

Chlorinated swimming pools and respiratory health

For over a century, swimming pool water has been chlorinated to protect health by controlling harmful microbes that might transmit infection. For some time, however, it has been suggested that in some circumstances there might also be some adverse effects on respiratory health of swimmers and pool workers.

These suggestions have arisen partly through scientists searching for factors that might be contributing to the rise in allergies seen in recent decades, including allergic asthma. Some studies have reported statistical associations for example between frequency of pool attendance as a child, or being an elite swimmer and an increased likelihood of having respiratory problems. Other studies, however, found no correlation.

It is known that the 'active chlorine' in the pool water can react with organic matter introduced to the pool by swimmers in the form of sweat, natural body oils or urine, for example, to form volatile chloramines. These compounds can make the eyes sting and at high levels can irritate the respiratory tract. The presence of high levels of chloramines causes a 'chlorine smell' and is an indication that the pool is not properly managed; this may also be a sign that disinfection is compromised. Proper pool maintenance, ventilation, swimmer hygiene and chlorination are critical to optimise disinfection and minimise the presence of chloramines.

What kinds of effects on respiratory health are being investigated?

Most studies are aimed at understanding whether swimming brings some increased risk of having 'asthma' which is a chronic inflammatory disorder of the airways. The inflammation causes an increase in hyper-responsiveness of the airways which leads to recurrent episodes of wheezing, breathlessness, chest tightness and coughing. In some people asthma is an allergic condition (i.e. caused and/or triggered by exposure to allergens), whereas in other people allergy is not involved.

Asthma is not a clearly defined condition for which there is one simple diagnostic test. Diagnosis by physicians can thus be variable, and is often difficult in young children. Consequently, studies tend to look at a range of symptoms such as wheezing, breathing difficulties, bronchial hyper-responsiveness and lung function measurements as well as allergic sensitisation, and often do not draw direct conclusions about asthma.

Is there consensus about a link between chlorinated pools and asthma?

Several studies report statistical associations suggesting a link between frequency of swimming and the risk of having asthma or a similar respiratory condition. However, these studies rarely show a conclusive link, and there are also other studies which suggest there is no link. Importantly, studies consistently find no correlation between swimming and the atopic status of the individual (i.e. swimming is not linked to the rise in allergies generally).

Studies conducted to date often suffer from a lack of robustness and consistency in criteria used to identify cases of asthma. They may also use crude parameters to assess exposure, such as reported or recalled frequency of pool attendance, with little or no measurement of substances or other agents to which swimmers are being exposed.

Several studies have therefore tried to identify 'biomarkers' that may help characterize cases of asthma and more accurately distinguish 'cases' from other subjects in studies. While some early

candidates have given misleading results, this remains an interesting area for future research.

The suggestion that respiratory problems could arise from the very low levels of known irritants such as chloramines normally present in pool air is also speculative. While exposure to high levels of such irritants can clearly cause problems such as Reactive Airways Dysfunction Syndrome (RADS), the idea that similar conditions might be caused by frequent exposure at very low levels is conjecture that has not yet been consistently proven.

Whilst attention has so far focused on chloramines and other disinfection by-products (DBPs), there are many other substances and biological agents (such as fungi, viruses and bacteria) present in the pool environment that can, in some circumstances, also cause respiratory problems. If it were ultimately proven that frequent pool attendance increased the risk of asthma, there should then be a wide range of agents that would need to be investigated as possible causes.

Are children potentially more vulnerable to respiratory problems from swimming?

If exposure during swimming can cause respiratory problems such as asthma, children might be more vulnerable due to their respiratory systems. The levels of exposure that might affect a child would probably be less, and infants and young children may be more vulnerable because their respiratory organs and immune systems are still developing. However, a systematic 'meta-analysis' that took into account robust studies found overall no statistically significant association between asthma and swimming in childhood. Swimming remains a recommended form of exercise for asthmatic children because their breathing is less affected by exercising in warm, moist air. Children are also more vulnerable to respiratory infections that might be transmitted in indoor environments; these can produce wheezing and in young children may lead to asthma in later years.

Are competitive swimmers more at risk of asthma?

Some elite athletes, particularly those engaged in endurance events or sport in cold atmospheres (e.g. cross-country skiers) have a greater prevalence of asthma-related symptoms, possibly reflecting very high breathing rates in harsh atmospheres. There is also increased prevalence among swimmers though this could reflect asthmatic elite athletes choosing swimming because the environ-

ment is less likely to induce symptoms. However, limited studies suggest asthma-related symptoms are not more prevalent among adolescent elite swimmers, even after years of recreational and competitive swimming. If symptoms develop in adulthood after many years of intense swimming it would be necessary to establish whether pools present additional contributory factors, what those are and how they may be eliminated.

