Bath Attendants

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Abstract

Bath attendants work in indoor or outdoor swimming facilities or, less frequently, at the seaside. Irritant and allergic occupational dermatitis in bath attendants can be induced by water, disinfectants, sunscreens, swimming clothes, or equipment. Especially repeated and prolonged wet work causes skin irritation and impairs the skin barrier function. Contact dermatitis to disinfectants is rarely observed and mainly caused by chlorinated or brominated by-products in the swimming pool water such as trihalomethanes (e.g., trichloromethane, chloroform), haloamines, haloacetic acids and haloketones; substances added to eliminate amines and organic

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contaminants such as potassium peroxymonosulfate; or disinfectants used to disinfect pool edges, showers, bathrooms or pediluvia such as sodium hypochlorite, aldehydes and quaternary ammonium compounds. Contact dermatitis associated with disinfectants used in swimming pools are rather due to irritancy, but may also be caused by true sensitization. Urticaria induced by swimming in pools can be cold-induced urticaria, aquagenic urticaria, or contact-urticaria to chlorinated water. Rare causes of occupational dermatoses in bath attendants are skin infections due to pathogens in the pool water, aquagenic pruritus, or skin cancer induced by exposure to UV-light during outdoor activities.

Keywords
Bath attendants · Swimming pool · Wet work · Disinfectants · Swimming equipment · Sunscreens · Chlorinated water · Brominated water · Trihalomethanes · Haloamines · Haloacetic acids · Haloketones · Potassium peroxymonosulfate · Sodium hypochlorite · Aldehydes · Quaternary ammonium compounds · Contact dermatitis · Cold-induced urticaria · Aquagenic urticaria · Contact urticaria

1 Introduction

Bath attendants work in indoor or outdoor swimming facilities or, less frequently, at the seaside. Irritant and allergic occupational dermatitis can be induced by water, disinfectants used in the pools, in the showers or on the pool edges; or by sunscreens, swimming clothes, or equipment.

2 Public Swimming Pools' Disinfection

Disinfectants are added to the pool water in order to inactivate pathogens.

A few disinfectants, such as chlorine, bromine, or treatment with ozone or ultraviolet (UV) radiation, are used in public swimming pools. Hexamethylene biguanide polymer, oxygen peroxide, quaternary ammonium compounds, sodium pentachlorophenate, silver and copper ions, which are used in private swimming pools, are not allowed in public pools.

Ozone and UV treatment are used in conjunction with conventional chlorine- or bromine-based disinfectants. They provide short-lasting disinfectant effects and break down halogenated by-products such as chloramines which can lead to an overall reduction in disinfectant use. A similar effect is achieved by oxidizing agents such as potassium peroxymonosulfate and potassium peroxydisulfate which are periodically added in particular to brominated pools.

Filtration is performed through filters with sand, membrane or diatoms (algae) in order to reduce the contamination of water with pathogens as well as organic and inorganic matter, e.g., deriving from swimmers and their body care products (Zwiener et al. 2007). Aluminum sulfate, aluminum chloride, or iron chloride can be added as flocculating agents to facilitate removal of dissolved material. To stabilize pH levels between 7.2 and 7.8 for chlorine-based disinfectants and between 7.2 and 8.0 for bromine-based disinfectants sodium carbonate or hydrochloric acid can be added.

3 Chlorine-Based Disinfectants

Chlorine-based disinfectants (chlorine gas, calcium/lithium/sodium hypochlorite, chlorinated isocyanurates, chlorine dioxide) are most commonly used to disinfect swimming pool water. In Germany, chlorine is the only disinfectant allowed for disinfection of public pools according to the German Industrial Norm DIN 19643 (Zwiener et al. 2007).

When chlorine is added to the water, free active chlorine consisting of hypochlorous acid (HOCl) and deriving hypochlorite ion (OCl^-) are formed. Hypochlorous acid is a much stronger disinfectant than hypochlorite ion. Levels of free chlorine considered to be acceptable in terms of safety and efficacy vary greatly around the world. In Germany levels of free chlorine must be kept in the range of 0.3–0.6 mg/l, whereas in the United States, the UK, and Australia concentrations of 1–3 mg/l are recommended (Zwiener et al. 2007). Active free chlorine is an unstable chemical substance which easily is degraded by UV radiation. It can be stabilized with adjunction of cyanuric acids which is widely used in disinfection of outdoor pools. Combined stabilized products are commercialized under the name chlorinated isocyonurates, chlorocyanurates, or chloroisocyanurates.

