

Sensitivity to chemical disinfectants: studies in humans

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The aim of the study was to evaluate chemical disinfectants in the working environment, the use of personal protective means and the sensitiveness to chemical disinfectants of medical staff handling chemical disinfection materials at the hospitals. Studies were conducted in nine hospitals of Vilnius. Studies regarding sensitiveness to disinfecting materials were performed with 314 volunteer medical employees who had been working with chemical disinfecting materials for six months at least. All the study participants were patch-tested with disinfecting materials and were questioned for the use of personal protective means. The study showed that when disinfecting and 20–30 minutes after the disinfection the concentrations of disinfectants (except ethyl alcohol) exceeded the maximum allowable concentrations in 29% of all measurements: isopropyl alcohol in 100%, hydrogen peroxide in 49%, glutaraldehyde in 18%, chlorine in 5% of all measurements. During the patch testing the prevalence of sensitiveness to the test chemical disinfectants reached up to 49.0% of cases. Positive allergic reactions were established for alkylamine compounds (47.1%), benzalkonium chloride (45.3%), ammonium compounds (32.0%), sodium perborate (25.5%), chlorhexidine (25.0%), glutaraldehyde (22.6%), sodium dichlorizocianurate (15.8%), hydrogen peroxide (13.9%) and chloramine (7.5%). When disinfecting, personal protective means were in different use: 84.1% of all employees tested always use rubber latex gloves, 45.9% protective face masks, 5.1% protective goggles, 2.6% respirators. This study showed that there were no significant differences in the prevalence rates of allergic reactions between permanent and not permanent users of protective gloves and masks.

Key words: chemical disinfectants, patch testing, sensitiveness, medical workers

INTRODUCTION

Chemicals as ecological factors of allergy are of great importance. Most of them are used in the different areas of human life. One of the problem is chemical disinfection in hospitals, which is performed to prevent the development of infections. There are various materials used for disinfection. To disinfect volatile organic compounds the active components of which are glutaraldehyde, chlorine and its compounds, hydrogen peroxide, ammonium compounds, alcohol, sodium perborate and alkylamine compounds are mostly used. Most chemical disinfection materials have a toxic-allergic effect and cause occupational injuries of skin and respiratory organs. One of the most effective active components of disinfecting materials is *glutaraldehyde*. Tests performed for employees having a contact with glutaric aldehyde in Denmark, Poland, Canada, Great Britain and USA revealed 3–44% of occupational skin diseases (contact

dermatitis, allergic contact dermatitis, etc.) and 12–13% allergic diseases (asthma, etc.), and the prevalence of symptoms was established (Hansen, 1983; Kiec-Swierczynska, 1995; Shaffer, Belsito, 2000; Kiec-Swierczynska, Krecisz, 2000a, 2000b; Di Stefano et al., 1998). During the skin patch testing, 10–14% of medical employees were diagnosed as being sensitive to glutaraldehyde. *Chlorine and its compounds* have a toxic effect on the nervous, respiratory and cardiovascular systems, cause irritating symptoms of eyes, the respiratory system, skin, allergic diseases of eyes (Bechgaard et al., 1985; Leroyer et al., 1999; Dijkman et al., 1981). Canadian scientists diagnosed a 19–46% prevalence of chronic rhinitis and chronic bronchitis for medical employees having a contact with chlorine compounds (Leroyer et al., 1999). According to the data reported from Denmark, Poland and the USA (Hansen, 1983; Kiec-Swierczynska, 1995; Shaffer, Belsito, 2000) 2–23% of employees were sensitive to benzalkonium chloride and chloro-

