



## Review Article

## Wet-work Exposure: A Main Risk Factor for Occupational Hand Dermatitis

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## ABSTRACT

Wet-work can be defined as activities where workers have to immerse their hands in liquids for >2 hours per shift, or wear waterproof (occlusive) gloves for a corresponding amount of time, or wash their hands >20 times per shift. This review considers the recent literature on wet-work exposure, and examines wet-work as a main risk factor for developing irritant contact dermatitis of the hands. The aim of this paper is to provide a detailed description of wet-work exposure among specific occupational groups who extensively deal with water and other liquids in their occupations. Furthermore, it highlights the extent and importance of the subsequent adverse health effects caused by exposure to wet-work.

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## 1. Introduction

Occupational skin diseases are ranked internationally as the second largest group of occupational diseases after musculoskeletal disorders [1]. They account for >45% of all occupational illnesses [2]. The most common occupational skin disease is contact dermatitis (CD), which makes up around 80% of all occupational skin diseases [3]. CD is an inflammation of the upper layers of the skin, which may manifest itself with the main signs and symptoms of dryness, redness, itching, flaking, scaling, cracking, blistering, and pain [4]. This condition may be caused by irritant or allergic reactions to the agents with which the skin comes into contact; consequently, it is usually divided into irritant contact dermatitis (ICD) or allergic contact dermatitis (ACD) [4,5]. The probability and severity of the reactions depend on such factors as the type and intensity of exposure. There is no absolute visual distinction between ICD and ACD [6].

ICD accounts for 50–80% of all occupational CD cases [7,8]. Industries such as printing, metal machining and treatment, food

preparation, painting, beautician services, hairdressing, and healthcare experience higher incidence rates of contact dermatitis than other types of occupational disorders and complaints [3]. More disproportionate rates of dermatitis have also been seen in industries such as agriculture compared to low-risk occupations such as office workers [9].

Dermal exposure to irritants and/or allergens is a necessary condition to cause CD. The main pathogenetic mechanisms are damage to the skin barrier for ICD, and immunological reactions for ACD [7]. Depending on their genetic constitution, some people may not develop an allergic reaction after exposure to potential allergens. An allergic reaction is a response of the immune system to a particular substance, with which an individual has previously come into contact, and to which he/she has been sensitized. It may be considered as an unwanted adverse side effect of the function of the immune system [10]. All allergic reactions are allergen specific and not dose dependent. Small quantities can cause allergy, whereas a certain minimum exposure to an irritant is necessary for the development of ICD [7]. The most common skin allergens vary

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among countries and over time, depending on specific industrial profiles. A recent Australian publication listed rubber accelerators, hairdressing products such as ammonium persulfate, 4-phenylenediamine base, glycerylmonothioglycolate, potassium dichromate, epoxy resin, and formaldehyde as being among the top sensitizers [11]. Further discussion of ACD is out of the scope of this paper.

In contrast, ICD and hand dermatitis in particular, which is the main concern of this paper, is a local inflammatory reaction, without any immunological response and production of specific antibodies. ICD is usually multifactorial, and not necessarily caused by a single agent [11]. Although chemical causes of ICD are well recognized, the contributions of physical, environmental, and mechanical factors to ICD are underestimated and often neglected. This paper looks at the contribution of wet-work exposure as a major risk factor of hand eczema, as demonstrated by several studies [5,12–14].

## 2. Search strategy

This study was carried out through a multidisciplinary review of the literature. Internet searching was the primary tool for this review. Relevant articles in the fields of dermatology, industrial hygiene, and exposure assessment were found using various databases such as Google Scholar (<http://scholar.google.com>), ScienceDirect (<http://scholar.google.com>), ScienceDirect ([www.sciencedirect.com](http://www.sciencedirect.com)), and PubMed (<http://www.ncbi.nlm.nih.gov/pubmed>). Searches were conducted using the combinations of terms “wet-work exposure”, “hand dermatitis”, “detergents”, “workers”, “hand eczema”, “occupation” and “industry”. The search was limited to papers in English language and covered the period of 1990–2013. These searches yielded >500 papers. After an initial review of the title and abstract of the papers found in the first step, >100 references remained. The abstracts were reviewed for information about wet-work exposure and occupational hand dermatitis. This further examination resulted in >70 citations relevant to this review, which are included as references in this paper.

