization to rubber additives such as thiuram mix, carba mix, and mercapto mix.²⁴

Beauty professionals are also exposed to various cosmetics and other personal care products, including makeup, lotions, shampoos, sunscreens, perfumes, and deodorants. These products contain numerous sensitizing chemicals, particularly fragrances and preservatives, which represent prevalent sensitizers in this industry.^{29,73-75}

Of note, the preservative pair methylisothiazolinone/methylchloroisothiazolinone is an emerging allergen in the beauty industry, paralleling increasing sensitization rates seen in the general population.^{76,77} The number of methylisothiazolinone-containing cosmetic products doubled between 2007 and 2010, including methylisothiazolinone-containing moist makeup remover wipes, leading to an onslaught of eyelid dermatitis.³¹

Other common sensitizers in personal hygiene products include sunscreens, lanolin, plant-derived extracts such as tea tree oil and balsam of Peru, and propylene glycol.^{24,73,78,79} Sunscreens and fragrances are commonly implicated in photoallergic CD, incurred after exposure to ultraviolet A radiation.⁸⁰

Hairdressers exhibit uniquely high sensitization rates to hair dyes (especially PPD), dye activators (toluene-2,5-diamine sulfate), bleaching agents (ammonium persulfate, hydroquinone), permanent wave chemicals (glyceryl, ammonium thioglycolate, cysteamine hydrochloride), and surfactants (cocamidopropyl betaine).⁸¹⁻⁸⁴ In a Danish register-based cohort of 101 hairdressers, 54% had reported an occupational ICD and 17% an ACD.⁶¹ Unfortunately, many available gloves worn by hairdressers are not sufficiently protective against CD to these agents.⁸⁵ Hairdresser hand dermatitis can be so severe that it prompts a career change in more than half those affected.^{86,87}

Nail technicians demonstrate increased sensitization to ingredients found in nail polishes and hardening lacquers. Tosylamide-formaldehyde resin is one such example, and a frequent cause of "ectopic" eyelid CD.⁷³ Acrylates are

increasingly reported as highly sensitizing culprits among nail technicians and consumers of nailcare. Acrylates are a class of synthetic plastics and resins found in nail lacquers, artificial and gel nails, and eyelash and hair extensions. Acrylate sensitivity can manifest as hand dermatitis, nail changes, and fingertip paresthesias.^{88,89} Other nail-related allergens include dibutyl phthalate (component of polishes), formaldehyde, and dyes, including carmine, manganese, and chromium.²⁴

Food service workers

Food service workers—including chefs, caterers, waiters, bartenders, grocers, butchers, fishmongers, and those in the food processing or packing industries—are highly susceptible to ICD and ACD owing to their frequent hand hygiene routines, wet work, glove use, and exposure to plant- and animal-based sensitizers. Both immediate type I (ie, contact urticaria, PCD) and delayed-type IV (ie, ACD, systemic CD) hypersensitivity reactions are commonly seen. Phototoxic contact dermatoses are also observed, typically after exposure to foods with furocoumarins (or psoralens) including citrus fruits, celery, carrot, and figs.⁹⁰

Many food service workers are affected by chronic irritant hand dermatitis. A cross-sectional analysis of food service workers patch tested by the North American Contact Dermatitis Group (NACDG) between 1994 and 2010 found an ICD rate of 30.6%, typically due to soaps, detergents, and water.⁹¹ Food sources of ICD are many, and include garlic, pineapples, mustard, onion, citrus juices, clove, and other spices.^{90,91} In many cases, the precise aggravating chemical is known, for example, allicin and diallyl disulfide in garlic and bromelain in pineapple.

ACD is also commonly seen in food service workers. The NACDG cross-sectional analysis found an ACD rate of 54.7%.⁹¹ The most common allergens were thiuram mix and carba mix, reflective of frequent glove use. ACD to food products is relatively rarer, but common causes include various fruits, vegetables, and spices. Many spices may contain clinically relevant amounts of *Myroxylon perireae*, or balsam of Peru, a common sensitizer. A 1987 review of food caterers with hand dermatitis found that 40% were sensitized to a food product, namely, fish and garlic.⁹² Bakers can develop contact urticaria or ACD from flour, flour additives, and flour bleaching agents such as benzoyl peroxide. Sensitivity to nickel is also observed, likely owing to frequent exposure to nickel-containing utensils and other cooking tools.

PCD is particularly common among food service workers.⁹³ The pathogenesis of PCD is unclear but may involve a type I IgE-mediated hypersensitivity reaction, a type IV cell-mediated delayed reaction, and/or a delayed reaction due to IgE-bearing Langerhans cells.⁹⁴ In a recent retrospective study of 336 Danish patients who professionally handle foods, 22% demonstrated evidence of PCD, most commonly to fruits, vegetables, and flour.⁹⁵ Handling of fish, shellfish, dairy, and meat products is also known to cause PCD.⁹⁰ Butchers and sandwich makers are more likely to have PCD to meats, whereas bakers exhibit higher rates of PCD to flour.⁹⁵

APPROACH TO DIAGNOSIS

The diagnosis of CD is based on patient's exposure history, physical findings, and patch testing results. Assessing specifically for occupational CD requires a detailed occupational history.

