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Prevalence of irritative symptoms in indoor swimming pool workers

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Synopsis

The aim of this cross-sectional study was to investigate the prevalence of self-reported respiratory, ocular and cutaneous symptoms in subjects working in indoor swimming pools of the Emilia Romagna Region in order to assess associations between health effects and the presence of DBPs. A questionnaire was drawn up to record information on health status and DBPs were evaluated in pool water, in environmental and alveolar air samples, collected from 133 subjects. The most prevalent self-reported health symptoms from workers with alveolar air values of THMs over 20.8 µg/m^3 (median value) were red eyes (68.4%), itchy eyes (57.9%), and nasal obstruction (56.1%). Asthma symptoms were reported by 10 subjects only, and of these, 8 had concentrations of THMs in the alveolar air higher than 20.8 µg/m^3. The majority of the other symptoms were reported with high frequency by the subjects that were most exposed, but the difference was not statistically significant. With regard to self-reported symptoms of cutaneous diseases, the frequency of verrucas, mycosis, eczema and rash was analysed only in pool attendants, who usually wear pool shoes in their working activities. Pool attendants experienced more mycosis than others workers employed in swimming pools.

Background

In recent years more attention has been paid to possible health risks associated with attending indoor swimming pools. In fact, in these environments chemical substances present in the water and air and microclimate parameters can influence the health and well-being of subjects attending indoor swimming pools, both because they are employed there (trainers, lifeguards and facility operators) and because they carry out sports or recreational activities.

With regard to chemical risk, it is well known that water disinfection treatment with chlorine and related compounds can cause a lot of Disinfection By-Products (DBPs) many of which are potentially dangerous for human health. Trihalomethanes (THMs), such as chloroform, dichlorobromomethane, dibromochloromethane and bromoform, are the most studied ones and are considered as an index of the total amount of halogenated DBPs exposure. The presence of THMs in pool water is well documented and the THMs levels in water vary as a consequence of the concentration of precursor compounds, disinfectant dose, residual disinfectant level, temperature and pH. Other disinfection by-products, such as bromate, chlorite, chlorate, halogenated acetic acids (HAAs), are well identified in drinking water, while information about their presence in pool water is limited and needs to be investigated more thoroughly, as many of these substances are potentially dangerous for human health.

Since many DBPs are volatile, they can be found in swimming pool environments. THMs in indoor air have been investigated and their concentrations vary widely, depending on the THMs present in water, air temperature, and, above all, the number of swimmers inside the pool who move the water. Subjects working inside indoor swimming pools can be exposed to these substances at concentrations that can reach high levels: although the most prevalent way of intake is inhalation, ingestion and dermal contact may be also considerable among subjects working inside the pool as trainers or hydrotherapists.

Epidemiological studies report unusually high rates of ocular and respiratory symptoms in subjects working inside swimming pools, especially lifeguards: recent studies suggest that environmental exposure to DBPs, particularly volatile chloramine, may be associated with irritative symptoms, respiratory distress, and exacerbation of pre-existing respiratory symptoms in indoor swimming pool workers and also in swimmers, especially children. Moreover, in subjects working inside indoor swimming pools such as hydrotherapists, a high frequency of contact dermatitis was recently evidenced.

To estimate the exposure of pool workers to DBPs is a difficult task. The majority of studies addressed this exposure by environmental monitoring, which makes it possible to measure the concentrations of the DBPs in water and air samples in indoor swimming pools, but it does not take into account the variability of the concentrations and, most of all, the factors that can influence the related intakes by the workers.

Biological monitoring is a more suitable procedure for investigating occupational exposure to DBPs, even though few epidemiological studies have been carried out in this field. Alveolar air sampling represents a suitable framework for studying workers' exposure to the volatile substances present in indoor swimming pools. Studies carried out in Italy on subjects working in these environments evidenced a good correlation between the exposure to THMs measured by breath analysis and the environmental concentrations of THMs in indoor swimming pools, suggesting that this biological matrix can be used for the evaluation of the intake of these substances.

Microclimate parameters (dry and radiant air temperature, air speed, relative humidity) can also influence wellness and health status of people working inside swimming pools for long periods of time. Air humidity, temperature and ventilation may be considered causes of respiratory discomfort and risk factors of respiratory disease.