Active free chlorine binds to organic and inorganic compounds resulting in the formation of chlorinated by-products, which are common irritants with a much lower disinfection capacity. The most frequent chlorinated by-product is trichloromethane ($CHCl_3$, chloroform) (Cammann and Hubner 1995), a trihalomethane (THM) resulting from chlorine combined with organic carbonated molecules in the water (e.g., deriving from skin scales, hair, urine, residuals from body care products, algae). Chloroform is involved in respiratory symptoms and eye irritation and can be traced in blood and urine of bath attendants (Cammann and Hubner 1995; Caro and Gallego 2007). Combined with organic nitrogen-containing compounds (urea, creatinine) generated by swimmers (sweat, urine), free active chlorine produces combined chlorine compounds, such as chloramines (NH_2Cl, $NHCl_2$, NCl_3). Chloramines and chloroform are volatile, partly vaporizing from water as gas, causing the typical "chlorine smell," especially in indoor pools, and irritating mucous membranes not only by direct water contact but also through the air. Mono-, di-, and trichloramines cause eye irritation, whereas trichloramines have also the potential to irritate air tracts (Massin et al. 1998; Jacobs et al. 2007). Other chlorinated by-products with irritant capacities include haloacetic acids (HAAs) and haloketones (Zwiener et al. 2007).

Threshold and maximum levels for chlorine concentrations need to be adhered to in order to provide sufficient safety and disinfection efficacy. The concentration of active free chlorine depends on the amount of organic contamination, the water temperature, solar irradiation, and the pH value of the water.

4 Bromine-Based Disinfectants

Bromine-based disinfectants are used in several countries (e.g., United States, UK, Spain) as an alternative for disinfection with chlorine, except for outdoor pools as bromine is rapidly depleted by UV radiation. Bromine added to the water turns into active bromine residuals, consisting of hypobromous acid (HOBr) and hypobromide (OBr^-). Easier to handle brominated compounds, such as 1-bromo-3-chloro-5,5-dimethyl-hydantoin (BCDMH), are usually used for pool water disinfection. BCDMH can be formed as solid sticks which, when in contact with water, release bromine, chlorine and leave 5,5-dimethyl-hydantoin. These compounds are commercialized under the tradenames of Di-Halo™, Aquabrome™, or Halobrome™. A two-part bromine system consists of a bromide salt (sodium bromide) activated by an oxidizing agent (e.g., hypochlorite or ozon).

The resulting compounds react with organic matter dissolved in the water (e.g., urea and creatinine) to form disinfection by-products, such as brominated trihalomethanes, bromamines, chloramines, organic bromine, and chlorine compounds that can act as irritants. Brominated trihalomethanes (also called haloforms), e.g., bromodichloromethane ($CHCl_2Br$), chlorodibromomethane ($CHClBr_2$), and tribromomethane (bromoform, $CHBr_3$), are volatile and can cause irritation of skin, eyes, and air tracts (Cammann and Hubner 1995; Chu and Nieuwenhuijsen 2002). Trichloromethane and bromodichloromethane are present at quantifiable concentrations in the peripheral blood of bath attendants (Cammann and Hubner 1995; Caro and Gallego 2007). The greatest uptake in pools is likely to be through dermal absorption while swimming and through inhalation from the air above the pool water surface.

5 Disinfection of Pool Edges

Sodium hypochlorite, aldehydes, quaternary ammonium compounds, or substances like Tego™ G (dodecyl aminoethyl glycine hydrochloride) or chloramine-T (sodium-p-toluenesulfonchloramide) are used to clean or to disinfect pool edges, showers, bathrooms or pediluvia.

