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Dermal Exposure to Occupational Chemicals and its Associated Health Effects

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Abstract

In the United States, there are many workers in various occupations and sectors who may be exposed to chemicals absorbed through the skin. Occupational skin contact can lead to many illnesses that can affect a person's health and performance at work. In general, there are three types of chemical-skin interactions of concern: direct skin effects, immune-mediated skin effects, and systemic effects. Hundreds of chemicals (metals, epoxies, acrylics, rubber additives, and chemical intermediates) found in nearly every industry cause direct and immune-mediated effects such as contact dermatitis and urticaria. It has been confirmed to cause them, but little is known about their numbers and types. A chemical that contributes to systemic effects to raise awareness, skin labeling assignments communicate skin absorption potential. However, there is a need for standardization among authorities to communicate accurate descriptions of occupational hazards. Exposure to complex mixtures, excessive hand washing, use of hand sanitizers, frequent washing, and other biological responses that enhance penetration and alter the outcome of skin chemical exposures. Studies have shown it can be irritating. Understanding the hazards of skin exposure is essential to properly implementing protective measures to ensure worker safety and health.

Keywords: Dermal; Chemical; Toxicity; Occupational

Introduction

The Centers for Disease Control and Prevention (CDC) estimates that more than 13 million workers in the United States, covering a wide variety of occupations and sectors, may be exposed to chemicals absorbed through the skin. With approximately 82,000 chemicals used in industry and an estimated 700 new chemicals introduced each year, the potential for dermal exposure to chemicals [1] increases sick leave and other significant economic losses are estimated to exceed $1 billion annually in the United States alone [2, 3]. In 2012, skin diseases alone accounted for 34,400 cases, or 3.4 cases per 10,000 workers. Occurred at a rate of, exceeds occupational respiratory diseases (19,300 cases at a rate of 1.9 per 10,000 workers) [4], according to the Bureau of Labor Statistics (BLS) report. The National Occupational Research Agenda (NORA) Division of the National Institute for Occupational Safety and Health (NIOSH) provides an overview of known and emerging issues related to occupational skin exposure to raise awareness of potential health hazards.

Functions of the Skin

The skin is the body`s largest organ accounting for more than 10% of total body mass. It is a very complex and dynamic organ composed of an outer epidermis and inner dermis with functions well beyond that of just a barrier to the external environment. Skin functions include but are not limited to barrier protection, water preservation, tactile sensation, thermal regulation, endocrine activity and vitamin D synthesis, immunological affector, and biotransformation of xenobiotis [5]. Dermal absorption depends largely on the barrier function of the stratum corneum, the outermost superficial layer of the epidermis, and is modulated by factors such as skin integrity, hydration, density of hair follicles and sebaceous glands, thickness at the site of exposure, physiochemical properties of the substance, chemical exposure concentration, and duration of exposure [6]. Low molecular weight (LMW) chemicals (molecular weight <500 Da) that have good solubility in both water and fat penetrate the skin more readily than large, highly hydrophilic or highly lipophilic compounds [7]. However, evidence suggests that reduced integrity or barrier dysfunction of the skin, through factors such as physical or chemical damage, may increase dermal absorption of chemicals leading to the entrance of larger molecules such as proteins [8], inorganic metal compounds, or nanoparticles [9]. For example, dermal exposure to solvents has been shown to reduce barrier function of skin by altering lipid and protein structures of the stratum corneum, thus promoting the systemic uptake of the solvent itself or other chemicals [10]. Enhanced systemic absorption of carbon disulfide, dimethylformamide, aromatic amines, 2-(2-butoxyethoxy) ethanol, and xylene was found in workers with skin abnormalities caused by previous exposure to these solvents [11, 12]. In the workplace, dermal exposure to chemicals may occur through direct contact with contaminated surfaces, deposition of aerosols, immersion, or splashes and can often occur without being noticed by the worker. This is particularly true for non-volatile chemicals, which remain on work surfaces for long periods of time. Prolonged exposures may result from contamination of clothing or permeation of chemicals through gloves, potentially resulting in enhanced absorption secondary to occlusion. Therefore, it is important for workers to understand the importance of skin exposure and what steps should be taken to prevent it.