hexyldine. *Hydrogen peroxide* is characterized by a skin-irritating effect. Cases of diffusive injury and poisoning of lungs due to an occupational contact with hydrogen peroxide have been described (Kaelin et al., 1988; Izu et al., 2000). *Ammonium compounds* may cause injuries of respiratory organs and skin (Bernstein et al., 1994; Purofit et al., 2000). In Poland, 37% of medical employees in contact with ammonium compounds were diagnosed as having positive allergic reactions (Kiec-Swierczynska, Krecisz, 2000). *Ethyl alcohol* has an irritating and toxic effect. *Isopropyl alcohol* is more toxic than ethyl alcohol and shows a toxic, allergic and possible carcinogenic effect. During the experimental analyses due to isopropyl alcohol, excrescence of mouth cavity, nose sinuses, larynx, lympholeucosis and reticulosarcoma were diagnosed (Ludwig, Hansen, 1977). *Sodium perborate and alkylamines* most frequently cause injuries of the respiratory system and skin. In most foreign countries, of the employees' sensitiveness to chemical disinfection materials done is regularly analysed. The results of these analyses are used for planning precautionary and preventive measures for employees' health. Such tests in Lithuania had not been done, therefore, the aim of this study was to estimate the chemical factors of working environment, the use of personal protective means and the sensitiveness to chemical disinfectants of medical staff handling chemical disinfection materials at hospitals.

MATERIALS AND METHODS

The study was conducted in nine hospitals of the Vilnius city.

Investigations of air pollution were done in disinfection premises of the hospitals, taking single air samples before disinfecting, during disinfection, immediately after the disinfection and 20–30 min after the disinfection. The minimal, maximal and average concentrations were determined and compared with Maximum Allowable Concentrations set by the Lithuanian State Hygiene Norms. *Tests of sensitiveness to disinfecting materials* were done with 314 volunteer medical employees who had been working with chemical disinfecting materials for six months at least. A permission of Medical Ethic Committee of Lithuania was obtained. To evaluate the sensitivity to chemicals, patch tests were applied. They were performed and evaluated according to the requirements of the European Contact Dermatitis Group. Patch testing was used to determine sensitiveness to glutaraldehyde, chloroamine, chlorhexidine, sodium dichlorizocianurate, hydrogen peroxyde, benzalkonium chloride, sodium perborate, alkylamine compounds and halogenated quarter compounds of ammonium of three different concentrations (0.1%, 0.5%, 1.0%). The studied chemicals were put into Finn chambers and stuck on the forearm for 48 h. After 48 h the

samples were removed and read by measuring the infiltration and oedema. After allergic skin tests, there were either latent sensitiveness, contact urticaria or allergic contact dermatitis diagnosed. All the employees in contact with disinfecting materials were questioned for *the use of personal protective means (PPM)*. The questionnaire was filled in by interviewing an employee personally, with a consultation of a specially trained investigator. The findings of sensitiveness and the use of PPM were expressed by prevalence rates (%) with associated 95% confidence intervals (95% CI).

RESULTS

Before disinfection, the average concentrations of all pollutants did not exceed maximum allowable concentrations (MAC) and were significantly ($p < 0.05$) lower than when disinfecting and 20–30 min after disinfection. The highest average concentrations for glutaraldehyde were noted right after disinfection (3.74 mg/m^3), for hydrogen peroxide right after disinfection (3.34 mg/m^3), for chlorine 30 min after disinfection (0.51 mg/m^3), for isopropyl alcohol right after disinfection (124.3 mg/m^3), for ethyl alcohol during disinfection (288.2 mg/m^3). When disinfecting and 20–30 min after disinfection, the concentrations of chemical pollutants in the air of the working environment in 29% of all measurements exceeded MAC: for isopropyl alcohol in all cases, for hydrogen peroxide in 49%, glutaraldehyde in 18%, for chlorine in 5% of all cases. The established concentrations of ethyl alcohol did not exceed MAC. The noted prevalence of sensitiveness to the test chemical disinfectants amounted to 49.0%. Most persons sensitive to chemical disinfectants were aged under 25 years (62.2%), had 6–10 years of working experience (59.5%), nurses of general practice (51.4%), employees of operating theatres (51.4%), those using antihistamine medicines (87.5%; $p < 0.05$), smoking daily (56.7%), not allergic to disinfecting materials used at home (51.9%; $p < 0.05$) and having suffered from allergic diseases in childhood (66.7%) (Table 1).

The most common chemical allergens are presented in Table 2. In most cases, positive allergic reactions were established for alkylamine compounds (47.0%) and benzalkonium chloride (45.3%).