6 Dermatoses

Only a few studies have systematically investigated the prevalence of occupational skin diseases in swimming pool workers, such as bath attendants, swimming teachers, or physiotherapists. An increased prevalence of self-reported skin complaints was revealed by questionnaires (Lazarov et al. 2005; Parrat et al. 2012). Predisposing and contributing factors for skin disease in this working population are heat and humidity (out of water), heat and wetting (in water), wetting and drying cycles, degreasing agents, previous skin disease and dry skin, infections, and contact to chemicals with irritant or allergenic capacities (Penny 1991). Contact irritants and allergens to consider are listed in Tables 1 and 2, respectively. Especially repeated and prolonged wet work causes skin irritation and impairs the skin barrier function by removal of skin lipids and maceration, which facilitates the entry of allergens and pathogens (Tsai and Maibach 1999). Changes in biophysical skin parameters, including pH, capacitance, and sebum levels, are found after recreational swimming in public pools (Gardinier et al. 2009). Due to irritation and augmentation of skin dryness, individuals with atopic dermatitis may experience worsening of disease (Morren et al. 1994; Seki et al. 2003). Overall, contact dermatitis to swimming pool disinfectants is rarely observed (Fisher 1987). Several studies suggest that dermatoses of swimmers or bath attendants are more commonly seen in brominated than in chlorinated pools (Gould 1983; Morgan 1983; Rycroft and Penny 1983; Fitzgerald et al. 1995). In contrast, Kelsall and Sims did not find a greater risk of developing skin rashes associated with brominated pools (Kelsall and Sim 2001). After visiting 19 brominated pools because of reports of rashes, Rycroft and Penny (1983) published a study showing that at least 5% of the users of a pool treated with Di-Halo™ (1-bromo-3-chloro-5,5-dimethylhydantoin) had experienced dermatoses, and high proportions of the staff were affected. Rashes cleared when the pool was treated with a solid chlorine disinfectant (Morgan 1983; Rycroft and Penny 1983). Reported adverse reactions are eye irritation, respiratory symptoms, soreness of the mouth, throat, vulva, female urethra and breasts, but dermatoses have also been observed. Rashes may develop within 12 h after swimming. Itching is the initial and sometimes only symptom. Dermatoses are mainly eczematous, with discoid and/or vesicular eczema, but pruritus, urticaria, or pruritic rashes have also been reported (Rycroft and Penny 1983; Fitzgerald et al. 1995; Loughney and Harrison 1998; Sasseville et al. 1999). The frequency and duration of exposure seem to be important factors, but some swimmers develop the eruption after only short-re-exposure to the pool water (Morgan 1983).

The mechanisms of dermatoses associated with chlorinated or brominated pools are not elucidated. They are rather due to irritancy but may also be caused by true sensitization. Patch tests have been performed using commercialized compounds containing 1-bromo-3-chloro-5,5-dimethylhydantoin (BCDMH) crumbled to make a 1% suspension in water. Rycroft and Penny performed such patch tests in 9 patients and Gould in 12 patients with negative results (Gould 1983; Rycroft and Penny 1983). These patch tests could give irritant results even in control subjects (Morgan 1983). Patch testing with swimming pool water yielded negative

Table 1 Contact irritants

Sodium hypochlorite
Trihalomethanes Trichloromethane ($CHCl_3$, chloroform) Tribromomethane (bromoform, $CHBr_3$) Bromodichloromethane ($CHCl_2Br$) Chlorodibromomethane ($CHClBr_2$)
Haloamines Chloramines (e.g., trichloramine) Bromamines
Chlorate
Bromate
Haloacetic acids
Haloketones
Pool and pool edge disinfectants Aldehyde Quaternary ammonium compounds

Table 2 Contact allergens

Contact dermatitis				
Substance	**Test**	**Concentration**	**Vehicle**	**Reference**
Water disinfectants				
Sodium/lithium hypochlorite	Patch test	0.5% or 1%	Water	(Osmundsen 1978; van Joost et al. 1987; Sasseville et al. 1999)
Sodium/lithium hypochlorite	Patch test with reading after 20 min or after performing an open application test	0.5% or 1%	Water	(Hostynek et al. 1989)
Commercialized compounds containing 1-bromo-3-chloro-5,5-dimethylhydantoin	Patch test	1%	Water or petrolatum	(Gould 1983; Rycroft and Penny 1983; Fitzgerald et al. 1995; Dalmau et al. 2012)
Oxidizing agent				
Potassium peroxymonosulfate	Patch test	5%	Petrolatum	(Kagen et al. 2004)
Ammonium persulfate (possible cross-reactivity with potassium peroxymonosulfate)	Patch test	2.5%	Petrolatum	(Kagen et al. 2004; Gilligan and Horst 2010)
Pool-edges disinfectants				
Glutaraldehyde	Patch test	0.3%	Petrolatum	
Formaldehyde	Patch test	2%	Water	
Benzalkonium chloride	Patch test	0.1%	Petrolatum	
Tego (dodecyl aminoethylglycine hydrochloride)	Patch test	0.1% or 1%	Water	(Valsecchi et al. 1985)
Flocculant				
Locron™ L (aluminum chlorohydrate)	Patch test	2%	Water	(Stenveld 2012)
Equipment				
1,3 Diphenylthiourea	Patch test	1%	Petrolatum	(Alomar and Vilaltella 1985)
1,3 Dibutylthiourea	Patch test	1%	Petrolatum	(Alomar and Vilaltella 1985)
Isopropyl-phenyl-paraphenylenediamine (IPPD)	Patch test	0.1%	Petrolatum	(Maibach 1975)
Mercaptobenzothiazole	Patch test	1%	Petrolatum	
Mercapto-mix	Patch test	1%	Petrolatum	
Thiuram-mix	Patch test	1%	Petrolatum	
Zincdiethyldithiocarbamate	Patch test	1%	Petrolatum	
Zincdibutyldithiocarbamat	Patch test	1%	Petrolatum	
Zincdibenzyldithiocarbamat	Patch test	1%	Petrolatum	
Sunscreens				
Sunscreens and their preservatives, vehicles, photoprotective agents	Patch test and Photopatch test			