## 3. Irritancy of wet-work

Water is a potential irritant, which may penetrate relatively easily through the stratum corneum [15]. Frequent exposure to water causes swelling and shrinking of the stratum corneum and can lead to hand dermatitis (hand eczema). Tsai and Maibach argued that several mechanisms such as osmolarity, pH, mineral content, and temperature might account for the irritancy of water [16]. It has also been argued that another factor in the development of ICD might be the extraction or dilution of the natural moisturizing factors in the stratum corneum [17]. People exposed to wet-work often wear water-resistant (occlusive) gloves (rubber or plastic) as a form of personal protective equipment. Within these gloves heat and moisture might collect through the occlusion effect [16,17]. The barrier function of the skin may be further impaired by occlusion. Occlusion might also be produced by clothing, rings, and sometimes inadvertently by barrier creams [15]. The physiology of the skin might be changed by occlusion and this may facilitate the activation of other potential irritants [18]. Continual exposure to water may also produce maceration (often called “cleaning woman’s hands”) [19]; and cutaneous irritation through desiccation of the skin may result from the repeated evaporation of water from the skin [20]. In addition to exposure at the workplace, domestic exposure to water and aqueous mixtures may also contribute to the development of hand eczema [21].

ICD can happen at any age and occur anywhere on the body, but hand dermatitis is the most common form of ICD. This is associated

with the way that hands interact with the environment and are often in contact with irritants [22]. Due to a thin layer of stratum corneum on the dorsum of the hands compared to the palms, ICD usually affects the backs of the hands first [23].

Elsner, amongst others, has argued that wet-work exposure is one of the important risk factors for hand eczema [24]. Duration of exposure to wet-work and high frequency of hand washing have been found to be associated with occupational contact dermatitis of the hands [1,25].

Household cleaning, dish washing, healthcare sector work, hairdressing, food preparation, metal work, and flower arranging are examples of occupations that might experience increased exposure to water, aqueous mixtures and wet objects [26]. A common feature of these jobs is the frequent use of fluids and the repeated or prolonged wetness of the hands; accordingly these jobs are often grouped as “wet-work”.

Wet-work has been recognized as a risk factor for developing hand eczema in hairdressing [12,27], nursing [13,28,29], cleaning [14], food handling [5], and metal working [14]. The main risk determinants of wet-work exposure for development of ICD in these occupations have been reported as the duration and frequency of exposure [7,28–31]. Other industries that have a high risk of hand dermatitis include manufacturing, construction, machine tool operation, food preparation, printing, metal plating, leather work, engine servicing, and floristry [3,32].

Development of ICD is a complex process. It is now recognized that defining it as a nonimmunological, nonspecific reaction of the skin to irritants is too simplistic [30]. Rather, ICD is determined by a number of endogenous (individual susceptibility) and exogenous factors (exposure characteristics), which trigger a series of pathophysiological changes including skin barrier disruption, cellular damage to the keratinocyte membrane, and proinflammatory mediator release (cytokines, which are principally released from keratinocytes) [22,32]. These cascade events eventually result in a clinical presentation that may be divided into several possible subtypes of ICD such as acute irritant contact dermatitis, subjective or sensorial irritation, cumulative irritant contact dermatitis, traumatic irritant contact dermatitis, pustular and acneiform dermatitis, frictional dermatitis, and hyperkeratotic hand dermatitis [33].

In a population-based study carried out by Meding and colleagues, hand eczema was predominantly caused by exposure to water, and a large proportion of this exposure occurred outside the workplace [34]. According to Jungbauer and colleagues, the contribution of frequency of wetting and drying cycles is more than that of total duration of wet-work exposure in development of hand dermatitis [1]. Flyvholm and Lindberg report that multiple short exposures to wet-work are more damaging than a single long exposure [35]. Ibler and colleagues also found a significant relationship between frequent hand washing and the presence of hand eczema [36]. These studies suggest that frequent hand-washing and drying episodes seem to be implicated in the causation of a greater number of cases of dermatitis compared to immersing the hands in water for longer periods.

In most countries, women have higher representation in wet-work occupations such as housekeeping, nursing, hairdressing and floristry, compared with men, and this might be a reason for their higher prevalence of hand dermatitis [37,38]. Hand dermatitis in women is also more common among younger women in their 20s, compared with older age groups [36,39]. This might be associated with decreasing transepidermal water loss and aging [40]. Having children aged <4 years in the household is also associated with the presence of hand eczema among healthcare workers in Denmark [34]. However, it is still not clear whether this is because of an increased susceptibility to hand dermatitis in women or greater exposure of women to irritants, particularly wet-work [30]. Further

studies are needed to determine if there is any difference in the susceptibility to hand dermatitis between men and women.

