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Water use and water saving in Italian hospitals. A preliminary investigation

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Abstract

Aim. The aim of this work is to investigate about water use, wastage, saving and reuse in hospitals.

Methods. An anonymous *ad hoc* questionnaire was tested in a sample of 36 public hospitals of Lombardy Region (21% of total public hospitals). Daily water consumption reported is on average equal to 481 m^3, ranging from 30 to 2280 m^3. There is a strong correlation between water consumption and number of hospital beds ($p < 0.005$). In 33 hospitals (92%) water consumption is measured and, among them, in about 48% more than one flow meter is installed; 86% consider "important" the reduction of water consumption and about 55% recognize that wastewater could be minimized within the structures.

Discussion. There is consensus about the need to train health personnel and to implement technical measures to improve the water resources management, but initiatives to raise knowledge and awareness of health personnel have been promoted only in 10% of hospitals.

Results. Results show not only a lack of awareness regarding water use and saving among the personnel in general, but also among heads of the hospitas' technical office and energy managers as well. For this reason, it will be of interest to carry out this investigation at national level and also to develop recommendations to support and promote a safe reuse of water in all the hospitals.

Key words

- hospitals
- water reuse
- sustainability management

INTRODUCTION

For more than a decade, water and energy demand have considerably increased due to drivers of global change such as climate change, population growth, urbanization, industrialization, living standard and rising income [1, 2].

In contrast to this, environmental sustainability measures were aimed at reducing energy consumption, pollutant emissions, waste production and water use [3]. All these elements are highly interconnected: water is essential in energy production, such as for hydro-power and for water cooling in thermal and nuclear power plants. Otherwise, pumping water through pipelines to consumers requests considerable energy, as well as transporting wastewater from homes to wastewater treatment plants, up to the final processing of sewage [4]. Thus water is a limited resource and must be protected and used in a sustainable way, based on the recycling, reuse and waste control [5].

The issue of water reuse has a central role in the water cycle. Treated water can be widely reused, but most commonly for non-drinking purposes [6]. The uses may include irrigation (agriculture, horticulture, leisure, green spaces and gardens), environmental purposes and domestic non-drinking purposes (flushing devices, etc.) [7]. The main objective of water reuse, with an attention to sustainable management of water resources, is to reduce the consumption of drinking water for inappropriate uses.

Integrated Water Resource Management (IWRM) has been developed to "promote the coordinated development and management of water, land and related resources in order to maximize the resultant economic and social welfare in an equitable manner without compromising the sustainability of vital ecosystems" [8].

With an attention to the sustainable management of water resources, it is therefore necessary to move towards a "new" paradigm that ensures the rational and optimized use of water resources [9]. The World Health Organization (WHO) estimates that, in the next 50 years, more than 40% of the world population will live in countries with water scarcity [10].

Hospitals (Hs) are among the most energy-intensive facilities [11], consuming more than twice the energy

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of offices or homes [12-14]. Actually, as argued by Brown *et al*. [15] "*although reducing health-related energy consumption and emissions alone will not resolve all of the problems of energy scarcity and climate change, it could make a meaningful contribution*". Energy is needed to provide lighting [16], to power medical equipment, to heat water, to supply heating and air conditioning; Hs also produce waste and indirect environmental impacts are associated with their purchasing activities [15]. Bearing in mind the above, water consumption plays a primary role in the energy management of health facilities. Water in Hs is an essential element for hygiene and health; depending on the activities which take place within the structure, Hs require a significant quantity of water per day, to be used in different ways and for different purposes [14]. For example, water for human use and/or food consumption has different quality characteristics compared to rehabilitational swimming pool water, sterilizers and dialysis water or even irrigation water [17].

Factors that have the greatest impact on the amount of water used in Hs are: bed number, number and type of wards and units, hospital age, access to water, general services present inside the structure, institutional management policies and awareness in managing the structure so as to safeguard the environment, climate, cultural and geographical factors [14, 17].

Several literature studies [14, 18-20] report that the amount of water used in Hs is between a minimum of 200 and a maximum of 1200 L bed^{-1} d^{-1}: the lowest values refer to developing countries while the highest to the industrialized ones. Furthermore, Verlicchi *et al*. [14] have shown that there is no correlation between the specific H consumption (expressed as L bed^{-1} d^{-1}) and H size (expressed as bed numbers) [21].

In general, however, water consumption varies both during the day [14] and during the year [14, 22] with higher consumption during the warmer months.

