




Determinants of bather hygiene in public swimming pools: a mixed-methods analysis of online discussion comments

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ABSTRACT

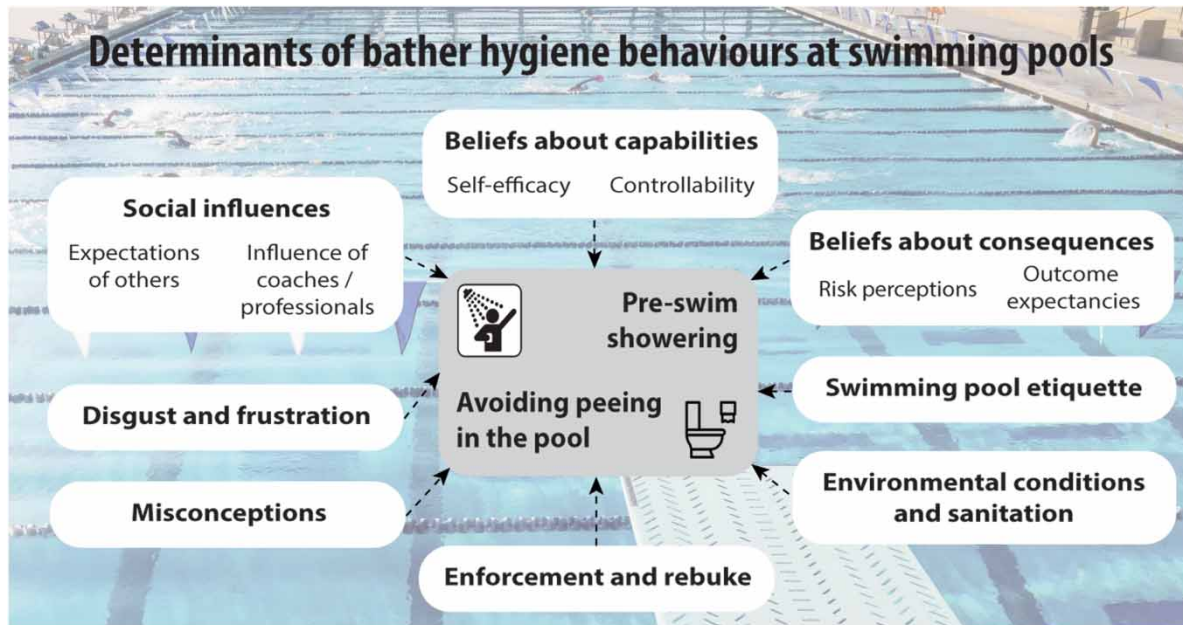
Swimming in public pools can expose bathers to microbiological (e.g., *Cryptosporidium*) and chemical (e.g., disinfection by-product) hazards, which can lead to recreational water illness. Adequate hygienic behaviours among bathers are important to reduce these risks. However, prior studies have found low compliance with pre-swim showering and avoidance of urinating in pools. We conducted a mixed-methods analysis of online discussion comments to identify key determinants of these two behaviours. We identified relevant discussion threads on Reddit, Quora, and swimming forums. Identified comments were classified as having a positive or negative sentiment towards the behaviour, and they were thematically analyzed according to the Theoretical Domains Framework (TDF). We analyzed 986 comments from 45 threads; 49.8% of comments were classified as expressing a positive sentiment towards the behaviour. Positive sentiments were more commonly expressed towards pre-swim showering compared to avoidance of urinating in pools (60.1 vs. 47.1%). Eleven themes were identified across the following eight TDF domains: beliefs about consequences ($n = 362$ comments), social influences ($n = 298$), beliefs about capabilities ($n = 240$), social/professional role and identity ($n = 144$), knowledge ($n = 138$), emotions ($n = 137$), reinforcement ($n = 78$), and environmental context and resources ($n = 33$). Results can help to inform targeted educational and outreach strategies with bathers to encourage increased adoption of hygienic behaviours.