Regulation of Occupational Dermal Chemical Exposures

There are at least 14 federal regulations and 3 agencies, including the Environmental Protection Agency (EPA), Food and Drug Administration (FDA), and the Occupational Safety and Health Administration (OSHA) that are involved in the regulation of occupational skin exposure in the United States [13]. Historically,

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efforts to control workplace exposures to hazardous agents have focused on inhalation rather than skin exposures. As a result, assessment strategies and methods are well developed for evaluating inhalation exposures in the workplace; however, standardized methods are currently lacking for measuring and assessing skin exposures [14]. There are currently no occupational exposure limits (OELs) set for dermal exposures; however, chemicals with risk associated with dermal penetration are given a skin notation assignment (S) as a guidance to warn against potential for increased risk of systemic toxicity because of dermal penetration in additional to inhalation exposure. NIOSH has 142 skin notations assigned to chemicals, OSHA lists 159 notations in the PocketGuide, and over 219 chemicals have a skin notation assigned by the American Conference of Industrial Hygienists (ACGIH). Historically, the main goal of the skin notation is to communicate the potential for dermal absorption; however, the criteria and protocol for the assignment of skin notations vary among the different agencies and have many limitations. Among these limitations are lack of information about the inherent toxicity of the chemical, which could result in the same skin notation for highly toxic chemicals and chemicals with limited toxicity that are absorbed through the skin; no warning about chemicals that produce direct damage to the skin (i.e., irritants, sensitizers, corrosives); the perception that chemicals that are not assigned a skin notation are safe following exposure via the dermal route; and detailed information about the rationale behind the skin notation assignment. In 2009, NIOSH announced a strategy aimed at overcoming many of the limitations in historical approaches to establishing skin notation [15]. The NIOSH Skin Notation (SK) profile is a We use a unique stepwise approach to collect information on systemic and direct effects such as sex. NIOSH SK assignments include the use of scientific data on physicochemical properties. Data from chemical, epidemiological, toxicological and mechanistic studies, and computational techniques including predictive algorithms and mathematical models using analytical or numerical methods. With the ultimate goal of better protecting workers from the risk of skin contact with hazardous chemicals, the Skin Notation Profile describes the potential health effects associated with skin exposure in potentially hazardous workplaces designed to inform occupational health professionals, researchers, employers and workers.

Occupations with the Highest Potential for Dermal Chemical Exposure

NIOSH estimates that 13.2 million workers in the United States are exposed to OSHA skin-labeled chemicals. Workers exposed to potentially harmful skin contact include those working in industries and sectors such as agriculture, manufacturing, cosmetics, healthcare, cleaning, painting, machinery, printing/lithography and construction. Chemicals known to cause ICD and ACD are present in virtually every environment, and links between chemical exposure and other types of systemic disease continue to be identified and the mechanisms underlying them elucidated. I'm here. To raise awareness, the section below discusses some of the most common chemicals found in the industry and their potential health effects from occupational skin exposure.

Health Care

Occupational skin diseases, including ACD, ICD, and urticaria, occur commonly among healthcare workers. Some of the most common allergens in the healthcare profession include biocides commonly used for applications such as the sterilization of medical devices that are sensitive to normal heat or steam sterilization processes [glutaraldehyde and ortho-phthalaldehyde (OPA)] and the disinfection of surfaces (quaternary ammonia compounds) [16]. Medical gloves containing certain rubber accelerators (thiuram mix and carba mix), and antibacterial hand sanitizers and soaps (chloroxylenol and cocamide diethanolamine) have also been identified as common sources of allergens [16]. In general, there are increased rates of ACD for healthcare workers compared to non-healthcare workers for the majority of the above-mentioned allergens [17].

For over 40 years, glutaraldehyde was the primary choice for disinfecting heat-sensitive medical devices with 376,330 workers exposed to glutaraldehyde from 1981 to 1983; its toxicity has been well described, and its use has been associated with dermatitis and occupational asthma. ACD from glutaraldehyde often causes chronic dermatitis, which frequently forces patients to leave their jobs. Owing to the known toxicities of glutaraldehyde, less offensive and presumably safer alternatives such as OPA have been introduced. OPA, the active ingredient present in Cidex OPA, has shown superior anti-mycobactericidal activity compared to that of glutaraldehyde, allowing for its use at lower concentrations. While there is limited toxicity data in humans and animals, there is evidence that similar to glutaraldehyde, OPA exposure can induce ana-phylaxis and IgE-mediated allergic responses. Fujita et al reported a case involving a female nurse who exhibited slight dyspnea and dry cough with a subsequent diagnosis of bronchial asthma and serous papules, and urticaria after working with OPA [18]. Animal studies also suggest that dermal exposure to OPA induces significant irritation and sensitization. Owing to its low volatility; it is presumed that the skin may be a significant route of exposure. Although a direct link between skin exposure to triclosan and human health has not been fully proven, the above studies raise concerns regarding exposure to this chemical.