In order to propose a strategic management and sustainable use of water resources in health facilities it is essential to know the quantity and the proportional water uses in Hs with the aim of promoting the conservation, reuse and recycling of water.

A study carried out on water use in Victorian health care facilities in Australia [6] showed that within Hs, the largest water consumption is attributable to the following activities: *hygiene* (washing, cleaning), *sanitation* (flushing wastes to sewer), *ingestion* (drinking, food preparation), *process* (cleaning, sanitizing, sterilising, laundering, heating, cooling, water filtering and softening) and *irrigation* (ornamental gardens and lawn watering). The study showed that for ablutions (basins, showers, sinks) the typical proportional use is between 20 and 40% of the total consumption. The contribution of sanitary flushing (toilets, pan sanitizers) is between 15 and 30%, while for the processes (sterilizers, laboratories and cooling) and for food preparation (kitchen) it is between 15 and 40% and 5 and 25%, respectively.

A survey on 26 Hs in Florida [34] showed that the largest amount of water was used for the cooling systems (about 53% of the total); moreover, the use of water for washing, for kitchens and in the processes, was estimated to be 10%, 5% and 4%, respectively. The same survey estimated a saving of about 32% of water used for the cooling systems simply adopting measures to improve the HVAC efficiency. For example, Norwood Hospital invested $ 5500 in water saving retrofits and currently saves $ 13 750 per year and this is equivalent to a 0.40 year payback period [23].

Hs are large consumers of energy, water included, therefore it is necessary to identify and adopt innovative design solutions and management to reduce water consumption in structures [24] and to ensure the safe use of reclaimed water sources. For example, at the University of Washington State, an aggressive water conservation program was implemented which included the adoption of a number of water-saving technologies [25]. These included cooling tower upgrades, equipment repairs, waterless urinals, low-flow toilets, replacement of water cooled vacuum pumps with air cooled pumps, water efficient clothes washers, and upgrades to sterilizers. The most significant and cost-effective upgrade was the installation of water conservation kits on the sterilizers.

Since health and patient care are top priorities, hospitals are often built without considering sustainability [26]. Therefore, hospitals have a very high potential for energy savings [27]. European and Italian legislations related to environmental sustainability require the use of methodologies aimed at the recovery and reuse of rainwater and grey water [7]. Many existing Hs have undertaken initiatives to reduce water consumption or to recycle the wastewater. For example some studies reported the efficacy of strategies aimed to save water during hand hygiene procedures in surgery: one investigation compared the techniques of surgical hand washing in terms of water saving [28]; other studies compared the surgical hands washing with the rubbing by alcohol-based products [29, 30], observing a substantial costs saving and water saving, with the second approach, without lose protective effect.

Jones [31], collecting water from the drains of 3 different types of scrub bays used in a standardized 5-minute scrub routine (one with an elbow-controlled tap, one with a spring-loaded foot-controlled tap, and one with a motion sensor-controlled tap), observed that only the spring-loaded foot-controlled tap turned off automatically between rinses reducing the water consumption of 3 times (about 50 litres per scrub) and concluded that water consumption could be reduced by selecting the most water-sparing plumbing fixtures for new buildings or retrofitting older facilities.

Dialysis is another context in which it is possible to reduce wastage: it consumes 120 to 800 litres of fresh water per treatment depending on the type and duration of the therapy session [15]. Much of that water is discarded in the reverse osmosis process that creates the dialysis fluid, and it is known as reject water. Considering that it is at low level of contamination, it could be recycled for grey water uses, with costs saving. This practice, however, is not widespread. For example, in United Kingdom [32], only 2 renal units (3.6%) that participated in a survey on sustainability in kidney care, reported installing facilities for recycling reject water.

In renovation projects and in the new Hs such mea-

sures have been widely developed mainly through rainwater reuse for watering and irrigation of gardens and parks, and/or to extinguish fires [33]. Rainwater however has some limitations, such as inconstant production over time and contamination problems during storage [7].

In Italy there are few data about water use and policy regarding water saving in Hs [34]. The aim of this survey is to investigate on knowledge, attitude and behaviours of Heads of the Hs' Technical Office (HTOs) about water use, wastage, saving, reuse and how this reflects on the energy consumption by the health facilities [35].

METHODS

A cross-sectional study was carried out in one Italian region, Lombardy a north-western region, with about ten millions inhabitants, that ranks first in Italy for population, second for density and fourth for surface area.

All public accredited hospitals (179 Hs) were included. The list of Hs was drawn up from the official website of the Italian Ministry of Health [46], which includes the following information: name and type of the structure, year of opening, number of beds divided in admissions, day hospital (DH) and day surgery (DS).