Key words: mixed-methods, recreational water, shower, socio-behavioural research, swimmers, urine

HIGHLIGHTS

- Users in online forums have inconsistent beliefs towards hygienic behaviours in swimming pools.
- Positive beliefs were more commonly expressed towards pre-swim showering compared to avoiding urinating in pools.
- Behaviours were mostly influenced by expectations of other swimmers, outcome expectancies, and self-efficacy.
- Other important factors related to risk perceptions, etiquette, emotions, and misconceptions.

GRAPHICAL ABSTRACT



INTRODUCTION

Swimming in public pools can expose bathers to microbiological and chemical hazards. These exposures can result in acute recreational water illness (RWI), which has a significant public health burden. For example, in the United States (US), 208 outbreaks of RWI were reported from 2015 to 2019, causing 3,646 illnesses and 13 deaths (Hlavsa *et al.* 2021). The most common cause of these RWI outbreaks and cases was *Cryptosporidium* (49% of 155 outbreaks with a known aetiology) (Hlavsa *et al.* 2021). *Cryptosporidium* is a particular concern for swimming pools given that it is highly infectious, excreted by infected bathers in high numbers, and is extremely tolerant to the levels of chlorine used for disinfection (Ryan *et al.* 2017; Gharpure *et al.* 2019). Previous studies have found that faecal contamination of swimming pool filters is common, with 58% of 161 filter samples testing positive for *Escherichia coli* across 127 pools in the Atlanta area in 2012 (Murphy *et al.* 2018). In addition to proper pool management and operation, one of the most important ways to prevent cryptosporidiosis and other enteric illnesses associated with swimming pools is to encourage hygienic behaviours among bathers (Ryan *et al.* 2017; Murphy *et al.* 2018). This includes not swimming within 2 weeks of experiencing diarrhoea as well as taking a pre-swim cleansing shower to remove faecal matter.

Cleansing showers prior to entering a swimming pool are also important to remove body oils, lotions, sweat, dirt, and other organic materials (Keuten *et al.* 2012). These compounds, along with urine and sweat released in the pool, react with chlorine in the water to form disinfection by-products (DBPs) (Carter & Joll 2017; Yang *et al.* 2018). Common DBPs found in swimming pool environments include trihalomethanes, haloacetic acids, and chloramines (Carter & Joll 2017; Yang *et al.* 2018). Exposure to volatile DBPs, such as trichloramines and chloroforms, in swimming pools is associated with respiratory and ocular symptoms (e.g., eye and throat irritations, cough) (Bureau *et al.* 2017; Chiu *et al.* 2017). There is inconclusive evidence of an association between DBPs and chronic effects, such as asthma, among frequent pool users and staff (e.g., lifeguards) (Villanueva *et al.* 2015; Valeriani *et al.* 2017). Urea levels in pool water, primarily present in bathers' urine, are a major contributor to the formation of DBPs (De Laat *et al.* 2011). Therefore, encouraging bathers not to urinate in swimming pools is a key hygienic strategy to help prevent the formation of potentially harmful DBPs.

Previous surveys of bathers have found that they commonly report urinating in swimming pool waters and often do not take a cleansing shower before entering the pool. For example, a 2019 survey of US adults found that 40% reported urinating in a swimming pool as an adult and 48% reported not showering prior to swimming (Water Quality & Health Council 2019). Higher levels of compliance (65–78%) were found via bather surveys in Italy and Canada (Pasquarella *et al.* 2013, 2014; Gallè *et al.* 2016; Omisakin & Young 2021). However, many bathers were found to lack an understanding of the purpose

and recommended method of conducting a cleansing shower (i.e., ideally nude using warm water and soap) to ensure its effectiveness (Pasquarella *et al.* 2013, 2014; Gallè *et al.* 2016; Omisakin & Young 2021). Additional research is needed to understand the psychosocial factors related to bathers' hygienic behaviours in swimming pools (Carter & Joll 2017; Ryan *et al.* 2017).