Results

In this cross-sectional study, 20 indoor swimming pools of the Emilia Romagna Region (northern Italy) were investigated in order to evaluate the prevalence of self-reported respiratory, ocular and cutaneous symptoms in subjects working inside indoor swimming pools and to assess associations between health effects and some indoor swimming pools characteristics such as microclimate parameters and the presence of DBPs.

During each sampling session, subjects working inside the swimming pools were asked to participate in the study and as a result, 133 subjects were enrolled on voluntary basis. A questionnaire was drawn up to record information on health status and work conditions inside the swimming pools and then administered to the workers who volunteered for the study. The questionnaire was divided into three sections: the first section recorded personal information about

the subjects (age, sex, weight, height, job, number of working hours by day and week, previous or parallel jobs, hobbies involving solvent use, smoking habits and medical history – asthma, chronic bronchitis, drugs assumption). The second section was related to the assessment of thermal conditions at work. Information on working clothing (underwear, swimsuit, shirt, sweatshirt, long/short sleeved t-shirt, etc.) and water and air perceived temperature and humidity, was also recorded. The third section collected information on the frequency (sometimes, often, never) of self-reported symptoms related to the respiratory, ocular and cutaneous apparatus.

We gathered information about the pool plants, such as the year of construction and renovation, the size of the baths and the related water volumes and air recycles. Information about water treatment and disinfection procedures was collected, too. All the sampling sessions were carried out during the winter period with closed windows. During each session, environmental air and water samples were collected and physical parameters (air temperature, air speed, relative humidity and illumination levels) were evaluated. Alveolar air samples were also collected from 115 subjects working inside the swimming pool.

In pool water samples, temperature, pH, cyanuric acid, residual combined and free chlorine were analysed and, among DBPs, THMs, bromate, chlorite, chlorate and halogenated acetic acids were evaluated. Only THMs were investigated in the environmental and alveolar air samples.
According to the present study, most of the pool workers were females (52.6%), with a mean age of 33 ys, non smokers (48.9%), and had worked in swimming pools for an average of 8 years: no statistical differences were observed between males and females. According to the questionnaire, 50% of the subjects had attended indoor swimming pools for more than 20 years, mainly as swimmers.

With regard to physical and chemical parameters, the following results were obtained: an illumination mean level of 760 ± 602 lux; air temperature values from 24°C to 30 °C; relative humidity over 70% in 7 out of the 20 indoor swimming pools. Water temperature ranged from 27°C to 29°C, while pH was 7.3 ± 0,2. Data on residual free and combined chlorine ranged from 0.7 to 2.0 mg/l and from 0.09 to 0.92 mg/l, respectively. Only 5 indoor swimming pools (25%) showed a residual combined chlorine value lower than 0.4 mg/l, the recommended value in the Italian guidelines. With regard to disinfection practices, 11 swimming pools (55%) were disinfected by both *sodium or calcium* hypochlorite and chloroisocyanurate compounds, 4 were disinfected only by sodium or calcium hypochlorite and 5 by chloroisocyanurate compounds. More than 50% of the swimming pools used algicides, pH adjusters and flocculants.

Table 1 shows the DBPs concentrations observed in pool water samples. Chloroform, dichloro-bromomethane, dibromochloromethane were measured at detectable levels in all the investigated pool waters, while bromoform was found in 6 swimming pools only. The mean value of THMs in water samples was 41.4 ± 30.0 µg/l and chloroform, the most prevalent DBP, showed a mean value of 32.8 ± 29.1 µg/l. The presence of bromates, chlorites, chlorates and HAAs was investigated in 16 indoor swimming pools, only. With regard to HAAs, mono, di and tribromoacetic acids were never found inside the pool waters while mono, di and trichloroacetic acids were detected in 7 (44%), 12 (75%) and 14 (87%) indoor swimming pools, respectively. Chlorites were observed at detectable levels in one indoor swimming pool only, at a concentration of 22 µg/l, while bromates were detected in 3 swimming pools (23 ± 21 µg/l). High chlorate values in water were observed in all the investigated pools (4717 ± 5758 µg/l), with a maximum value of 19.537 µg/l.