Mathias's criteria for occupational causation of CD

Establishing a connection between a CD and a specific occupation can be challenging. Oftentimes this evaluation is required to justify a patient's missed workdays, need for work accommodations, or to complete a Workers' Compensation claim.

In consideration of this, in 1989 Mathias outlined 7 criteria (Table II) for establishing occupational causation and aggravation of CD.⁹⁶ The Mathias criteria of occupational causation of CD require 4 of 7 criteria be met to determine that a CD is occupationally related. These criteria have demonstrated consistent validity.⁹⁷

Obtaining history

The clinician should thoroughly assess the patient's occupational activities and exposures, as well as leisure activities. This should include contact with workplace chemicals, objects, and PPE, and evaluation of cleansing rituals. In some cases, it may be necessary to visit the workplace to more adequately assess possible exposures, particularly those that the patient may not consider relevant. Physicians can request an official employment description from the employer and the material safety data sheets (MSDSs) of any hazardous chemicals used in the workplace; however, MSDSs often do not include all salient information about potential irritant or allergic constituents.

Distribution of dermatitis

The distribution and pattern of a CD can provide clues to the culprit exposure. Exposed skin—most commonly the hands, forearms, face, neck, “v” of the anterior chest—is most commonly affected. Airborne irritants or allergens will additionally involve skin that is exposed to the air. Irritants or allergens that accumulate under jewelry or clothing increase allergen concentration and risk for dermatitis in these areas. Dust-borne allergens tend to accumulate on clothing and lead to dermatitis in associated areas, for example, under the neck collar, at the belt or sock line, and in flexural areas. Irritants and allergens can be transported ectopically to remote areas of the body including the face, trunk, and genitalia.

Patch testing

Patch testing is the criterion standard for diagnosing CD. Patch testing involves the preparation and systematic application of allergens in standardized concentration to the skin. The patch testing process typically occurs over 4 to 5 days and includes initial patch placement on day 1, removal of patches and initial read approximately 48 hours later to assess for irritant reactions, and the final patch test read approximately 72 to 96 hours after application to assess for allergic reactions.

The most commonly used screening trays include the Thin-Layer Rapid Use Epicutaneous (T.R.U.E.) Test, North American Standard Series (from the NACDG), and the Core Allergen Series. Standard screening trays do not include all potentially relevant occupational allergens, however. Important allergens may be missed without the addition of supplemental trays.⁹⁸ The NACDG standard tray missed at least 1 occupationally related allergen in 4.3% of tested food service workers between 1994 and 2010.⁹¹

Supplemental trays exist for many of the aforementioned occupations, including the bakery, hairdresser, pesticide, textile, cosmetic, and antimicrobial series, among others. Additional allergens should be incorporated when the clinical history suggests

possible relevance; however, an unknown workplace substance should never be tested because the potential for inadvertent harm often outweighs the benefit.

In cases in which an allergen preparation is not available for patch testing, repeat open application test—or the repeated application of a suspected allergen to a small area of skin twice daily for up to 2 weeks—can be considered.⁹⁸ Although ICD is often diagnosed on the basis of negative patch testing result, it is important to note that not all possible allergens are present in commonly used patch test panels. Also, patch tests or provocation tests for the evaluation of ICD are generally discouraged given their high false-positive rate.

Photo-patch testing or skin prick testing should be pursued if evaluating for a photoallergic or type I hypersensitivity reaction, respectively.

TREATMENT AND PREVENTION

The mainstay of treatment for all contact dermatoses is identifying the offending substance and subsequent avoidance. Options for avoidance include process change, removing the hazard from the workplace entirely, performing other work in the same profession that does not require exposure to the problematic material, or substituting with another nonallergenic material (such as using gloves without rubber accelerators). Some workers may not be able to avoid the exposures and are forced to change career paths. Symptomatic treatment of occupational dermatitis is similar to treatment for other forms of CD. Acute flares can be treated with topical corticosteroids or steroid-sparing agents, and particularly severe flares (eg, from *Toxicodendron*) may benefit from a short course of oral corticosteroids. Phototherapy is an option for hand dermatitis.⁹⁹ Education is imperative in the avoidance and treatment, because the dermatitis will not improve with continued exposure.¹⁰⁰

Strategies have been proposed to aid in the prevention of occupational CD including substituting less irritating or allergenic materials, use of PPE, and use of machinery to reduce personal exposure.¹⁰¹ Personal hygiene (hand washing) is important; however, it should be done within reason because excessive washing may contribute to irritant dermatitis.¹⁰² Protective gloves can also play an important role in prevention of dermatitis; however, they can also cause occlusion of allergens/irritants and further exacerbate dermatitis.

MSDSs are important documents that manufacturers and distributors of chemical products must make available to workers and consumers. The document has a specific and detailed format and is meant to ensure that all who come into contact with the material have the proper information on how to safely use it and the potential hazards involved. The most recent MSDS formats have been internationally standardized. It is important to note, however, that not all potential allergenic substances have an MSDS.

CONCLUSIONS

Occupational CD is a major concern in many industries. It is the cause of much personal and professional distress, loss of revenue, and decreased productivity. Virtually any chemical can be implicated, but there are several key players across multiple professions. A detailed occupational history, physical examination,

and patch testing can help to make the diagnosis. Treatment includes identification of the substance and avoidance, which often is quite challenging.

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