MATYJA, Mateusz, KOWALSKA, Marta, MAZUR, Anna, BRODZIAK, Julia, FOJCIK, Katarzyna, CISZEWSKA, Wiktoria, KOSZTYŁA-CZECH, Zofia, WIŚNIEWSKI, Tomasz and DWORAK, Michal. Rhinitis in Swimmers: A Clinical Issue at the Intersection of Sports Medicine and Otorhinolaryngology. Quality in Sport. 2025;47:66927. eISSN 2450-3118.
https://doi.org/10.12775/QS.2025.47.66927
https://apcz.umk.pl/QS/article/view/66927

The journal has been awarded 20 points in the parametric evaluation by the Ministry of Higher Education and Science of Poland. This is according to the Annex to the announcement of the Minister of Higher Education and Science dated 05.01.2024, No. 32553. The journal has a Unique Identifier: 201398. Scientific disciplines assigned: Economics and Finance (Field of Social Sciences); Management and Quality Sciences (Field of Social Sciences).
Punkty Ministerialne z 2019 - aktualny rok 20 punktów. Załącznik do komunikatu Ministra Szkolnictwa Wyższego i Nauki z dnia 05.01.2024 l.p. 32553. Posiada Unikatowy Identyfikator Czasopisma: 201398. Przypisane dyscypliny naukowe: Ekonomia i finanse (Dziedzina nauk społecznych); Nauki o zarządzaniu i jakości (Dziedzina nauk społecznych).
The authors declare that there is no conflict of interest regarding the publication of this paper.
Received: 27.11.2025. Revised: 06.12.2025. Accepted: 06.12.2025. Published: 06.12.2025.

Rhinitis in Swimmers: A Clinical Issue at the Intersection of Sports Medicine and Otorhinolaryngology

Mateusz Matyja [MM]

Wojewodzki Szpital Specjalistyczny nr 5 w Sosnowcu

Plac Medykow 1, 41-200, Sosnowiec

ORCID: https://orcid.org/0009-0001-8928-0170

E-mail: Matyja.Mateusz1@gmail.com

Marta Kowalska [MK]

Medical University of Silesia

Poniatowskiego 15, 40-055 Katowice

ORCID: https://orcid.org/0009-0001-1397-9102

E-mail: martaa.kowalska@yahoo.com

Anna Mazur [AM]

Medical University of Silesia

Poniatowskiego 15, 40-055 Katowice

ORCID: https://orcid.org/0009-0007-3433-4550

E-mail: ankat.mazur@gmail.com

Julia Brodziak [JB]
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
ORCID: https://orcid.org/0009-0000-3332-9919
E-mail: juliak.brodziak@gmail.com

Katarzyna Fojcik [KF]
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
ORCID: https://orcid.org/0009-0000-5249-8398
E-mail: kat.fojcik@gmail.com

Wiktoria Ciszewska [WC]
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
ORCID: https://orcid.org/0009-0008-9090-9715
E-mail: wiktoria.ciszewska@gmail.com

Zofia Kosztyła-Czech[ZKC]
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
ORCID: 0009-0001-0839-4476
E-mail: zkosztyla@gmail.com

Tomasz Wiśniewski [TW]
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
ORCID: https://orcid.org/0009-0001-7919-8309
E-mail: tomasz.wisniewski650@gmail.com

Michał Dworak [MD]
Medical University of Silesia
Poniatowskiego 15, 40-055 Katowice
ORCID: https://orcid.org/0009-0006-9771-0421
E-mail: dworakmichal98@gmail.com

Corresponding Author
Mateusz Matyja, E-mail: Matyja.Mateusz1@gmail.com

Abstract

Introduction: Chronic rhinitis impairs sleep quality, mood, and overall quality of life, which is critical in competitive athletes, for whom optimal respiratory function is a prerequisite for high physical performance. The prevalence of rhinitis in the athlete population is higher than in the general population, with the highest rates observed in swimmers and winter sports athletes. Training in a closed swimming pool provides specific exposure to water disinfection byproducts (chloramines, trichloramine, trihalomethanes), which can damage respiratory tract epithelium and lead to rhinitis.

Materials and methods: A review of selected literature in the PubMed database was conducted using the following keywords: 'rhinitis', 'swimmers', 'chlorinated water', "trichloramine", 'Disinfection byproducts.'