Given that online forums and communities are increasingly used by the public to disseminate and communicate information about health-related behaviours (Zhao & Zhang 2017), we conducted a mixed-methods study to analyze user comments in online forums related to the topic of hygienic behaviours in swimming pools. The study's purpose was to determine the psychosocial and environmental factors guiding bathers' reported use and adoption of the following two specific hygienic behaviours: showering before swimming and avoiding urinating in swimming pools. Results can be used by public health professionals and the swimming pool industry to inform the development of targeted education materials and strategies to improve bather hygiene.

METHODS

Data collection process

Given their wide popularity among Internet users worldwide, we pre-selected the community-based websites Reddit and Quora to identify online discussions about swimming pool hygienic behaviours. Reddit contains thousands of different topic-specific communities called subreddits where users can post news articles, questions, and other content, which generate discussion among community members. Quora is a question-and-answer website where users post questions related to any topic, which are then answered by various other community members. We also searched for and identified swimming-specific discussion forums using iterative Google searches related to the behaviours of interest (e.g., 'shower before swimming discussion forum'). Using this approach, we identified relevant discussion forum threads from the following three different swimming-related forums: Marathon Swimmers Forum, the UK Swimming Forum, and the Slowtwitch Triathlon Forum.

To identify discussion threads relevant to our behaviours of interest, we conducted iterative searches within each of the forums using different search phrases (e.g., 'shower before swimming', 'pre-swim shower', 'pee in pool'). Within Reddit, we conducted searches across all subreddit communities as well as specifically within the 'swimming' community, which is dedicated to the discussion of recreational and competitive swimming. Within Quora, we also used the 'related questions' area beside each question to identify pertinent additional questions. Across all forums, we selected all relevant threads that contained at least one discussion comment.

For each relevant discussion thread identified, we recorded information on the post title, behaviour addressed (pre-swim showering or urinating in the pool), posting date, and forum source. We then reviewed all discussion comments within each thread and saved those that we considered to be relevant to a database for analysis. We considered relevant comments to be those that directly addressed the topic of discussion. Comments that were extraneous, insincere, or spam were excluded from consideration. For each relevant comment, we recorded the posting date and whether any external sources were referenced.

Data analysis

We conducted a mixed-methods analysis of the identified discussion comments (Fetters *et al.* 2013). The quantitative approach consisted of a content analysis to classify each comment as having a positive or negative sentiment towards the hygienic behaviour. Comments that supported and agreed with the importance and use of a pre-swim shower and the avoidance of urinating in swimming pool water were classified as positive, while those providing opposite views were classified as having a negative sentiment towards each behaviour. To minimize subjectivity in this process, two independent raters assessed and classified each comment. We descriptively tabulated the comment classifications and stratified them by the discussion threads' behaviour topic and forum source. χ^2 tests were used to assess statistical significance at the $P \leq 0.05$ level. We also tabulated and summarized the other recorded characteristics of the discussion threads and posts. Descriptive analysis was conducted in Stata IC 14.2 (StataCorp, College Station, TX, USA).

To determine the psychosocial factors guiding bathers' use and adoption of hygienic swimming behaviours, we conducted a qualitative thematic analysis of the discussion comments (Braun & Clarke 2006). This process was guided by the Theoretical Domains Framework (TDF), which consists of a comprehensive set of 14 different domains of psychosocial and environmental factors that influence health behaviours (Atkins *et al.* 2017). The TDF framework can be used to identify the key influences of a behaviour, which can guide the development of behaviour-change interventions (Atkins *et al.* 2017). Two

independent reviewers coded all comments into the most relevant TDF domains. Coding was reviewed after coding approximately 75–100 comments, and results were discussed to resolve disagreements and ensure consistent interpretation of content. Results were periodically reviewed thereafter. Once all comments were coded and merged across reviewers, content within each domain was reviewed and specific themes were developed (Atkins *et al.* 2017). Themes represent the underlying factors that influence bathers' use of the hygienic behaviours (Atkins *et al.* 2017). Qualitative analysis was conducted using NVivo 1.4 (QSR International, Chadstone, Victoria, Australia).