In table 2 THMs levels in environmental and biological samples are reported in the different areas inside the swimming pools: no environmental air samples were collected in the offices and engine rooms. The mean value of THMs in the poolside environments was 81.1 ± 45.5 µg/m^3 while lower values were observed in the café (34.7 ± 29.3 µg/m^3) and in the reception area (30.0 ± 29.9 µg/m^3): the difference between the groups was statistically significant.

Pool attendants showed the highest mean value of THMs in alveolar air samples, while subjects working in the café area, office and engine rooms showed lower levels.
THMs in alveolar air samples and the correspondent values in ambient air were highly correlated (r = 0.672; p = 0.000).

With regard to comfort/discomfort of conditions inside the swimming pools, 65 (48.9%) employees reported comfortable air temperature conditions, 94 (70.7%) considered the temperature of the water inside the pools comfortable, while 83 (62.4%) subjects considered the humidity inside the pool environments very high. According to microclimate parameters, the Predicted Mean Vote (PMV) showed generally acceptable thermal conditions, tending towards warm (vote= 0.6 $\pm$ 0.6**),** and the Predicted Percentage of Dissatisfied (PPD%) among workers was 19.8%.

In figure 1 the prevalence of irritative and other respiratory symptoms, asthma-related symptoms and ocular symptoms is reported according to the median value of THMs observed in alveolar air samples taken from 115 workers. The most prevalent self-reported health symptoms from workers with alveolar air values of THMs over 20.8 µg/m^3 (median value) were red eyes (68.4%), cold occurrence (66.7%), itchy eyes (57.9%), nasal obstruction (56.1%), sneezing (47.4%): red eyes, itchy eyes and nasal obstruction only showed a statistically significant difference. Symptoms relative to the presence of asthma were reported by 10 subjects out of the 115 who participated in the biological monitoring: 8 of them had concentrations of THMs in the alveolar air of over 20.8 µg/m^3. The majority of the other symptoms were more frequent in the most exposed subjects, but the difference was not statistically significant.

With regard to self-reported symptoms of cutaneous diseases, the frequency of verrucas, mycosis, eczema and rash was analysed in pool attendants who usually wear pool shoes in their working activities. Pool attendants experienced generally more verrucas, mycosis eczema and rash than others workers in swimming pools and the difference of self-declared mycosis frequency was statistically significant (p=0.013).

Conclusions

In this study the presence of DBPs in indoor swimming pool waters are confirmed. THMs, found in all the investigated pools, prove to be the most frequently DBPs in pool waters: the observed concentrations confirm the results of other authors in similar studies. Other DBPs are also found in pool waters samples such as chlorinated HAAs, mainly as trichloroacetic acids, while compounds derived from bromine were never observed at detectable levels. The presence of chlorites and bromates was limited, while chlorates were found in all the pools, and concentrations were sometimes very high. The presence of these compounds in the waters, rather than a true disinfection by-product, can be considered a consequence of the use of hypochlorite as a disinfecting agent: the chlorates are contained as impurities. There are no studies in the literature on the presence of these compounds in pool waters and on the possible effects on subjects exposed to them, and therefore further investigation is necessary.

With regard to the THMs in the various ambients of the swimming pools, we confirmed the different conditions of exposure in the different areas: high at the poolside, low in the café and reception area. On the whole, environmental levels of THMs measured inside the swimming pools are generally low, in agreement with previous data, but the concentrations vary, according to where they are measured. The concentrations vary widely: poolside environments show values of THMs that are approximately double those in the other investigated areas.

Indoor swimming pool employees have different jobs; the highest exposure level is linked to poolside trainers who inhale the THMs released into the air from the pool water after chlorination. In pool attendants, the mean value of THMs in alveolar air samples was higher than in subjects working in other areas, confirming that different environmental exposure inside the swimming pool can induce a different internal dose in occupationally-exposed workers. The significant correlation between ambient and alveolar air samples confirm that breath analysis can be considered a good biological indicator of occupational exposure to low levels of THMs.