The development of rhinitis in swimmers is multifactorial. Contact with disinfection byproducts plays a role in the pathogenesis of swimmer's rhinitis, leading to irritation, increased epithelial permeability, and the development of mucosal hyperreactivity, which promotes the dominance of the non-allergic irritant rhinitis phenotype in competitive swimmers. A significant deterioration in quality of life has been demonstrated in swimmers with rhinitis, as assessed using validated scales, in particular the miniRQLQ. The review emphasises the role of chronic exposure to the swimming pool environment as a modifiable risk factor and indicates that limiting contact with irritants – through the use of swimming clips, optimising ventilation, and improving water quality – can lead to reduced symptom severity and partial reversibility of changes in the nasal mucosa. Attention was drawn to the significant heterogeneity in definitions

and diagnostic criteria in the literature, which makes it difficult to assess the disease's prevalence and mechanisms clearly.

Conclusions: Understanding the phenotypes and endotypes of rhinitis in swimmers is crucial for effective prevention and treatment. Multidisciplinary care should include otorhinolaryngologists and allergists, focusing on identifying the rhinitis phenotype and reducing exposure to disinfectants. Preventing swimmer's rhinitis can be achieved by using swimming nose clips and ensuring well-ventilated swimming pools. There's a pressing need to create consistent definitions in clinical settings, especially when it comes to non-allergic rhinitis (NAR). We need to ensure that NAR is included in research studies and conduct thorough observations to understand how changes might improve after reducing exposure to triggers. Additionally, we should dive deeper into the molecular mechanisms that lead to damage in the epithelial barrier. This will pave the way for developing targeted treatments and preventive measures that can really make a difference.

Keywords: swimmer's rhinitis; non-allergic rhinitis; water disinfection byproducts; quality of life; competitive sport

1. Introduction

Chronic rhinitis is a condition characterised by persistent inflammation of the nasal mucosa, leading to impaired sleep, mood, and overall quality of life. In competitive athletes, these disorders are significant because of their impact on breathing efficiency and on achieving high physical performance, for which optimal respiratory function is a key requirement (Bousquet et al., 2020). Athletes as a group show a high incidence of upper respiratory tract symptoms; in reviews, the incidence of rhinitis in this population is estimated at 27–74%, with the highest values observed in swimmers and winter sports athletes (Bougault et al., 2010). Training in indoor swimming pools involves specific exposure to irritants such as hypochlorite,

chloramines, trichloramine, and trihalomethanes, which can lead to epithelial damage and exacerbate rhinitis symptoms (Bernard et al., 2015; Kanikowska et al., 2018; Villanueva et al., 2015). This review aims to present the current state of knowledge on chronic rhinitis in competitive swimmers and, secondarily, in swimming pool workers, a professional group exposed to similar environmental conditions, in a practical way beneficial to athletes, coaches, and specialists interested in this issue.

2. Definitions and classification of rhinitis

Most clinical and epidemiological studies on rhinitis are based on its classic division into allergic and non-allergic forms:

– allergic rhinitis (AR) – is a type I hypersensitivity reaction, dependent on immunoglobulin E (IgE), occurring in the nasal mucosa in response to exposure to an allergen in a previously sensitised individual. (Bousquet, 2001; Wise et al., 2023)

– Non-allergic rhinitis (NAR) – is a chronic condition diagnosed by excluding other causes, such as CRSwNP, NARES, AERD, infectious rhinitis, anatomical defects, drug-induced rhinitis, adverse drug reactions, cerebrospinal fluid leakage, or pregnancy-related rhinitis. It is primarily characterised by nasal congestion and watery discharge, as well as postnasal drip (without reflux) and coughing. (Kaliner et al., 2009)

The definition of both entities varies considerably between authors and centres. A global review by Savouré et al. identified 156 definitions of rhinitis in the literature, which the authors grouped into categories: unspecified rhinitis, AR, and NAR, with additional subdivisions based on symptoms, medical diagnosis, and IgE/SPT tests (Savouré et al., 2022). This enormous heterogeneity translates directly into a wide range of frequency estimates – this problem is repeated in studies of swimmers and significantly hinders analysis.

3. Epidemiological data

In a systematic review of 13 studies by Surda et al., the prevalence of AR in athletes ranged from 21% to 56.5%, with NAR assessed in only one study (6%) (Surda et al., 2017). In an analysis by training environment, no increased incidence of rhinitis was found in athletes (land sports) compared to the general population. In contrast, in swimmers (water sports), the incidence of rhinitis (AR+NAR) was 40–74%, and in cross-country skiers (cold environment), it was 46% (Surda et al., 2017).