In many occupations, cumulative irritation by chemicals, water, detergents, dry air and other irritants is required to cause dermatitis. Irritant dermatitis develops when the sum of all irritations exceeds the tolerance and repair capacity of the skin, as shown in Fig. 1. The repair capacity of the skin is not able to compensate for the damage, before new irritation occurs. Therefore, the new damage successively builds upon previous damage and impairs the barrier functions of the skin.

Long or repeated exposure to water, along with the simultaneous effects of washing and cleaning agents, disinfectants, solvents, alkalis, and acids can damage the barrier properties of stratum corneum and underlying skin layers (living epidermis). The damaged barrier function facilitates the effects of external substances and can further increase the loss of water and electrolytes from the living epidermal layer (transepidermal water loss) [42].

#### 4. Overview of high-risk occupations

Several occupations with high exposure to water and aqueous mixtures are regarded as high-risk occupations for developing hand eczema. A number of these occupations and the most common irritants involved are shown in Table 1. In a study by Anveden and colleagues (2009), 6% of the employed population in Sweden reported occupational exposure to water >20 times a day [43]. This compares with an Australian study by Keegel et al in which 9.8% of the employed population reported washing their hands >20 times per day and 4.5% reported immersion in liquids for more than 2 hours per day [44]. Table 1 lists a number of the most common skin irritants and the occupations where these irritants are involved. The following section provides summaries of some published literature with the emphasis on wet-work exposure as a main risk factor for hand dermatitis among hairdressers, florists, food handlers, cooks and chefs, and nurses, as a number of high-risk occupational groups.

##### 4.1. Hairdressing

Hairdressing is one of the occupations most affected by hand dermatitis [45–47]. The continuous wetting and drying of the hands during several hairdressing procedures, as well as contact with a wide range of chemical substances contained in cosmetic

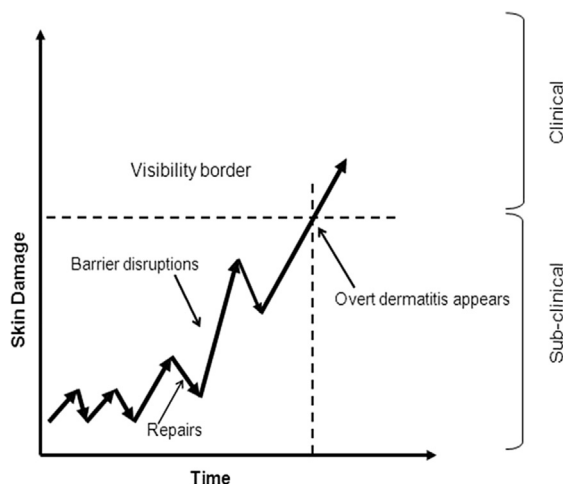


Fig. 1. A schematic view of the development of irritant contact dermatitis. (Adapted and modified from [41]).

Table 1

High-risk occupations and the most common irritants for developing hand eczema

Occupation	Common irritants
Hairdressing	Wet-work Shampoos Permanent wave solutions Oxidizing/bleaching agents Cleansers and detergents
Healthcare	Wet-work Disinfectants Some medications/Alcohol Cleansers and detergents
Catering	Wet-work Cleansers and detergents
Cleaning and housework	Wet-work Cleansers and detergents Abrasives
Cement workers and construction industry	Wet-work Cement Cleansers and detergents Fiberglass
Agriculture	Solvents Cleansers and detergents Plants
Woodwork	Wet-work Solvents Detergents Sawdust
Rubber industry	Wet-work Solvents Detergents Friction/mechanical factors
Engineering	Wet-work Cutting fluids Acids and alkalis Solvents Paints Cleansers and detergents

products may remove the natural lipids from the skin and cause it to dry out, flake, split, and crack.

In the UK, hairdressers and barbers rank among the top three occupational groups with the highest ICD rates reported to the EPIDERM surveillance scheme [45]. Up to 70% of hairdressers have been reported to experience work-related skin damage at some point during their career [46]. More than 2 hours of wet-work per day has been identified as a major risk factor for ICD among hairdressers [12,48]. Lee and Nixon also observed that when a high proportion of the time is spent on wet tasks such as shampooing and rinsing hair, as often happens with apprentice hairdressers, ICD occurs early in an individual's hairdressing career [49]. The frequency of shampooing has also been shown to be correlated with the occurrence of ICD [50,51].