Subjects with above average levels of THMs in alveolar air claimed a frequency of asthmatic symptoms higher than subjects that were less exposed, and this fact confirms the observations of previous epidemiological investigations. Moreover, even though our study does not include hydrotherapists as a professional category, we nevertheless observed a general increase in symptoms of the cutaneous apparatus in pools attendants, together with a significantly higher frequency of mycosis, and this fact also confirms what is stated in literature.

It is worth studying all possible measures that should be adopted to reduce exposure as far as possible. Preventive measures such as alternative disinfection methods, increased water recycling and increased ventilation could reduce exposure. Technology should therefore be directed at reducing the generation of THMs during the chlorination process and at controlling their concentrations in the ambient air, as disinfection is unquestionably the most important step in the treatment of water for public supply and, at the moment, chlorination is the most feasible method.

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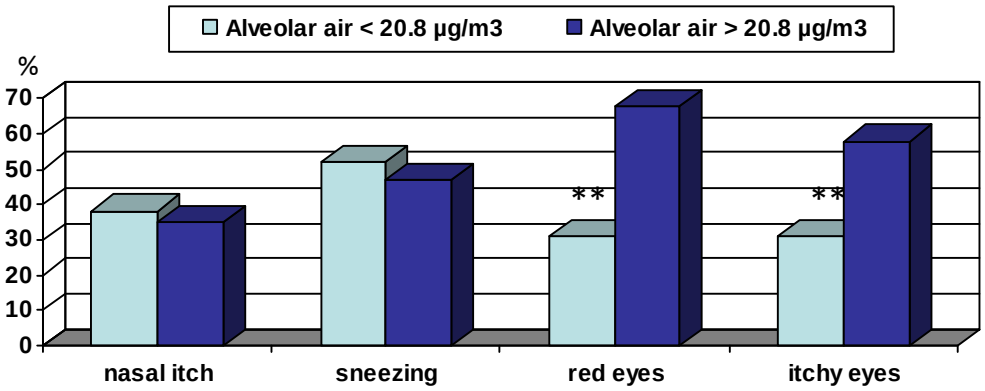
Table 1. DBPs in indoor swimming pool waters of the Emilia Romagna Region.

	Pool water			Tap water		
Parameters	Positive samples %	Mean + SD	Min-Max	Positive samples %	Mean + SD	Min-Max
Total THMs (µg/l)	20/20 (100%)	41.4 ± 30.0	6.8 – 134.0	10/20	4.8 ± 1.5	0.5-13.5
Chloroform (µg/l)	20/20 (100%)	32.8 ± 29.1	2.5 - 122	10/20	2.8±3.4	0.1-9.5
Dichlorobromomethane (µg/l)	20/20 (100%)	5.7 ± 5.4	1.4 – 18.3	9/20	1.3±1.3	0.1-3.5
Dibromochloromethane (µg/l)	20/20 (100%)	2.4 ± 3.4	0.2 – 11.7	7/20	0.8±1.2	0.2-3.5
Bromoform (µg/l)	6/20 (30%)	1.4 ± 1.5	0.1 – 3.6	2/20	1.1±1.2	0.2-1.9
Total HAAs (µg/l)	16/16 (100%)	170± 122	11 – 403	3/20	9.7±9.9	3.0-21.0
Monochloroacetic acid (µg/l)	7/16 (44%)	21 ± 22	2 – 65	-	-	-
Dichloroacetic acid (µg/l)	12/16 (75%)	67 ± 85	9 – 291	1/20		3.0
Trichloroacetic acid (µg/l)	14/16 (87%)	126± 98	37 – 403	2/20		5.0-21.0
Monobromoacetic acid (µg/l)	0/16 (0%)	-	-	-	-	-
Dibromoacetic acid (µg/l)	0/16 (0%)	-	-	-	-	-
Tribromoacetic acid (µg/l)	0/16 (0%)	-	-	-	-	-
Chlorites (µg/l)	1/16 (6%)	22	-	15/16	182 ± 134	65-441
Bromates (µg/l)	3/16 (19%)	23 ± 21	10 - 48	-	-	-
Free chlorine (mg/l)	20/20 (100%)	1,3 ± 0,3	-	-	-	-
Combined chlorine (mg/l)	20/20 (100%)	0,5 ± 0,2	-	-	-	-
Chlorates (µg/l)	16/16 (100%)	4717 ± 5758	5 – 19537	20/20	107 ± 136	2-499