RESULTS

Quantitative analysis

A total of 45 threads were analyzed, containing 986 relevant comments that were analyzed. The number of relevant comments per thread ranged from 1 to 136 (mean = 21.9, SD = 29.5). Of the 45 threads, 28 (62.2%) discussed urinating in a pool, while 17 (37.8%) focused on showering before swimming. The threads about urinating in a pool generated more discussion on average: 28.1 (SD = 35.1) vs. 11.6 (SD = 11.6) comments per thread. Analyzed threads were posted from 2009 to 2021 (median of 2017). Most threads were identified on the Reddit website ($n = 24$, 53.3%), with 16 (35.6%) published on Quora and the remaining 5 (11.1%) from three different swimming and triathlete forums.

Overall, approximately half of users expressed a positive sentiment towards the behaviour discussed (Table 1). Positive sentiments were more commonly expressed towards showering before swimming compared to avoiding urinating in the pool, with most comments (79.9%) discussing the latter behaviour (Table 1). No trends were identified by forum source (Table 1). Only 30 (3.0%) users cited external sources in their comments, of which 26 were considered to be credible and reliable.

Qualitative analysis

A total of eight TDF domains were represented in the forum discussion comments: beliefs about capabilities ($n = 240$ comments), beliefs about consequences ($n = 362$), emotions ($n = 137$), environmental context and resources ($n = 33$), knowledge ($n = 138$), reinforcement ($n = 78$), social influences ($n = 298$), and social/professional role and identity ($n = 144$). Table 2 summarizes the key themes identified within each domain including illustrative quotes from users.

Two themes were identified under the *beliefs about capabilities* domain. For 'self-efficacy of the behaviour', some users noted that it was easy for them to hold their bladder for the duration of their swim. In contrast, others indicated it was difficult or not possible to do so. Some users noted that they did not have an urge to urinate while swimming, while others stated that they urinated in pools due to laziness or the inconvenience of removing high-technology swimwear (i.e., tech suits). Some users noted that pre-swim showering is often not properly conducted. For 'controllability of the behaviour', users noted that they did not have a choice or that it was a waste of time to avoid urinating in the pool due to their strict training regimen, while others indicated that they normally took bathroom breaks. Similarly, contrasting opinions were noted on the length of time required to take a pre-swim shower.

Table 1 | Classification of 986 forum discussion comments about hygienic behaviours in swimming pools, stratified by behaviour and source

Variable	Classification: n (%)		χ^2 test value	P-value
	Negative	Positive		
Behaviour topic			10.5	<0.001
Showering before swimming	79 (39.9)	119 (60.1)		
Urinating in the pool	416 (52.8)	372 (47.2)		
Source of comments			0.941	0.625
Reddit	324 (49.3)	333 (50.7)		
Quora	78 (50.3)	77 (49.7)		
Swimming and triathlete forums	93 (53.5)	81 (46.6)		
Total	495 (50.2)	491 (49.8)		

Table 2 | Summary of theoretical domains, themes, and illustrative quotes from 986 online discussion comments about hygienic behaviours in swimming pools