Are non-chlorinated pools safer?

It is not yet clear whether use of swimming pools increases the risk of asthma or not. It is thus not possible to say whether non-chlorinated pools are safer. The great majority of pools are disinfected by chlorination and no studies have yet systematically compared respiratory health problems between swimmers using non-chlorinated *versus* chlorinated pools. Whilst some studies have included swimmers using non-chlorinated pools, their findings are inconclusive about the relative impact on respiratory health. In considering alternative methods of disinfection, it must be remembered that the purpose of disinfection is to protect health by preventing infection transmission and these risks would need to be similarly compared before any significant conclusion could be drawn.

Are indoor pools likely to be a greater risk than outdoor pools?

If adverse effects on respiratory health of swimmers were arising from volatile by-products of chlorination, such as chloramines or trihalomethanes, levels in the air around indoor pools would often be higher than around open-air pools and this could give rise to increase the risk. However, if the air in the breathing zone immediately above the pool surface were the critical exposure, this may not be the case since higher levels of by-products can often be present in the water in outdoor pools.

What research is needed and being done on this topic?

In 2007, experts in respiratory health, environmental epidemiology, swimming pool operation, chemistry and analytical methods met to review the current science. They recommended a range of future research to help establish whether use of swimming pools can give rise to asthma, what the relevant agents are, and how they may best be controlled to eliminate such risks.

The recommendations included:

- Studies and development of methods to characterise and routinely measure relevant agents in pool environments, and show how levels vary with pool use and management. This should include both inorganic and organic chemical substances as well as biological agents, and should focus particularly on irritants and allergens.
- Toxicological studies to establish firm dose/response relationships for such agents.
- Models to describe and quantify exposure to such agents in relation to patterns of activity in the pool.
- Better epidemiological studies using the above measures, and including use of harmonised definitions of asthma and validated biomarkers where possible that can temporally relate exposure to subsequent development of asthma.

What is the view of regulatory and international bodies on the use of chlorine in swimming pools?

Chlorination, sometimes in conjunction with other technologies, is by far the most widely used means of disinfection for pools worldwide. It is supported by the World Health Organization (WHO) and other bodies such as the US National Swimming Pool Federation and CDC. The UK Pool Water Treatment Advisory Group has set guidelines for pool management and disinfection to ensure that people can gain the health benefits of swimming in safety. Minimum levels of active chlorine must be present, often by law, to ensure effective disinfection to prevent transmission of infection. As regards disinfection by-products, WHO considers that “the risks from exposure to chlorination by-products in reasonably well managed swimming pools would be considered small and must be set against benefits of aerobic exercise and risks in the absence of disinfection.”

Is there a safe level for chlorine used in swimming pool, and for its by-products?

WHO considers that adequate disinfection can generally be achieved with around 1 ppm (mg/l) free available chlorine (FAC) in the pool though up to 2 - 3 ppm may be needed in hot tubs for example because of higher temperatures and bather loads. Regulations in Europe generally set an FAC range for pools between 0.4 ppm and 1.4 ppm. If pools are ‘shock dosed’ with up to 20ppm for several hours to control problem organisms or situations,

WHO considers it safe for bathers to return when levels have fallen below 5 ppm.

WHO considers that combined chlorine (mainly chloramine by-products), in the pool water should be kept below half the FAC level to maintain bather comfort, notably freedom from eye irritation. As regards chloramines in the air, WHO has set a provisional guideline value of 0.5 mg/m³ expressed as trichloramine.

Assessments of DBPs and the safety of active chlorine (and all other pool disinfectants) are also a requirement under European biocides regulations.

What can we do to ensure any risk to respiratory health is minimised?

There are already regulations and guidelines in place to control the levels of active chlorine and by-products in pools. Good pool management, which includes good design, effective ventilation and proper user behaviour, seeks to minimise the levels of by-products in both the pool and the air to avoid problems such as eye irritation. If there is some increased risk of asthma from using pools it is not yet clear whether this is arising from well- or poorly-managed pools. When further studies have defined whether there is a risk, and what the critical agents are, it should be possible to eliminate the risk by managing pools appropriately to minimise exposure to those agents.

Further reading

Childhood Asthma and Environmental Exposures at Swimming Pools: State of the Science and Research Recommendations Weisel CP *et al.* 2008. *Environ Health Perspect*: doi:10.1289/ehp.11513. [Online 30 September 2008]

Asthma and swimming: a meta-analysis. Goodman M, Hays S. *J Asthma*. 2008 Oct;45(8):639-47

Guidelines for safe recreational water environments. Volume 2, Swimming pools and similar environments. World Health Organization 2006. ISBN 92 4 154680 8

Pool Management Guidelines: PWTAG Swimming Pool Water, Treatment & Quality Standards.

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