results (Gould 1983; Morgan 1983). Prick tests with Di-Halo™ (diluted at 1% in water and 1% in petrolatum) performed in one patient yielded negative results (Rycroft and Penny 1983). Conversely, Fitzgerald et al. observed positive results in reading patch tests performed with Halobrome™ diluted at 1% and 0.1% in water in three sensitized patients (32 negative controls). Patch tests performed with 5,5-dimethyl-hydantoin, a degradation product of Halobrome™, tested diluted at 1% in water, yielded negative patch-test results. (Fitzgerald et al. 1995). Similarly, Sasseville et al. found a positive patch test for Di-Halo™ diluted at 1% in water, but no reaction against 5,5-dimethyl-hydantoin diluted 2% in water in a woman who developed a rash after swimming in a private pool disinfected with Di-Halo™. Moreover, positive patch-test results against sodium hypochlorite and lithium hypochlorite diluted at 1% in water were detected in the same women. It was concluded that these reactions were due to chlorine released by Di-Halo™ (Sasseville et al. 1999). Dalmau et al. report 10 cases of allergic contact dermatitis caused by exposure to BCDMH used as disinfectant in different swimming pools in Spain. All patients had a positive patch test reaction to BCDMH derived from Aquabrome™ at 1% in petrolatum (Dalmau et al. 2012). At least one case was work-related.

Several cases of allergic contact dermatitis to potassium peroxymonosulfate have been reported (Kagen et al. 2004; Yankura et al. 2008; Gilligan and Horst 2010; Salvaggio et al. 2013). This chemical is added primarily to brominated swimming pools and hot tubs to eliminate amines and organic contaminants. Due to cross-reactivity, a positive patch test reaction to ammonium persulfate at 2.5% in petrolatum might be a good indicator for sensitization to potassium peroxymonosulfate even though a few cases might be missed (Kagen et al. 2004; Gilligan and Horst 2010).

Sodium hypochlorite is a disinfectant and antiseptic with the brief and rapid action of chlorine. It can be used in pools and on pool edges. Hypochlorite solutions may be irritating to the skin. Sodium hypochlorite sensitization is rare but may occur. A 43-year-old woman was reported to have developed a severe bullous contact dermatitis on both arms while handling sodium hypochlorite. Patch tests performed with sodium hypochlorite diluted at 0.5% in water (222 negative control patients) had strong positive results and induced a severe flare-up of the dermatitis (Osmundsen 1978). Van Joost et al. reported two cases of sodium hypochlorite contact dermatitis in housewives with positive patch-test results when tested diluted at 1% in water with no irritative results in 107 negative controls (van Joost et al. 1987). Hostynek et al. recommend that an open skin test or a skin prick test for immediate-type reaction to sodium hypochlorite precede patch testing with 48-h occlusion (Hostynek et al. 1989). A higher incidence of contact dermatitis in hydrotherapists working in pools chlorinated by gaseous chlorine instead of other forms of chlorine compounds may be explained by a temporary drop in the water pH after using larger amounts of gaseous chlorine according to Pardo et al. (2007).

Leg and foot eczema induced by Tego™ G (dodecyl aminoethyl glycine hydrochloride) was reported in a swimming trainer (Valsecchi et al. 1985). Tego™ G, used to clean and disinfect bath and pool surfaces, gave positive patch-test results when tested at 0.1% and 1% diluted in water (10 negative controls).

A case of a 36-year-old female swimming teacher was reported who developed generalized itch and rash when exposed to pool water. She had a positive patch test reaction to the flocculant Locron™ L based on aluminum chlorohydrate and tested at 2% diluted in water (8 negative controls) (Stenveld 2012).