Domains ^a	Themes	Illustrative quotes	N (%) of comments
Beliefs about capabilities	Self-efficacy of the behaviour	Because I'm a girl who prefers one piece swimsuits and trying to take those off while they're wet is painful and takes forever, so I'd prefer to just pee in the pool where it dissipates nearly instantly... I suggest that 99% of the people that actually 'shower' before swimming are doing it wrong. I usually see a 10 sec. pirouette under the water, if that.	195 (19.8)
	Controllability of the behaviour	I get that's its gross but I'm trying [to] go hard this year and I can't leave in the middle of a practice just to pee. Masters swimmer here. I have never peed in the pool. Also swam in high school, never peed in it then. This is gross and I can't believe people can't take 60 seconds to run (carefully on wet deck) to the loo.	51 (5.2)
Beliefs about consequences	Outcome expectancies of the behaviour	Think about the dilution ratio. A competitive sized pool is well over a couple hundred thousand gallons. An Olympic sized one is like 600,000 gallons. It's a rule for a reason – because it causes less stress on the filtration system and chemical balance of the pool if everyone rinses off all their dead skin cells, sweat, urine, snot, and fecal material before they jump into the pool.	221 (22.4)
	Risk perceptions related to the behaviour	The pool is filtered, cleaned and chlorinated. What's the big deal? Now the only time I shower before swimming is when I run first, because I am sweaty and I feel more comfortable cleaning up. The pool is full of germs and general yuckiness (just like the rest of the world). My advice is to put it out of your mind, dive in and have fun!	157 (15.9)
Emotions	Disgust and frustration with the behaviour	Who wants to swim in someone else's dead skin? Nasty. The fact that people think it is okay to piss in the pool is mind-blowing. Peeing in the pool knowingly as an adult is disgusting and is deserving of a verbal spray, ban from the pool and if a repeat offender a good old fashioned punch on would be warranted.	133 (13.5)
Environmental context and resources	Environmental conditions and sanitation	The showers are (a) not heated and (b) outdoors, and while pleasantly lukewarm in the summer, I'm a wuss about cold and find it extremely unpleasant to take a cold shower in 50F air temperatures. The toilets are so gross where I swim and you have to go barefoot in there.	33 (3.3)
Knowledge	Misconceptions about the behaviour	Yes you do [need to shower]. If you have been mowing, digging in the yard, anything that you can get dirty. If you just got home from the office than [sic] you don't have to shower. Just hope the public pool doesn't use an additive to the water to detect pee. It will change the color of the water the pee mixes with. Forming a floating ring around you.	115 (11.7)
Reinforcement	Enforcement and rebuke of the behaviour	Most swimmers go in the pool dry and the lifeguard and the pool manager say nothing about it, which is really unforgivable. New Zealand here. Nobody pisses in the pool here to the best of my knowledge. Getting caught doing it would result in your being ordered out of the pool and your membership terminated with extreme prejudice.	74 (7.5)

(Continued.)

Table 2 | Continued

Domains ^a	Themes	Illustrative quotes	N (%) of comments
Social influences	Expectations of other swimmers	I swam D1 and you got the ‘side-eye’ if you are the one that’s always getting out to go to the bathroom. Growing up, I swam for a team that had multiple swimmers who went to the Olympics. If we had to pee, we got out of the pool and used the bathroom. I now live in an area with multiple large age group teams, many of which have swimmers who make it to Olympic trials. When I’m at the pool, I routinely see swimmers getting out of the water to go to the locker room, then come back on deck and get back in the water.	247 (25.1)
	Influence of coaches and professionals	Our coach, like many coaches of national-caliber teams, does not allow us to get out and go to the bathroom during practice time. She feels that people just use it as an excuse to miss something difficult, and that it is a distraction. I also don’t think coaches who don’t like people using the bathroom are in the wrong at all. The coach wants to make sure that everyone gets the full workout in.	85 (8.6)
Social/professional role and identity	Swimming pool etiquette	People who do [pee in pools] have no respect for others and have an inflated sense of self-importance. Whether it’s a health hazard or not is beside the point – the world is not your toilet, people! [I pee in pools] specifically because I’m not supposed to, and I love the feeling of getting away with doing something bad.	144 (14.6)

^aNote: not all comments within each domain were coded within themes, and comments were sometimes coded across multiple domains and themes.

Two themes were identified under the *beliefs about consequences* domain. For ‘outcome expectancies of the behaviour’, users often expressed little concern for the impact of urinating in pools given its small relative contribution to pool volume and its dilution. However, some noted its effect on the formation of DBPs and associated bather irritations. Competitive swimmers also noted that they avoided leaving the pool for bathroom breaks to prevent other swimmers from taking their lane. In contrast, users generally supported showering prior to swimming for various reasons including removal of faecal matter, organic material, and scented lotions and perfumes. Yet, there was some disagreement about whether a cleansing shower (with soap) was needed vs. a quick rinse or a shower earlier in the day. For ‘risk perceptions related the behaviour’, several users did not believe, were not concerned about, or chose to ignore possible adverse health effects of either behaviour, noting that chlorine would destroy any contaminants or that the filtration system would remove contamination. Others indicated that they had never experienced any adverse health effects due to the practices.