To obtain information about water and energy consumption within health facilities, an anonymous questionnaire, previously tested in a pilot study performed in some public Hs of Rome, was used. Besides collecting information on the type and location of structures, it includes 17 questions concerning daily water consumption; the incidence of water consumption compared to the total energy consumption of the H; systems used for monitoring water consumption; water saving practices adopted, the perception of water wastage as a problem and the training and awareness of health personnel.

The survey was carried out in order to provide an updated overview on the following aspects:

- perception of the importance of sustainable water use;
- awareness of water consumption in hospitals, quantification and distribution by type of use, if available;
- possible use of systems to reduce water consumption and wastage;
- reuse of greywater and/or rainwater, with details of their purposes.

The questionnaire was submitted via e-mail to the HTOs of each H. After about thirty days, in case of non-return of the compiled questionnaire, the authors mailed reminders, up to a maximum of three. The distribution of the questionnaire went up from February 2013 to May 2013.

Collected data were inserted into a database prepared using Microsoft Office Excel 2007.

The completed questionnaires were divided into broad groups according to the type of structure and complexity of performance:

- *presidi ospedalieri* (Hospital Centers – HCs), characterized by lower number of beds and lower complexity of care, that form part of Local Health Units (LHUs), the third level of Government after the Central Authority and the Regions, transformed into public firms with laws 502/1992 and 503/1993;
- *aziende ospedaliere* (Hospital Firm – HFs), larger accredited hospitals with financial autonomy and performance of high complexity of care.

The results of the questionnaires were analysed using χ^2 test or Fisher's exact test to compare proportions; Spearman's Rank correlation coefficient was used for quantitative variables or ordered qualitative variables.

RESULTS AND DISCUSSION

Among the 40 structures that filled in the questionnaire, 19 were HFs (65.5% of the 29 public/accredited HFs of Lombardy) and 21 were HCs (14% out of 150 public HCs). Four structures were excluded because of incomplete answers; therefore the data described refer to 36 hospitals (21% of the total number of Public Hs in Lombardy). Hs which filled in the questionnaire belong to nine of the twelve provinces of the region (*Figure 1*).

The Hs analysed have an average number of beds of 383 (ranging from a minimum of 17 to a maximum of 1530) and a distribution divided into the following quartiles: Q1 = 109; Q2 = 261; Q3 = 571.

Perception of the importance of sustainable use of water

The majority of respondents (86%) consider "important" the reduction of water consumption in hospital; among them, 61.3% recognizes that wastewater could be minimized within the structures and 54.8% implemented technical measures to improve the water resources management. Regarding the behavior of staff, 32.3% state that they have an attitude to reduce water consumption and in about 10% of health facilities, initiatives to raise awareness of health personnel have been promoted.

Awareness of water consumptions

All facilities provided information on daily water consumption; it was on average equal to 481 m^3, ranging from a minimum of 30 m^3 to a maximum of 2280 m^3. There was a strong correlation between water consumption and number of beds ($p < 0.005$).

Not all the HTOs who completed the questionnaire were able to give an indication on water consumption according to various activities within Hs. In particular, only 12 structures (33%) gave indications about the use of water in the Hs. The uses reported were: sanitary flushing (100%), ingestion (92%), processes (92%), ablution (92%), fire service (58%), garden irrigation (42%) and leaks in the distribution system or from the terminals (33%).

Figure 2 shows the box-plots of the distribution of water consumptions for each activity: the whole distribution for sanitary flushing and processes is concentrated, while for ingestion and ablution the distribution is rather symmetrical.

To find out whether the data concerning water consumption activities accounted for only an estimate or were the result of measurements, feedback about the presence in the structures of a single or multiple flow meters has been taken into account. The answers showed that in 33 hospitals (92%) water consumption is measured and, among them, in about 48% of cases, more than one flow meter is installed.