Aquagenic pruritus, which is frequently associated with polycythemia vera, may also occur (Fisher 1993; Heitkemper et al. 2010).

Urticaria induced by swimming in pools can be a cold-induced urticaria (Bentley 1993; Siebenhaar et al. 2009) or aquagenic urticaria (Sibbald et al. 1981; Treudler et al. 2002; Frances et al. 2004). However, one has to keep in mind a possible sensitization to chlorinated water if urticaria appears only after swimming in chlorinated swimming-pool water and not after swimming in

Table 3 Contact urticariogens

Urticaria				
Cold-induced urticaria				
Aquagenic urticaria				
Contact urticaria to chlorinated water:				
Substance	**Test**	**Concentration**	**Vehicle**	**Reference**
Chlorinated swimming pool water	Scratch test	As is	As is	(Neering 1977)
Sodium hypochlorite	Open application test	1%	Water	(Hostynek et al. 1989)
Chloramine T (sodium-p-toluenesulfonchloramide)	Patch test	0.2%	Water	(Dooms-Goossens et al. 1983)

fresh water or after sea bathing. Chlorinated swimming pool water, sodium hypochlorite, and chloramine T (syn. sodium-p-toluenesulfonchloramide) have been reported to cause occupational contact urticaria (Neering 1977; Dooms-Goossens et al. 1983; Hostynek et al. 1989). Kanerva et al. reported the case of a 48-year-old hospital bath attendant who developed occupational allergic contact urticaria, with rhinitis and sneezing, induced by a chloramine-T solution which was used to disinfect hospital bathrooms (Kanerva et al. 1997). Causes of urticaria related to swimming pools are listed in Table 3.

7 Other Causes of Contact Dermatitis

In bath attendants working in outdoor swimming pools, sunscreen may induce contact dermatitis or photosensitivity (Scheuer and Warshaw 2006).

Contact dermatitis to dibutylthiourea was reported by Alomar and Vilaltella in a 13-year-old boy who developed intense bilateral eyelid eczema while using black neoprene goggles. Patch tests performed with 1,3 diphenylthiourea and 1,3 dibutylthioruea both diluted at 1% in petrolatum gave positive results (Alomar and Vilaltella 1985). A probably toxic reaction caused by neoprene-rubber-lined swim goggles induced a periorbital leukoderma in a 12-year-old swimmer (Goette 1984). Others reported allergic contact dermatitis due to phenolformaldehyde resin and benzoyl peroxide in swimming goggles (Azurdia and King 1998). A series of patients with facial dermatitis, induced by sensitization to *N*-isopropyl-*N*-phenylparapheylenediamine (IPPD) contained in scuba-diver face masks, have been described. Patch tests performed with the rubber from the mask and IPPD diluted at 0.5% in petrolatum had positive results (Maibach 1975; Tuyp and Mitchell 1983).

8 Infectious Dermatoses

Mycotic or viral contamination from pool edges may induce dermatophytosis, plantar warts, or mollusca contagiosa (Choong and Roberts 1999; Penso-Assathiany et al. 1999; Fantuzzi et al. 2010; Tlougan et al. 2010). Atypical mycobacterial infections by *Mycobacterium marinum* can provoke swimming-pool granuloma (Fisher 1988). Epidemic folliculitis induced by *Pseudomonas aeruginosa* has been described in swimming pools and whirlpools (Gustafson et al. 1983; Jacobson 1985). Inadequate disinfection of the water can lead to this Pseudomonas folliculitis with a papulopustular rash, predominantly involving the buttocks, hips, and axillae, appearing within 8–48 h after swimming in the pool. Pseudomonas aeruginosa can be isolated from the skin lesions or from the water.

9 Other Skin Diseases

Bath attendants working at outdoor swimming pools are particularly vulnerable to skin cancer owing to high sun exposure on the job. A high percentage of outdoor aquatic staff reports a history of severe sunburn (Gies et al. 2009). Although sun protection measures (e.g., sunscreen, wearing a hat, covering up, or staying in the shade) are widely known among outdoor bath attendants and life guards, they are not always practiced (Geller et al. 2001; Hall et al. 2009). Symmetric erythematous linear plaques on the palms of young swimmers were named "pool palms" and were suggested to be caused by rubbing the palms on rough pool wall and floor surfaces while swimming (Blauvelt et al. 1992).

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