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Hygienic surveillance in swimming pools: Assessment of the water quality in Bologna facilities in the period 2010–2012☆

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ABSTRACT

In the three-year period 2010–2012, 80 public swimming facilities in the metropolitan area of Bologna (Emilia Romagna Region, Italy), including 144 pools (69 indoor, 75 outdoor), were monitored to assess the microbiological and chemical water quality, after about ten years of implementing the new Italian guidance which introduced the principles of internal safety plans in the surveillance of swimming pools. According to the Italian guidance, water samples were collected from supply water (370 samples), pool water (645), and recirculating water entering the pool (307). The samples of supply water always conformed to the microbiological limits for drinking water. The pool water did not conform to the Italian legal requirements in around 16% of indoor pools and 25% of outdoor pools. In 65% of non-compliant samples, only one parameter exceeded the required standards. The microorganisms of faecal origin were isolated very rarely (Enterococci in less than 2% of samples) and pH and residual chlorine showed good compliance in pool water, implying an efficient management of the internal control. The inlet water exceeded the required standards in about 36% and 50% of samples, respectively in indoor and outdoor pools. However, 83.6% of the corresponding samples of pool water met the required limits. The microbiological incongruities were prevalently due to high levels of total heterotrophic counts (THCs) and *Pseudomonas aeruginosa*, and were indicative of bacterial colonization of the filters. The sampling of inlet water can thus be indicated as a critical control point for checking the correct functioning of the filters. The non-conformity of samples led to pool closure only in 1.5% of cases. In the other cases, the operators were officially invited to perform the corrective measures previously established in the plan of risk assessment. On the whole, the approach based on internal safety plans produced satisfactory results in terms of pool water quality, demonstrating the effective working of the internal system of analysis and management of risks.

1. Introduction

The evolution of scientific knowledge on health risks in recreational environments, along with the need to update the strategies for their prevention, has led to the adoption of new rules on the hygiene of swimming pools in different countries. At an international level, the WHO Guidelines for Safe Recreational-water Environments (2006), which are currently under review, describe the state of knowledge regarding the detrimental impacts of the recreational use of swimming pools and spas on the health of users, as well as the monitoring and control of the hazards associated with these environments. The guidelines are intended to be used as the basis for the development of national approaches to controlling the hazards that may be encountered in swimming pools and spas, as well as providing a framework for policy-making and local decision-taking [1].

The need for national guidelines or regulations has been highlighted in many countries [2,3]. Regulations and guidelines vary considerably across Europe [4]. In the United Kingdom, chemical and bacteriological swimming pool water quality is monitored in accordance with the guidelines produced by the Pool Water Treatment Advisory Group (PWTAG) [5]. In Germany, the quality of swimming pool water is not regulated by law, but technical regulations for the operation of swimming pools are defined in DIN19643, updated in November 2012 [6]. In Austria a new regulation was enacted in October 2012, in order to expand the requirements on water quality of swimming pools, whirl pools, whirl tubs and small natural swimming ponds [7]. In the United States no single federal agency regulates the design, construction, operation and maintenance of swimming pools. This means that codes vary considerably among different states and local health departments. Efforts are underway to develop a Model Aquatic Health Code (MAHC) to be used as a national voluntary guideline [3,8]. The first edition of this health code should be completed by the end of 2013 [9,10].

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In this international setting, the Italian Ministry of Health and the representatives of the Italian Region signed an *Agreement on the hygienic aspects for the construction, maintaining and control of swimming pools* on 16 January 2003 [11]. The document sets out technical norms regarding hygiene-health aspects in the construction, maintenance and control of swimming pools. It also provides a list of physical, chemical and microbiological parameters for the water, in each case indicating limits valid at a national level regarding both the supply water and that of the pools. The guidance was implemented within the *Inter-regional protocol of swimming pools* and requires the legal approval of each region to become operational [12]. In the Emilia Romagna Region the national provision was adopted as regional law in 2005.

The innovative line of the regulation attributes a fundamental role in the prevention of health risk not only to the official controls, but requires all facility managers to be guarantors of the hygienic quality and safety of swimming pools. The safety quality must be ensured by internal control protocols based on the identification of the critical steps for the hygienic risks of a swimming pool and the adoption of appropriate procedures to control associated hazards. The safety plan includes a monitoring programme for pool water. In other countries such as The Netherlands the swimming pool regulations, now being updated, adopted the same innovative approach, based on internal safety plans and analysis and management of risks [13].

In Italy, the Prevention Departments of the Local Health Authorities are responsible for the vigilance of swimming pool environments and may make use of the Regional Agencies for Environmental Protection (ARPAs) for the chemical, physical and microbiological testing. They are also responsible for the supervision of internal safety plans and documents produced by the self-checking activities and the surveillance of the suitability of corrective actions adopted should values be exceeded.