The 2018 study by Surda et al., involving 101 elite swimmers, 107 non-elite swimmers, 38 non-swimming athletes, and 50 control subjects who did not practise sport (Surda et al., 2018) showed the prevalence of rhinitis (according to the ISAAC questionnaire) at: 45% in elite swimmers, 31% in non-elite swimmers, 32% in non-swimming athletes, and 24% in the control group, which means a significantly higher incidence of rhinitis in elite swimmers compared to the control group (Surda et al., 2018). The incidence of AR was similar across groups (12–18%), whereas NAR was significantly more common in swimmers: 33% in the elite group and 22% in the non-elite group, compared with the control group and land athletes (Surda et al., 2018). Quality of life analysis (miniRQLQ) showed a significantly poorer overall quality of life and in most domains in swimmers compared to other groups, and the number of hours spent in the pool correlated with symptom severity and deterioration in quality of life (Surda et al., 2018).
In a study by Bougault et al., an intensive training season was associated with increased rhinitis symptoms and deterioration in RQLQ scores in competitive swimmers; after a 2-week break from training, RQLQ scores improved, highlighting the role of exposure to the pool environment (Bougault et al., 2010). Similarly, Gelardi et al. described the coexistence of allergic and non-allergic rhinitis in a group of swimmers, with a predominance of cytological features of neutrophilic inflammation and improvement of symptoms after 30 days of using swimming nose clips to limit mucosal contact with pool water (Gelardi et al., 2012).

4. Studies on rhinitis among swimming pool employees

Although the primary focus of this review is on swimmers, studies of swimming pool employees provide important insights into the impact of the swimming pool environment on the nose. In a study by Erkul et al., 27 indoor swimming pool employees were compared with 49 individuals from a control group; the group of employees showed a higher incidence of rhinitis symptoms, a higher number of epithelial cells and eosinophils in nasal swabs, and no difference in the frequency of positive skin tests, which can be interpreted as features of chronic mucosal irritation and mainly non-allergic inflammation (Erkul et al., 2014). Similar conclusions can be drawn from the study by Fornander et al., which found that swimming pool staff had elevated markers of inflammation in nasal washings (Fornander et al., 2012).
Reviews by Kanikowska et al. and Villanueva et al. emphasise that swimming pool employees (lifeguards, technical staff) complain more often than other occupational groups of sinusitis, sore throat, chronic cough, and symptoms of rhinitis, and some studies observe increased percentages of inflammatory cells in nasal cytology (Kanikowska et al., 2018; Villanueva et al.,

2015). At the same time, trichloramine concentrations in the air of most swimming pools are below WHO thresholds, and the results of epidemiological studies are inconclusive, suggesting a significant impact of local conditions (ventilation, pool load, water quality standards) (Villanueva et al., 2015).

5. The role of the chlorinated indoor swimming pool environment and rhinitis

Chlorination of water with sodium hypochlorite or chlorine gas leads to the formation of chloramines (including trichloramine) and organic compounds such as trihalomethanes and haloacetic acids, which accumulate just above the water surface and can irritate the skin, conjunctiva, and mucous membranes of the respiratory tract (Villanueva et al., 2015). These compounds are collectively defined as disinfection byproducts. Trichloramine is a volatile substance with a characteristic odour that most of us identify as the 'smell of a swimming pool'; at high concentrations, it causes a sharp cough, shortness of breath, and symptoms of nasal irritation (Villanueva et al., 2015).

Long-term, low-level exposure – typical for swimmers and swimming pool workers – can lead to damage to the epithelial barrier, increased permeability of the respiratory epithelium, chronic inflammation, and the development of bronchial hyperresponsiveness, asthma, and rhinitis, especially in children and competitive swimmers (Bernard et al., 2015; Kanikowska et al., 2018). However, it should be noted that some studies – including the prospective ALSPAC cohort analysed by Font-Ribera et al. and an extensive population-based cross-sectional study conducted by Jacobs et al. among 2,359 Dutch children aged 6–13 – did not confirm a significant increase in the risk of asthma or allergic symptoms in children attending swimming pools; in the ALSPAC cohort, swimming was associated with better lung function and a lower incidence of asthma, especially in children with previous airway obstruction, compared to their non-swimming peers (Jacobs et al., 2012; Font-Ribera et al., 2011).