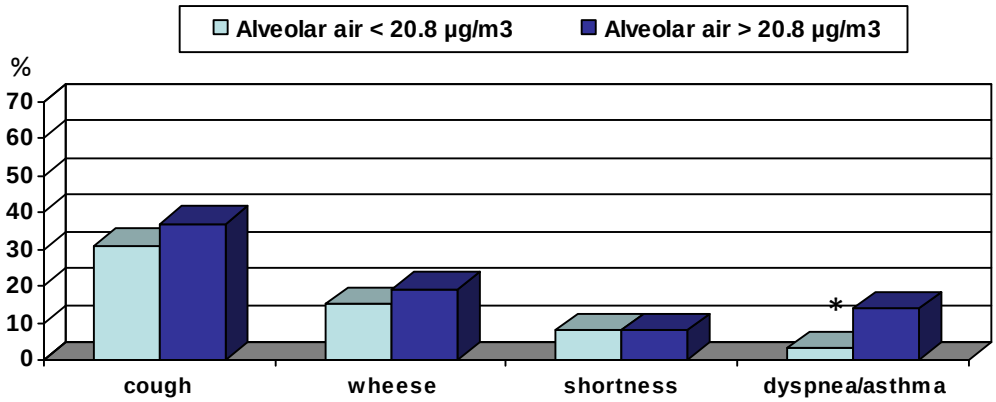
Table 2 THMs environmental and biological values in the investigated areas in indoor swimming pools.

	THMs in ambient air μg/m^3		THMs in alveolar air μg/m^3		
	n. samples	Mean ± SD	n. samples	Mean ± SD	Range
Poolside	20	81.1 ± 45.5	72	28.5 ± 20.2	1.0 – 123.0
Cafè	8	34.7 ± 29.3	9	17.6 ± 12.1	2.8 – 32.5
Reception area	18	30.0 ± 29.9	16	14.4 ± 12.0	0.1 - 37.0
Office	-	-	9	15.6 ± 10.6	3.3 – 35.3
Jolly	-	-	4	13.0 ± 4.6	7.9 - 19.0
Engine room	-	-	5	13.6 ± 4.4	9.6 - 19.7

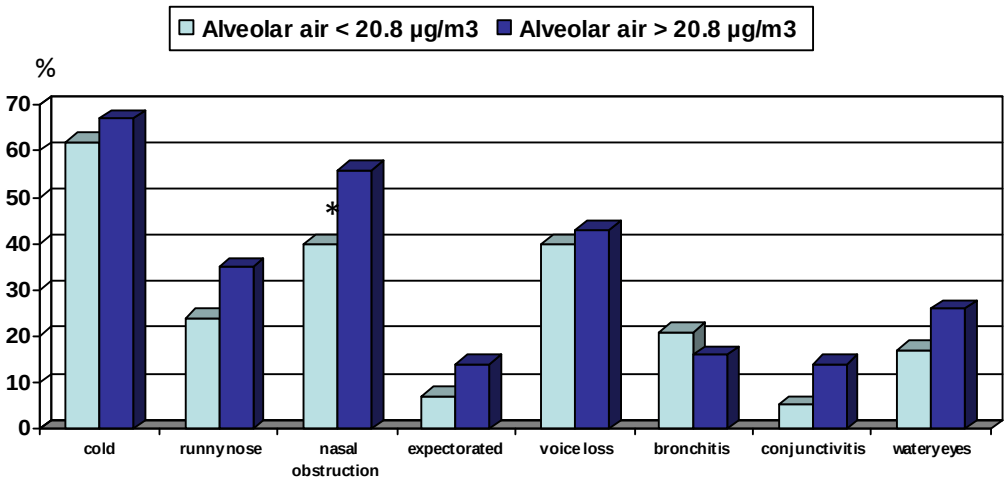
Figure 1 Prevalence of irritative and other respiratory symptoms, asthma-related symptoms, ocular symptoms, is reported according to the median THMs value observed in alveolar air samples collected from 115 subjects working inside the investigated indoor swimming pools.



** p < 0.001



* p < 0.05



* p < 0.05

Table 6 Self-reported symptoms of cutaneous diseases in pool attendants.