In a study from 2005, Perkins and colleagues found that wet-work was significantly associated with prevalence of hand dermatitis among hairdressers, and those who performed more frequent wet-work were found to have an increased risk ratio [51]. As hairdressing is a female-dominated occupation, more women are affected by ICD in this occupation [48].

##### 4.2. Floristry

According to data reported to the EPIDERM surveillance scheme, floral arrangers and florists were the occupational group most affected by ICD with the highest estimated annual rate of 127 per 100,000 workers in the UK during 2007–2009 [52].

Exposure to wet-work and plant sap, and the trauma from manipulating a knife between thumb and forefinger to cut stems is highly common among floral designers and florists. Diepgen and Coenraads have also reported that wet-work is one of the main

causes of ICD among florists [53]. Some of the daily wet tasks in floristry include cutting the stems, opening bunches of flowers, and placing them in the buckets of water, trimming, stripping off the leaves, changing the water in buckets, making frames, and washing tools and buckets.

#### 4.3. Catering

ICD has been reported as a common skin problem in the catering business [54], accounting for ~10% of all occupational CD in the UK [55]. The UK Health and Safety Executive (HSE) quotes ICD as one of the occupational health priorities in the food and hospitality industries [56]. HSE also estimates that there may be as many as 600 new catering-related ICD cases every year; this is almost two new cases every day [55].

Wet-work, food and vegetables, and soaps and detergents have been reported as the most common agents for ICD among chefs and catering assistants in the UK [57]. Teo and colleagues studied 457 workers in restaurant, catering and fast-food outlets and found that the most frequent skin disorder in this sector was ICD. The most common irritants were found to be wet-work and detergents (77%) [58].

HSE also argued that contact with water, soaps and detergents causes 55% of all ICD cases in the food industry, and 40% of the cases come from contact with food stuffs such as sugar, flour/dough, citrus fruits, vegetables, spices and herbs, fish and sea-foods, meat, and poultry [55].

#### 4.4. Nursing

Hand eczema has also been identified as the most common occupational skin problem among healthcare workers [59,60]. Nurses, as a large subgroup of healthcare workers, are known to have a high prevalence of hand eczema, mainly caused by the intense exposure to wet-work and irritants in nursing activities [13,60].

Hand washing is a common technique in the prevention of the spread of infections in healthcare settings [61]. Subsequently, wet-work and exposure to soaps and detergents are an integral part of the nursing profession. Although repeated exposure to water and antibacterial soaps, along with occluded skin account for the majority of hand eczema cases among healthcare workers, this group is also exposed to a number of other irritants such as antiseptics/germicidals, alcohol (ethyl, isopropyl), drying agents, and miscellaneous medications.

It is estimated that ~1,000 nurses develop work-related ICD each year in the UK. Nurses have been reported to have an incidence of diagnosable ICD, which is almost seven times higher than the average for all healthcare professions [62]. The most frequently reported suspected agents for hand dermatitis among nurses in the UK are soaps and detergents, wet-work, rubber materials, and chemicals [63]. Smith and colleagues investigated the effects of working environment on the prevalence of ICD among a group of Chinese nurses and found that wet-work was the most important risk factor [64]. Similar findings have also been reported in other studies [65–67].

### 5. Domestic exposure to wet-work

The focus throughout this review has been on occupational wet-work exposure. However, it should be noted that water exposure during leisure time contributes to the wet-work exposure of an entire day. In a study by Meding and colleagues, it was found that high water exposure over the entire day was considerably more frequent than exposure at work. A significant proportion of water exposure occurred outside work [34]. Ibler and colleagues also investigated the relationship between domestic and occupational

exposures to wet-work and hand eczema [36]. Twenty-three percent of participants with hand eczema reported washing their hands >10 times per day outside the workplace, compared to 16% of those participants without hand eczema. Thirty-one percent of those with hand eczema also reported having children younger than 4 years compared to 23% of those parents of children without hand eczema.

Other domestic wet-work exposures are use of occlusive gloves in cooking, cleaning, dishwashing, and clothes washing. Those with hand eczema reported more frequent glove use than those without eczema. In this study, other domestic activities such as gardening, contact with soil and plants, repairing motor vehicles, and renovation and redecoration were not found significantly associated with prevalence and severity of hand eczema [36].