The theme ‘disgust and frustration with the behaviour’ was identified under the *emotions* domain. These users indicated revulsion towards not showering before swimming and urinating in swimming pools. Some were also annoyed and aggravated at those that reported engaging in these behaviours.

One theme was identified within the *environmental context and resources* domain: ‘environmental conditions and sanitation’. These users noted various factors that influenced their hygienic behaviours including cleanliness and location of the shower and washroom facilities, improper pool maintenance, and water and air temperatures.

One theme was identified for the *knowledge* domain: ‘misconceptions about the behaviour’. These users expressed various myths about the behaviours, such as the ability and use of pool chemicals and dyes to detect whether a bather urinates in the water. Users also expressed some misunderstandings, including a lack of awareness of DBPs and believing that urinating in a pool is not a concern because urine is sterile.

The theme ‘enforcement and rebuke of the behaviour’ was identified under the *reinforcement* domain. Several users indicated that pre-swim showering rules and discouragement of urinating in the pool were often not enforced. Others suggested that in their country (e.g., New Zealand, Iceland, Finland, and South Korea), these practices are more strictly enforced and followed than in North America. Other users indicated that they did not urinate in swimming pools due to a fear of being caught due to changes in the water colour from pool chemicals or dyes.

Two themes were identified for the domain of *social influences*. Related to the ‘expectations of other swimmers’, users frequently noted that ‘everyone does it’ or that it is a social norm to urinate in the pool, particularly among those on competitive teams. However, others noted that other swimmers and teammates never engaged in this practice. Related to the ‘influence of coaches and professionals’, competitive swimmers noted that their coaches frequently pressured or required them to urinate in the pool while training. Users also referred to Olympians and other elite-level swimmers as influencers and promoters of this behaviour. Similar sentiments were noted for both themes related to pre-swim showering.

One theme was identified under the *social/professional role and identity* domain: ‘swimming pool etiquette’. Several users noted that bathers have a responsibility to follow the recommended hygienic behaviours out of respect and consideration for others, regardless of health risks. In contrast, some users reported that they urinated in pools because they enjoyed disobeying rules and eluding detection.

DISCUSSION

This study provided an in-depth, mixed-methods evaluation of online discussion forum comments to understand key determinants towards adopting hygienic behaviours in swimming pools. Our sample population included online users of discussion forums, which likely do not represent the general population. For example, most of our analyzed threads and comments were identified on the Reddit website, and users of this website are more likely to be of male gender and younger than the general population (Amaya *et al.* 2019). Additionally, our sample population likely included more competitive swimmers than the general population, as we included forums and subreddits specific to or frequented by this community. This may reflect more positive sentiments towards and overall support for the hygienic behaviours examined in this study, as prior studies suggest that having completed swimming pool courses or previously working as a lifeguard may be associated with increased compliance with hygienic swimming behaviours (Pasquarella *et al.* 2014; Omisakin & Young 2021).

We identified twice as many threads and more discussion comments about urinating in swimming pool water compared to the topic of pre-swim showering. Additionally, users tended to disagree more with each other in threads that discussed urination in pools about whether this was an acceptable behaviour and its possible impacts on pool water quality and bather health, suggesting that this was a more contentious issue than pre-swim showering. This was supported by our content analysis that found more positive sentiments towards pre-swim showering; however, a substantial proportion (more than one-third) of users discussing both behaviours indicated negative sentiments. In the US, the Centers for Disease Control and Prevention (CDC) has developed promotional and educational material aimed at improving swimmer hygiene, including infographics, videos, media releases, social media content, and promoting a ‘Healthy and Safe Swimming Week’ in May each year (United States Centers for Disease Control and Prevention 2022). However, our findings indicate that enhanced efforts may be needed to address the key psychosocial and environmental determinants of these behaviours and increase the uptake and adoption of this messaging.