Regarding rhinitis, cytological and clinical data in swimmers indicate that, in addition to the classic allergic form, a non-allergic irritant phenotype also plays an important role: neutrophilic rhinitis is frequently observed (Surda et al., 2018). In the study by Surda et al., the high prevalence of NAR in swimmers with a comparable prevalence of AR in other groups supports the hypothesis that chronic irritation of the mucosa, rather than an increased prevalence of sensitisation to environmental allergens, plays a key role in this population (Surda et al., 2018). Similar conclusions can be drawn from studies of swimming pool employees, who were found to have features of chronic rhinitis and an increased number of inflammatory cells in smears,

with no difference in the frequency of positive skin tests compared to the control group, which supports the toxic-irritating effect of the swimming pool environment (Erkul et al., 2014; Fornander et al., 2012). Surda et al. showed that in swimmers, the miniRQLQ score and symptom severity increase with the number of hours spent in the pool per week. Bougault showed that after stopping training (2 weeks), nasal symptoms decreased, further supporting the influence of exposure. Gelardi observed an improvement in symptoms after using a swimming nose clip in a group with neutrophilic inflammation.

6. Limitations of available studies

Analysis of the available literature reveals several recurring methodological and conceptual limitations, which significantly influence the interpretation and generalisability of findings concerning rhinitis in swimmers.

First, a major challenge is the heterogeneity of definitions used to classify rhinitis. Studies rely on various diagnostic approaches, including self-reported symptoms, physician diagnosis, ISAAC-based questionnaires, or the presence or absence of sensitisation confirmed by skin prick tests or serum IgE. These differences result in inconsistent classification of AR and NAR and often do not distinguish between acute viral symptoms and chronic inflammatory conditions, increasing the risk of misclassification bias.

Another limitation is the underrepresentation of non-allergic rhinitis (NAR) in epidemiological reports. Despite evidence indicating that NAR may constitute a substantial proportion of rhinitis cases in swimmers, most studies have historically focused on allergic mechanisms, likely due to the availability of allergy testing and traditional interest in IgE-mediated diseases. Consequently, irritant-induced phenotypes, including neutrophilic rhinitis, are insufficiently described, and their actual prevalence is likely underestimated. This limitation is particularly relevant in populations exposed to chlorination byproducts, where irritant-driven inflammation may predominate.

The predominance of cross-sectional designs is another significant constraint. Most data are derived from single-time-point assessments, which do not allow evaluation of seasonal fluctuations, training-cycle influences, or long-term changes in nasal mucosal function. Cross-sectional studies cannot determine causality or temporal relationships—thus, they cannot answer whether swimming triggers rhinitis, exacerbates pre-existing conditions, or merely unmasks subclinical mucosal susceptibility. Prospective cohort studies are rare, despite their

essential role in characterising the trajectory of symptoms across training seasons or competitive periods.

A further limitation is the insufficient integration of clinical phenotypes with biological endotypes, which not only hinders accurate identification of swimmer-specific rhinitis mechanisms, but may also reduce the long-term usefulness of these studies as classification systems for rhinitis evolve. Although selected studies incorporate nasal cytology or inflammatory markers, this remains the exception rather than the rule. This gap makes it difficult to distinguish between allergic and irritant-driven inflammation, or to identify mixed phenotypes, which are frequently reported in swimmers. The lack of biomarker-driven stratification may mask heterogeneity within study populations and limit the ability to define swimming-specific rhinitis endotypes. Finally, studies rarely consider environmental variability, including differences in water treatment protocols, pool ventilation systems, bather load, training intensity, and the chemical composition of byproducts across facilities. These factors vary substantially and may profoundly influence local exposure levels. Their omission limits the comparability of studies and may explain inconsistent epidemiological findings. Together, these limitations underscore the need for methodological standardisation in future research.

6. Summary

The literature indicates that rhinitis is common among swimmers, especially at the competitive level, and that the non-allergic phenotype is associated with exposure to pool water disinfection byproducts. In contrast, the prevalence of allergic rhinitis does not differ significantly from that of the general population .At the same time, the high heterogeneity of definitions and diagnostic methods makes it difficult to compare research results and accurately assess the real burden of rhinitis. Standardising definitions, accounting for contemporary concepts of phenotypes and endotypes, and better characterising environmental exposures should be a priority for future research on rhinitis in swimmers.