Anveden and colleagues also reported that domestic wet-work exposure is common in men and women [43]. In that study, women reported spending more time doing housework, a relationship between wet work exposure and the time spent on housework was reported.

### 6. Regulations and measurement of wet-work

Regulations on wet-work exposures are still lacking in most countries. In Germany, regulation of wet-work exposure has been proposed and has reached the stage of guidelines, which were introduced by the German Federal Ministry of Labour and Social Affairs in September 1996 to regulate the duration and frequency of exposure to wet-work (TRGS 531: Technische Regel Für Gefahrstoffe) [68]. This guidance was subsequently replaced by TRGS 401 in May 2006. An English version is available at: [http://www.baua.de/nn\\_54598/en/Topics-from-A-to-Z/Hazardous-Substances/TRGS/pdf/TRGS-401.pdf](http://www.baua.de/nn_54598/en/Topics-from-A-to-Z/Hazardous-Substances/TRGS/pdf/TRGS-401.pdf).

These guidelines recommend that workers should not have their hands wet for >2 hours, or repeat handwashing episodes >20 times per shift, and water-resistant gloves should be worn no longer than a maximum continual time of 4 hours per day in most jobs [69]. Similar guidelines including these levels were also published in Australia in 2005 as the Australian “ASCC Guidance on the prevention of dermatitis caused by wet-work” [70].

The German guidance has had a significant effect on the reduction of dermatitis among several occupations involving wet-work as demonstrated by Dickel and colleagues, who reported that the annual incidence rate of dermatitis among hairdressers decreased from 194 cases to 18 per 10,000 workers from 1990 to 1999. This is not only highly significant, but also clinically important as it means the annual incidence of dermatitis decreased by a factor of 10 [69]. A number of studies also showed that decreasing the frequency of handwashing episodes is an effective strategy for reducing the occurrence of hand dermatitis among hospital nursing staff [1,44,71].

To the best of our knowledge, there is no specific and validated objective instrument that measures dermal exposure to wet-work. None of the current direct and indirect methods for dermal exposure measurement is suitable for the measurement of duration and frequency of wet-work exposure. All recognized methods for measuring dermal exposure as discussed by Behroozy only measure mass or concentration of the contaminant on the skin or surfaces, and none of them is designed to measure wet-work exposure [72]. The most commonly used methods to assess the quantity of wet-work exposure are by self-reported questionnaire administered to exposed individuals, or by direct observation to see how often and for how long an individual is exposed to wet-work. Observation method appears to provide more reliable data than questionnaires as demonstrated by Jungbauer and colleagues [73], but observation of the activities during a shift is time-consuming

and requires great concentration of the observer. It is also susceptible to observer bias. Furthermore, these methods are prone to errors and need to be validated against a reference method prior to use. It should also be noted that the direct and indirect methods previously developed for dermal exposure assessment only measure chemicals which are deposited on the skin or a surface, or absorbed into the body through the dermal pathway [72].

## 7. Treatment of ICD caused by wet-work exposure

The preferred approach for treatment of ICD is determining all contributing factors and prevention of contact with these agents as much as possible, and according to the hierarchy of controls. Furthermore, education about skin care and benefits of using moisturizers is helpful. With regard to wet-work exposure, reducing the duration and frequency of wet hands is effective. Drug treatments generally rely on topical corticosteroids, although recent concerns challenge the use of topical corticosteroids in the treatment of ICD [30].

## 8. Summary

Wet-work is a key exposure in investigating hand eczema. Nonoccupational wet-work exposure contributes to the exposure of an entire day. The purpose of this paper is to highlight the importance of wet-work occupational dermal exposure and the subsequent adverse health effects, thereby providing a survey of the extent of the problem. Many occupational groups including healthcare workers, hairdressers, food handlers, flower arrangers, metal workers and construction workers are exposed to wet-work. Furthermore, in most cases, wet-work exposure is accompanied by detergents and cleansers, which in turn may aggravate the adverse effects of exposure. Measuring wet-work exposure might be a challenging issue in the field of occupational dermal exposure assessment. Some gaps still exist in dermal exposure measurement methodology, and as a result, few approaches and models have been developed to tackle these problems. There is still no validated instrument to assess wet-work exposure, except the costly, time-consuming and imperfect observation and questionnaire methods. More valid and less-labor techniques are required to measure wet-work exposure.

## Conflicts of interest

No potential conflicts of interest relevant to this article were reported.

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