When disinfecting, 84.1% of all the employees tested always used rubber latex gloves, 45.9% used protective face masks, 5.1% protective goggles, 2.6% respirators. When disinfecting with different disinfecting materials, the frequency of the use of PPM was different but did not exceed 97.3% of persons using latex gloves and 70.3% of those using protective face masks. According to the type of reaction, latent sensitiveness which was more frequent than allergic contact dermatitis (8.3%; $p < 0.05$) and con-

Table 1. Characteristics of study participants

Characteristics	Tested to chemicals (n)	Persons positive to chemicals N (%)
All:	314	154(49.0)
Age group (years):		
< 25	37	23(62.2)
26–35	111	64(57.7)
36–45	101	47(46.5)
> 45	65	20(30.8)
Work seniority (years):		
< 2	14	7(50.0)
2–5	74	33(44.6)
6–10	89	53(59.5)
11–20	80	40(50.0)
> 20	57	21(36.8)
Work place:		
operating room	210	108(51.4)
clinical department	91	42(46.1)
laboratory	13	4(30.8)
Job title:		
GP nurse	207	108(52.2)
GP nurse assistant	100	46(46.0)
physician	7	–
Antihistamine medicines use:		
no	228	99(43.4)
yes	32	28(87.5)
seldom	54	27(50.0)
Smoking:		
never	175	88(50.3)
in the past	33	14(42.4)
every day	67	38(56.7)
seldom	39	14(35.9)
Allergy to chemicals:		
no	256	133(51.9)
yes	58	21(36.2)
Personal history of allergic diseases:		
no	308	150(48.7)
yes	6	4(66.7)

tact urticaria (3.2%; $p < 0.05$) prevailed (37.6%). The prevalence of latent sensitiveness, contact urticaria and allergic contact dermatitis for different disinfecting materials is presented in Table 3.

There were significant differences ($p < 0.05$) in the occurrence of allergic contact dermatitis and contact urticaria for those taking all protective measures.

The highest latent sensitiveness was determined for benzalkonium chloride, ammonium and alkylamine compounds, contact urticaria was mostly evoked by alkylamine compounds, glutaraldehyde and benzalkonium chloride, allergic contact dermatitis by benzalkonium chloride, chlorhexidine and alkylamine compounds. Cases of latent sensitiveness, allergic con-

tact dermatitis and contact urticaria were more frequent among those always using rubber latex gloves and protective face masks, with the exception of cases of contact urticaria which were more frequent among those medical employees who not always or never used gloves. No significant differences in the prevalence rates of allergic reactions between permanent and not permanent users of protective gloves and masks were established.

DISCUSSION

The study showed that disinfection with glutaraldehyde, hydrogen peroxide, chlorine, isopropyl and ethyl

Table 2. Most common disinfective chemical allergens

Chemical disinfectant	Tested persons, n	Positive reactions in persons, n (%)	95(%) CI
Alkylamine compounds	102	48(47.1)	37.1–57.2
Benzalkonium chloride	214	97(45.3)	38.5–52.2
Ammonium compounds	100	32(32.0)	23.0–42.1
Sodium perborate	149	38(25.5)	18.7–33.3
Chlorhexidine	20	5(25.0)	8.7–49.1
Glutaraldehyde	168	38(22.6)	16.5–29.7
Natrium dichlorizocianurate	101	16(15.8)	9.3–24.4
Hydrogen peroxyde	129	18(13.9)	8.5–21.1
Chloramine	60	8(7.5)	2.8–15.6

Table 3. Outcomes of patch testing in PPM users in comparison with non-PPM users

Type of outcomes	Tested persons	Positive persons	Prevalence (%)	95%CI
Latent sensibilisation				
All	314	118	37.6	32.2–43.2
PPGs	264	106	40.1	34.2–46.3
NPPGs	50	12	24.0	13.1–38.2
PPMs	144	58	40.3	32.2–48.8
NPPMs	170	60	35.3	28.1–43.0
Allergic contact dermatitis				
All	314	26	8.3*	5.5–11.9
PPGs	264	22	8.3	5.3–12.3
NPPGs	50	4	8.0	2.2–19.2
PPMs	144	15	10.4	5.9–16.6
NPPMs	170	11	6.5	3.3–11.3
Contact urticaria				
All	314	10	3.2*	1.5–5.8
PPGs	264	7	2.7	1.1–5.4
NPPGs	50	3	6.0	1.2–16.5
PPMs	144	7	4.9	2.0–9.8
NPPMs	170	3	1.8	0.4–5.1

PPGs – permanent protective glove users; NPPGs – not permanent protective glove users; PPMs – permanent protective mask users; NPPMs – not permanent protective mask users.