The authors also emphasise that, in addition to promoting strict hygiene protocols among pool users as a low-cost and potentially effective method of reducing the chemical burden of the pool environment, ensuring adequate ventilation within indoor pool facilities and encouraging the use of nose clips among swimmers may further decrease chronic mucosal exposure to irritant disinfection byproducts and help mitigate the development or persistence of rhinitis symptoms. However, further studies are required to confirm the efficacy of these preventive strategies.

Disclosure

Authors do not report any disclosures.

Author'scontribution:

Conceptualization: **[MM];[JB]**

Methodology: **[ZKC] [TW] [MD]**

Investigation: **[MM]; [MK]; [AM]; [JB]; [KF], [WC] [ZKC] [TW] [MD]**

Software: [**AM];[ZKC]**

Check: **[MM]; [MK]; [AM]; [JB]; [KF], [WC] [ZKC] [TW] [MD]**

Data Curation: **[MK];[JB]**

Project Administration: **[MM];[MK]**

Writing-Rough Preparation: **[MM]; [MK]; [AM]; [JB]; [KF], [WC] [ZKC] [TW] [MD]**

Formal Analysis: **[MM];[MK]; [AM];**

Editing: **[MM];[KF]; [ZKC] [TW]**

Resources:**[MM];[AM];[KF]**

Supervison:**[MK]; [MM];**

All authors have read and agreed with the published version of the manuscript.

Funding Statement:

This study did not receive special funding.

Institutional Review Board Statement:

Not Applicable

Informed Consent Statement:

Not Applicable.

Data Availability Statement:

Not Applicable.

Conflict of Interest:

The authors declare no conflict of interest.

AI.

AI (Grammarly and Deeply) was utilized for two specific purposes in this research. Text analysis of clinical reasoning narratives to identify linguistic patterns associated with specific logical fallacies. Assistance in refining the academic English language of the manuscript, ensuring clarity, consistency, and adherence to scientific writing standards. **AI** were used for additional linguistic refinement of the research manuscript, ensuring proper English grammar, style, and clarity in the presentation of results. It is important to emphasize that all AI tools were used strictly as assistive instruments under human supervision. The final interpretation of results, classification of errors, and conclusions were determined by human experts in clinical medicine and formal logic. The AI tools served primarily to enhance efficiency in data processing, pattern recognition, and linguistic refinement, rather than replacing human judgment in the analytical process.

References:

Bernard, A., Nickmilder, M., & Dumont, X. (2015). Chlorinated pool attendance, airway epithelium defects and the risks of allergic diseases in adolescents: Interrelationships revealed by circulating biomarkers. *Environmental research*, *140*, 119–126. https://doi.org/10.1016/j.envres.2015.03.034

Bousquet, J., Khaltaev, N., Cruz, A. A., Denburg, J., Fokkens, W. J., Togias, A., Zuberbier, T., Baena-Cagnani, C. E., Canonica, G. W., van Weel, C., Agache, I., Aït-Khaled, N., Bachert, C., Blaiss, M. S., Bonini, S., Boulet, L. P., Bousquet, P. J., Camargos, P., Carlsen, K. H., Chen, Y., … AllerGen (2008). Allergic Rhinitis and its Impact on Asthma (ARIA) 2008 update (in collaboration with the World Health Organization, GA(2)LEN and AllerGen). *Allergy*, *63 Suppl 86*, 8–160. https://doi.org/10.1111/j.1398-9995.2007.01620.x

Bousquet, J., Anto, J.M., Bachert, C. *et al.* Allergic rhinitis. *Nat Rev Dis Primers*6, 95 (2020). https://doi.org/10.1038/s41572-020-00227-0.