Additional biocides such as quaternary ammonium compounds are ubiquitous in healthcare settings as they are active ingredients in many sprays and wet-wipe products used for disinfecting surfaces and floors, resulting in the exposure to these chemicals in cleaning staff, nurses, physicians, and technicians. Epidemiological data and case studies indicate that healthcare workers have an elevated risk for development of sensitization and allergic asthma from either dermal or inhalation exposure to these chemicals. Among the identified quaternary ammonium compounds, benzalkonium chloride (BAC) [alkyldimethylbenzylammonium chloride (ADBAC)], benzethonium chloride (BEC), and didecyldimethylammonium chloride (DDAC) [19] are known sensitizers in humans. A study evaluating 142 patients with suspected allergies to BAC and BEC confirmed sensitization by patch test to these compounds in 20% of the patients and identified potential co-reactions between the two quaternary ammonium compounds in 85% of the subjects who tested positive [20]. Contradictory to the human data, animal data typically describe these compounds as irritants and/or very weak sensitizers. However, these animal models may lack the complexity associated with actual occupational exposures. With regard to hand hygiene, healthcare workers have very high frequencies and durations of wet hands (70–100 times per shift) and glove use (1.5 hours per shift). Repetitive exposure to wet work and repetitive glove use are significant factors in development of occupational ICD among healthcare workers, and the development of ICD may predispose these individuals to induction of sensitization and subsequent ACD because the skin is more susceptible to chemical penetration. Research has begun to bring to light the importance of danger signals in sensitization. These early signaling events in the skin (potentially a result of barrier breakdown or irritation caused by excessive hand washing, exposure to chemical irritants, glove usage, and wet work) are thought to provide

a bridge between the innate and adaptive immune systems, and are of pivotal importance for the initiation of cutaneous immune responses, including those to chemical allergens resulting in skin sensitization.

In addition to the frequent glove use contributing to decreased barrier integrity, gloves are one of the more frequent sources of chemicals inducing ACD [21]. Although the prevalence of latex allergy has been reduced by decreasing powder and protein content of gloves, the use of rubber accelerators such as carbamates and thiurams still persists in latex and nitrile gloves. One of Cao et al. in a study conducted, 23 patients with his ACD were evaluated with a glove rubber accelerator. Each had a positive patch test reaction to one or more rubber accelerators, including carbamates, thiurams, 2-mercaptobenzothiazole, and 1, 3-diphenylguanidine.Allergic to these chemicals in medical settings. is prevalent, sensitized workers are offered alternative or accelerator-free glove options.

Health care workers are well known to be exposed to sensitizing biocides and antimicrobials, but they are also exposed to high concentrations of antimicrobials, such as triclosan, which are not generally thought to cause sensitization. In a study by MacIsaac et al. because of its endocrine-disrupting properties, recent evidence suggests that exposure to triclosan may contribute to increased cancer risk and developmental benefits such as reduced working hour's impact EDCs, including triclosan, may be responsible, at least in part, for the recent increase in the incidence of asthma and allergic diseases [22]. A recent study found that urinary triclosan concentrations were positively associated with aeroallergens, food sensitization, and asthma exacerbations potentially high exposure to triclosan, a known allergen and due to the suspected health effects described above, triclosan is currently under review by the National Toxicology Program for developmental, immunotoxicity, and reproductive toxicity.

Conclusion

Large numbers of people in all occupations are exposed to potentially harmful chemicals, and these numbers are expected to increase as the number of chemicals used increases. Dermal and inhalation are the two most common routes of occupational exposure to chemicals. Efforts have been made in the past to regulate respiratory exposure. However, the contribution of dermal exposure to the development of systemic disease is increasingly recognized. In particular, studies are beginning to show a contribution of dermal exposure to the development of respiratory sensitization and changes in lung function. The skin is the body's largest organ, and it is known that low-volatility chemicals can penetrate directly into the skin and cause toxicity, but there is also evidence of a contribution from vaporized or aerosolized chemicals that cannot be overlooked. I have. Although contact dermatitis is one of the most common and best understood occupational diseases, it is also of professional importance to raise awareness of the potential systemic effects of dermal contact with chemicals. Skin exposure not only contributes to systemic exposure to chemicals, but the skin is also a very biologically active organ, metabolizing chemical species, triggering a cascade of immunological events, and other

Workers should be exposed not only to the hazards associated with chemicals in the environment, but also to conditions that may facilitate systemic absorption of those chemicals. Be careful. Factors such as excessive hand washing, use of hand sanitizers, frequent wet work, exposure to chemical mixtures, or wearing sealed gloves alter skin integrity or function, affecting additional biological responses. It plays a role in promoting the penetration or sensitization of chemicals by providing.

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