Most of the user comments related to the beliefs about consequences domain, with users questioning the usefulness and impact of the hygienic behaviours or expressing a lack of concern about possible impacts and associated health risks. This domain includes the concepts of risk perceptions, attitudes, and outcome expectancies, all of which are important components of key behavioural change theories such as the Theory of Planned Behaviour, its extension the Reasoned Action Approach, and the Health Action Process Approach (Schwarzer 2008; McEachan *et al.* 2016; Atkins *et al.* 2017). These constructs are important drivers of health-related behaviour change in different contexts and should be incorporated into behaviour-change strategies (McEachan *et al.* 2016; Sheeran *et al.* 2016). To address these constructs, future education and outreach activities with bathers should aim to provide more information about why these behaviours are recommended and their associated health impacts. For example, this could include highlighting the prevalence of and prior outbreaks of bather irritations due to DBPs among swimmers and pool staff (Bureau *et al.* 2017; Chiu *et al.* 2017). Further, the role of bather hygiene in the formation of DBPs should also be emphasized, particularly under conditions of heavy use such as during swimming competitions (Weng & Blatchley 2011).

Several users commented on their ability to perform and perceived control over each behaviour (e.g., a lack of time or ability to leave the pool for urination, or to take a proper cleansing shower). These concepts, including self-efficacy and behavioural control, are also important components of the behaviour-change theories described above as well as consistent predictors of health-related behavioural change (McEachan *et al.* 2016; Sheeran *et al.* 2016). As a behaviour-change strategy to address these constructs, bathers should be encouraged to urinate before showering and entering the pool deck, with

reminders from pool staff for all bathers to take a bathroom break at regular intervals (e.g., once per hour or as needed). Additionally, signage could also be given in the shower area to illustrate the recommended steps for taking an effective cleansing shower, as reported shower times vary widely among bathers and they often do not use soap (Water Quality & Health Council 2019; Omisakin & Young 2021).

Social influences were another critical determinant of bathers' hygienic behaviours, which corresponds with the importance of this construct as a key predictor of behaviour change in the health psychology literature (McEachan *et al.* 2016; Sheeran *et al.* 2016). Users frequently discussed how their behaviours were influenced by or aligned with the actions and expectations of other swimmers and their teammates. This finding corresponds with a prior study about pre-swim showering, which found that bathers were more likely to report showering if they witnessed others also taking a shower before entering the pool deck (Omisakin & Young 2021). Coach attitudes were also mentioned as a barrier to practising hygienic behaviours, as they were sometimes noted to discourage bathers from leaving the pool to prevent training disruptions. These findings suggest a culture among many competitive swimmers of disregarding the importance of these behaviours and of not wishing to disobey their coaches or disappoint their teammates. There is a need for a cultural shift in this population to promote and encourage hygienic behaviours. This should include education of coaches, lifeguards, and other aquatic instructors, who can directly influence swimmers, about the importance of these behaviours and their health impacts. Similar interventions targeting social norms have been effective to improve health behaviours in other settings (Tang *et al.* 2021).

Specifically related to urinating in pools, public comments from Olympic swimmers (e.g., Michael Phelps, Carly Geehr, and Ryan Lochte) were often mentioned by users as contributing to their perceived normalization of the behaviour. For example, in 2012, Phelps noted in a video interview that 'everyone pees in the pool... it is kind of a normal thing to do for swimmers ... chlorine kills it, so it is not bad' (WSJ Staff 2012). The impact of celebrities on influencing people's health-related knowledge, attitudes, and behaviours, both positively and negatively, is well documented (Hoffman & Tan 2015). Efforts to promote the importance of pre-swim showering and not urinating in pools among professional swimmers could further help to encourage hygienic behaviours among recreational and competitive swimmers.

Numerous user comments discussed the importance of swimming etiquette as a determinant of their hygienic behaviours. This finding relates to the psychosocial construct of the moral norm, which refers to an individual's perception of the moral obligation or correctness of performing a particular behaviour (Rivis *et al.* 2009). Moral norm is increasingly recognized as an important construct affecting behavioural change intentions (Rivis *et al.* 2009). To address this construct, swimming pool operators should take additional efforts to promote bather hygiene through well-placed and engaging signage and verbal instructions to establish such etiquette and expected behaviours. Additionally, prior research has found that reading the pool rules was associated with a greater reported adoption of both behaviours investigated in this study (Pasquarella *et al.* 2013, 2014; Omisakin & Young 2021).