Bougault, V., Turmel, J., & Boulet, L. P. (2010). Effect of intense swimming training on rhinitis in high-level competitive swimmers. *Clinical and experimental allergy : journal of the British Society for Allergy and Clinical Immunology*, *40*(8), 1238–1246. https://doi.org/10.1111/j.1365-2222.2010.03551.x

Erkul, E., Yaz, A., Cıngı, C., İnançli, H. M., San, T., & Bal, C. (2014). Effects of indoor swimming pools on the nasal cytology of pool workers. *The Journal of laryngology and otology*, *128*(5), 442–446. https://doi.org/10.1017/S0022215114000784

Fornander, L., Ghafouri, B., Lindahl, M., & Graff, P. (2013). Airway irritation among indoor swimming pool personnel: trichloramine exposure, exhaled NO and protein profiling of nasal lavage fluids. *International archives of occupational and environmental health*, *86*(5), 571–580. https://doi.org/10.1007/s00420-012-0790-4

Gelardi, M., Ventura, M. T., Fiorella, R., Fiorella, M. L., Russo, C., Candreva, T., Carretta, A., & Passalacqua, G. (2012). Allergic and non-allergic rhinitis in swimmers: clinical and cytological aspects. *British journal of sports medicine*, *46*(1), 54–58. https://doi.org/10.1136/bjsm.2009.066456

Jacobs, J. H., Fuertes, E., Krop, E. J., Spithoven, J., Tromp, P., & Heederik, D. J. (2012). Swimming pool attendance and respiratory symptoms and allergies among Dutch children. *Occupational and environmental medicine*, *69*(11), 823–830. https://doi.org/10.1136/oemed-2011-100621

Kanikowska, A., Napiórkowska-Baran, K., Graczyk, M., & Kucharski, M. A. (2018). Influence of chlorinated water on the development of allergic diseases - An overview. *Annals of agricultural and environmental medicine : AAEM*, *25*(4), 651–655. https://doi.org/10.26444/aaem/79810

Kaliner, M. A., Baraniuk, J. N., Benninger, M., Bernstein, J. A., Lieberman, P., Meltzer, E. O., Naclerio, R. M., Settipane, R. A., & Farrar, J. R. (2009). Consensus Definition of Nonallergic Rhinopathy, Previously Referred to as Vasomotor Rhinitis, Nonallergic Rhinitis, and/or Idiopathic Rhinitis. *The World Allergy Organization journal*, *2*(6), 119–120. https://doi.org/10.1097/WOX.0b013e3181a8e15a

Kurowski, M., Jurczyk, J., Krysztofiak, H., & Kowalski, M. L. (2016). Exercise-induced respiratory symptoms and allergy in elite athletes: Allergy and Asthma in Polish Olympic Athletes (A(2)POLO) project within GA(2)LEN initiative. *The clinical respiratory journal*, *10*(2), 231–238. https://doi.org/10.1111/crj.12210

Papadopoulos NG, Guibas GV. Rhinitis Subtypes, Endotypes, and Definitions. Immunol Allergy Clin North Am. 2016 May;36(2):215-33. doi: 10.1016/j.iac.2015.12.001. Epub 2016 Feb 28. PMID: 27083098; PMCID: PMC7127043.

Wise, S. K., Damask, C., Roland, L. T., et al. (2023). International consensus statement on allergy and rhinology: Allergic rhinitis – 2023. International Forum of Allergy & Rhinology, 13, 293–859.

Savouré, M., Bousquet, J., Jaakkola, J. J. K., Jaakkola, M. S., Jacquemin, B., & Nadif, R. (2022). Worldwide prevalence of rhinitis in adults: A review of definitions and temporal evolution. *Clinical and translational allergy*, *12*(3), e12130. https://doi.org/10.1002/clt2.12130

Surda, P., Walker, A., Putala, M., & Siarnik, P. (2017). Prevalence of Rhinitis in Athletes: Systematic Review. *International journal of otolaryngology*, *2017*, 8098426. https://doi.org/10.1155/2017/8098426.

Surda, P., Putala, M., Siarnik, P., Walker, A., Bernic, A., & Fokkens, W. (2018). Rhinitis and its impact on quality of life in swimmers. *Allergy*, *73*(5), 1022–1031. https://doi.org/10.1111/all.13359

Villanueva, C. M., Cordier, S., Font-Ribera, L., Salas, L. A., & Levallois, P. (2015). Overview of Disinfection By-products and Associated Health Effects. *Current environmental health reports*, *2*(1), 107–115. https://doi.org/10.1007/s40572-014-0032-x

Font-Ribera, L., Villanueva, C. M., Nieuwenhuijsen, M. J., Zock, J. P., Kogevinas, M., & Henderson, J. (2011). Swimming pool attendance, asthma, allergies, and lung function in the Avon Longitudinal Study of Parents and Children cohort. *American journal of*

respiratory and critical care medicine, *183*(5), 582–588. https://doi.org/10.1164/rccm.201005-0761OC