* $p < 0.05$ (versus latent sensitisation).

alcohol in the hospitals of Vilnius caused a big air pollution of working premises with active components of disinfecting materials. The MAC for glutaraldehyde when disinfecting was exceeded 1.3 times, for hydrogen peroxide 8–11 times. 20–30 min after disinfection the maximal concentrations of all the disinfecting agents tested (except ethyl alcohol) exceeded MAC. The average concentrations of isopropyl alcohol when disinfecting and after the disinfection exceeded MAC in 100% of the cases, hydrogen peroxide in 49%, glutaraldehyde 18%, chlorine in 5% of all the cases tested and were less than before the disinfection. Only the concentration of ethyl alcohol did not exceed the MAC. According to the data of the researchers from Great Britain, Finland and the USA (Di Stefano et al., 1998), occupational health injuries (asthma, etc.) may also be caused by consi-

derably higher exposures to disinfecting materials than national standards of most countries provide.

Working under such conditions the use of personal protective is obligatory. Meanwhile this study established that when disinfecting at the hospitals of Vilnius rubber latex gloves were used by 84.1%, protective face masks by 45.9%, and other personal protective means (protective goggles and respirators) were almost not used. The main reasons for such a situation are not effective internal control for personal safety requirements as well as insufficient provision of hospitals with personal protective means as a result of the financing problems of hospitals.

The patch testing showed 49.0% of the medical employees examined to be sensitive to chemical disinfection materials, in most cases to alkylamine

compounds and benzalkonium chloride and in least cases to chloramine and hydrogen peroxide. The main reasons of it are not yet really known, but it is expected that these are the allergenicity of these compounds and an exposure time. According to the reaction type, most frequent was latent sensitiveness (37.6%) which was reliably more frequent than allergic contact dermatitis (8.3%) and contact urticaria (3.2%). Benzalkonium chloride is noted in the scientific studies of other authors as one of the most frequent occupational allergens (Kiec-Swierczynska, Krecisz, 2000b; Rustemeyer et al., 1994). The prevalence of latent sensitiveness, allergic contact dermatitis and contact urticaria to alkylamine compounds respectively amounted to 15.7%; 4.9% and 1.9%, to benzalkonium chloride to 18.2%; 6.5% and 1.4%, to sodium perborate 8.7%; 1.3% and 0.7%, to glutaraldehyde 8.3%; 1.8% and 0.6%, to hydrogen peroxide 3.9%; 1.5% and 0.8%. Similar results were published in the recent scientific studies of foreign authors: the frequency of allergic reactions to benzalkonium chloride fluctuated between 7.1% and 23.8%, to glutaraldehyde between 10.8% and 17.6% (Shaffer, Belsito, 2000; Kiec-Swierczynska, Krecisz, 2000a). The results of the research showed that reliably more persons sensitive to disinfecting materials were among medical employees aged under 25 years (62.2%) and having 6–10 years of work experience (59.5%). These data are in agreement with studies of other authors (Hansen, 1983). This difference may be explained by insufficient occupational skills of younger employees, disregard of Labour Safety Requirements and lower education (no positive allergic reactions were determined for physicians).