Negative emotions of disgust and frustration were expressed towards bathers who did not follow recommended hygienic behaviours. Such constructs have also been shown to be important determinants of other hygienic behaviours (e.g., safe food handling), and could also be incorporated into future messaging (Ammann *et al.* 2020). For example, interventions incorporating visual images, virtual simulations, or cues demonstrating the impact of unhygienic behaviours (e.g., introducing faecal matter or formation of DBPs in the pool) could help to influence more positive behaviours (Ammann *et al.* 2020). However, such strategies may not influence those who are less sensitive to such cues.

Low awareness about pool hygiene was identified in some of the user comments analyzed in this study and has also been reported in prior surveys (Pasquarella *et al.* 2013, 2014; Water Quality & Health Council 2019; Omisakin & Young 2021). While increasing knowledge is not consistently associated with behaviour change, it is an important precursor needed to facilitate possible action (Young *et al.* 2017). Future messaging should aim to address common misconceptions, such as the belief that only microbiological (vs. chemical) hazards are a health concern in pools (Water Quality & Health Council 2019).

Some users noted a need to increase the enforcement of hygienic behaviours at pools as a deterrent. While enforcement of such behaviours may not be feasible in practice, regular reminders to bathers could help to reinforce their importance (Cheung *et al.* 2012). Pool operators and staff should develop policies that include regular reminders for bathers about the importance of these behaviours. Future research should further investigate possible cultural and geographic differences in these hygienic behaviours and their enforcement, which were noted by some users.

Some users noted that various environmental factors affected their use of the hygienic behaviours. A physical environment and resources conducive to supporting and promoting hygienic behaviours should be implemented at swimming pools to

facilitate behaviour change (Kwasnicka *et al.* 2016). For example, pool operators should ensure their facilities are designed to encourage showering and discourage urinating in the pool, including maintaining high cleanliness and sanitation, providing soap for showers, and (where appropriate) providing heated showers.

Despite using an iterative searching approach, it is possible that we could have missed some important threads or other forum websites that could have contained additional, relevant discussion comments. However, we believe this would not have a notable impact on our results, as we are confident that saturation was reached across the key themes, with multiple user comments providing supporting evidence in each area. We were not able to capture any socio-demographic characteristics of users, and as noted previously, they may not represent the general population of swimming pool users. Future primary research in this area (e.g., interviews, focus groups, and surveys) should collect such information to examine behavioural relationships with age, gender, and other socio-demographic factors. It is possible that some minor errors in classification of comment sentiments could have occurred. However, we attempted to minimize this by ensuring coding by two independent reviewers, with reviews to check agreement and ensure consistent interpretation.

CONCLUSION

This study has evaluated online discussion comments to provide an in-depth assessment of the psychosocial and environmental determinants of the following two recommended hygienic behaviours at swimming pools: pre-swim showering and avoidance of urinating in the pool. Users identified a low perception of risk for these behaviours and a lack of concern and knowledge about their consequences for pool water quality and bather health, indicating future education and outreach are needed to highlight the purpose and health consequences of each behaviour. A low self-efficacy and perceived control over these behaviours was also identified, along with a strong influence of teammates, coaches, and professional swimmers. Pool staff and coaches should encourage bathers to take regular bathroom breaks and to shower before swimming. Interventions to change social and cultural norms of hygienic behaviours are needed, especially in competitive swim team environments. Pool operators should review and enhance messaging and signage to establish and illustrate hygienic behaviour etiquette and rules, with regular reminders to bathers. They should also ensure facilities are appropriately designed and maintained to promote these behaviours (e.g., clean and sanitary shower areas). Public health authorities and inspectors should incorporate these findings and recommendations into their training and outreach with pool operators and staff.

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DATA AVAILABILITY STATEMENT

All relevant data are included in the paper or its Supplementary Information.

CONFLICTS OF INTEREST STATEMENT

The authors declare there is no conflict.

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