The aim of this work was, firstly, to outline the framework of the hygienic quality of swimming pool waters in the territory of the Local Health Authority of Bologna (Emilia Romagna Region, Italy) after about 10 years of implementing the new regulation on the safety of these environments. A second aim was to highlight any critical points of this system with a view to proposing any necessary amendments to the national guidance of January 2003, which is now undergoing revision.

2. Methods

2.1. Setting

The Local Health Authority of Bologna covers a geographic area of about 3000 Kmq, extending over the whole metropolitan territory of the city of Bologna. The resident population is about 860,000 inhabitants. In this territory there are a total of 80 swimming plants supplied with fresh water and open to the public (30 indoor, 41 outdoor and 9 in/outdoor). The vigilance over swimming pools is overseen by the Prevention Department of the Local Health Authority. The methods and frequency of controls take into account the type of plant, with particular attention to the critical points highlighted in the risk assessment and safety plan made by the swimming pool managers. On average 3 and 1 samplings/year are respectively carried out for each indoor and outdoor swimming pool.

2.2. Monitoring

The Local Health Authority of Bologna, in the three-year period 2010–2012, monitored a total of 80 swimming facilities, including 144 swimming pools (69 indoor, 75 outdoor) supplied with fresh water. In accordance with the Italian guidance and regional law, water samples were collected from supply water (370 samples), water entering the pool – hereafter named inlet water – (307) and pool water (645). The samples were collected according to the standard procedures [11].

The parameters monitored were those stated by the Italian guidance. The samples of pool water were taken from the pool, at a depth of 50 cm; the samples of inlet water were drawn from the input pipeline which, after filtration and chlorination, carries the recirculating water to the swimming pool. In order to neutralise the residual free chlorine, 10% sodium thiosulphate was added in sterile bottles for bacteriological analysis (1 mL l^{-1}), whereas acid-preserved glass bottles were used for chemical analyses. Water temperature and residual chlorine (N,N-Diethyl-p-PhenyleneDiamine (DPD) colorimetric method, colorimeter Orbeco-Hellige, Model 942-001, NY, USA) were determined at the time of collection [14].

2.3. Bacteriological analysis

Microbiological samples were analysed within 12 h of collection using the standard plate method to determine the total heterotrophic counts (THC) at 22 °C and 36 °C (UNI EN ISO 6222:2001, medium: YEA — Biolife) and the standard membrane filter (MF) technique to determine *Pseudomonas aeruginosa* (UNI EN ISO 16266:2008, medium: Pseudomonas CN Agar — Liofilchem), *Staphylococcus aureus* (ISTISAN Reports 2007/05 A 018A, 2007, medium: Baird Parker Agar — Liofilchem), *Escherichia coli* (ISTISAN Reports 2007/05 A 001B, medium: TTC Tergitol 7 Agar — Biolife) and Enterococci (UNI EN ISO 78992:2003, medium: Slanetz Bartley Agar — Liofilchem).

2.4. Physical and chemical analyses

The physical–chemical parameters were measured in accordance with the standard methods stated by the Italian National Institute of Health (ISS) for oxygen demand (volumetric method: ISTISAN Reports 2007/31, ISS BEB 027) and pH (potentiometric method: ISTISAN Reports 2007/31, ISS BCA 023) and by the National Research Council (CNR) for turbidity (UV–VIS spectrophotometric method: APAT CNR IRSA 2110 Man 29 2003) and nitrates (chromatographic method: APAT CNR IRSA 4020 Man 29 2003).

Data were tabulated with the aid of the software 5.1 Sequential LIMS (Laboratory Information Management System) database (http://www.softwarepoint.com/default.htm) using the BusinessObjects software application that enables dynamic reporting of data from heterogeneous data sources using the SQL language. Data were analysed through descriptive statistical calculations.

3. Results

The samples of supply water always conformed to the microbiological limits established for drinking water by the Italian law D. Lgs. 31 of 2001 (THC, 36 °C < 10 cfu/mL; THC, 22 °C < 100 cfu/mL; *E. coli* and Enterococci absent in 100 mL) which is the Italian transposition of the European Community Directive 98/83/CE [15].

Table 1 shows the number of swimming pools monitored in the three years of surveillance and the relative compliance to the legal requirements. The outdoor swimming pools failed to meet the standards more frequently than indoor swimming pools. For both indoor and

Table 1
Compliance of swimming pools to water standards in the three year vigilance.

Year		Indoor swimming pools		Outdoor swimming pools	
		Inlet water	Pool water	Inlet water	Pool water
2010	Samples (N)	88	128	41	72
	Non-compliant samples	28 (31.8%)	20 (15.6%)	23 (56.1%)	18 (25.0%)
2011	Samples (N)	69	149	36	71
	Non-compliant samples	28 (40.6%)	25 (16.8%)	19 (52.8%)	19 (26.8%)
2012	Samples (N)	46	143	27	82
	Non-compliant samples	18 (39.1%)	21 (14.7%)	9 (33.3%)	20 (24.4%)
Total	samples (N)	203	420	104	225
	Non-compliant samples	74 (36.5%)	66 (15.7%)	51 (49.0%)	57 (25.3%)