The summarized results of the present research on the use of disinfecting materials at the hospitals of Vilnius could be regarded as an actual occupational health and safety problem. Basing on the results of this study, hospital administrators and medical personnel should be informed about the risks caused by disinfecting materials to health and the most actual problems of working with disinfecting materials. The preventive measures such as protective gloves and masks in our studies showed to be not effective. Similar data have been published in other countries (Kiec-Swierczynska, Krecisz, 2000a; Izu et al., 2000). For an effective prevention of occupational health injuries, new disinfecting methods will be suggested according to the example of Scandinavian countries using modern technologies and equipment for thermal disinfection instead of unhealthy chemical disinfection methods. Thus, chemical disinfection means are used temporarily, Labour Safety Standards must be strictly followed, proper personal protective means must be used, changes of the health state of medical personnel must be monitored, and working under exposure to chemical disinfecting materials

must be limited in the case of symptoms of allergic disease.

CONCLUSIONS

1. When disinfecting and 20–30 min after disinfection, the concentrations of the disinfectants tested (except ethyl alcohol) exceeded the maximum allowable concentrations on average in 29% of all measurements: isopropyl alcohol in 100%, hydrogen peroxide in 49%, glutaraldehyde in 18%, chlorine in 5% of all measurements.

2. The noted prevalence of sensitiveness to the chemical disinfectants tested amounted to 49.0%. Positive allergic reactions were established for alkylamine compounds (47.1%), benzalkonium chloride (45.3%), ammonium compounds (32.0%), sodium perborate (25.5%), chlorhexidine (25.0%), glutaraldehyde (22.6%), sodium dichlorizocyanurate (15.8%), hydrogen peroxide (13.9%) and chloramine (7.5%).

3. The most frequent allergic reaction to disinfectants was allergic contact dermatitis.

4. Disinfecting personal protective means were in different use: 84.1% of all the employees tested always used rubber latex gloves, 45.9% used protective face masks, 5.1% protective goggles, 2.6% respirators.

5. There were no significant differences in the prevalence rates of allergic reactions between permanent and not permanent users of protective gloves and masks.

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PMOGAUS ORGANIZMO JAUTRUMO CHEMINĖMS DEZINFEKCIJOS MEDPIAGOMS TYRIMAI

Santrauka

Ištirtas medicinos darbuotojų, dirbančių su dezinfekcinėmis medžiagomis, darbo aplinkos oro užterštumas, individualių apsaugos priemonių naudojimas ir jautrumas dezinfekavimo medžiagoms devyniose Vilniaus miesto ligoninėse. Alerginiai „odos lopo“ testai atlikti 314 savanorių, kurie buvo dirbę su cheminėmis dezinfekavimo medžiagomis ne trumpiau kaip 6 mėnesius. Tyrimo dalyviai apklausti dėl individualių apsaugos priemonių naudojimo. Nustatyta, kad dezinfekcijos metu ir praėjus 20–30 min. po jos tirtose teršalų koncentracijos darbo aplinkos ore 29% visose tirtose atvejose (išskyrus etilo alkoholi) buvo didesnės už maksimalias leistinas normas: izopropilo alkoholis – 100%, vandenilio peroksidas – 49%, glutaraldehidai – 18%, chloras – 5% visose tirtose atvejose. „Odos lopo“ tyrimais 49,0% tirtos medicinos darbuotojų nustatytas jautrumas cheminėms dezinfekavimo medžiagoms. Teigiamose alerginių reakcijų paplitimas alkilamino junginiams sudarė 47,1%, benzalkonio chloridui – 45,3%, halogenizuotiems ketvirtiniams amonio junginiams – 32,0%, natrio peroksoboratui – 25,5%, chlorheksidinui – 25,0%, glutaraldehidui – 22,6%, natrio dichlorozocianuratui – 15,8%, vandenilio peroksidui – 13,9%, chloraminui – 7,5%. Individualiai apklausus nustatyta, kad 84,1% tirtos medicinos darbuotojų dezinfekcijos metu naudoja apsaugines pirštines, 45,9% – veido kaukes, 5,1% – apsauginius akinius, 2,6% – respiratorius. Statistiškai patikimų alerginių reakcijų paplitimo skirtumų tarp medicinos darbuotojų, nuolat ir ne visada naudojančių apsaugines pirštines ir veido kaukes, šiuo tyrimu nenustatyta.

Raktažodžiai: cheminės dezinfekavimo medžiagos, „odos lopo“ mėginiai, alerginės reakcijos, medicinos darbuotojai