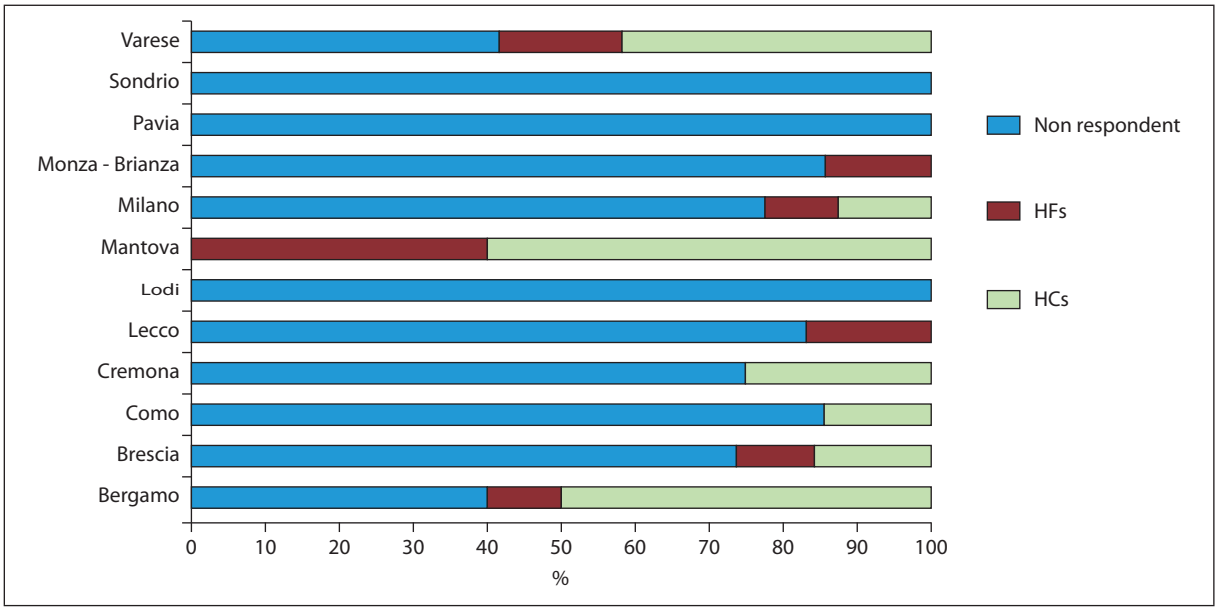

Figure 1
Distribution of involved hospitals by province and typology.

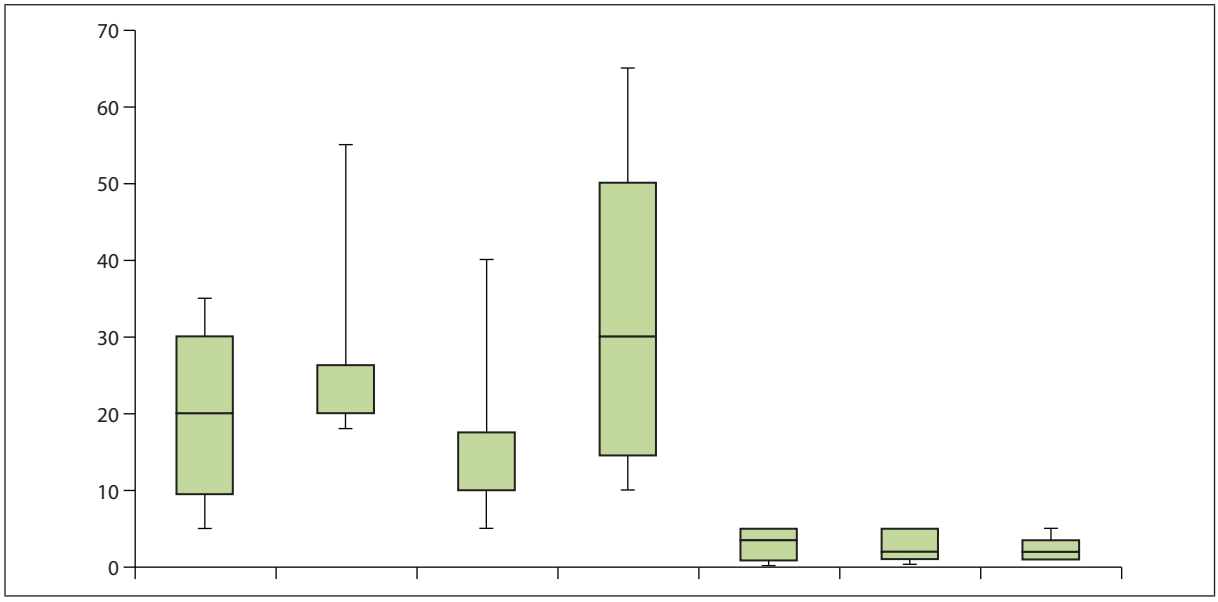

Figure 2
Distribution of water consumptions for each activity.

Measures adopted to reduce water consumption and wastage

In about 30% of cases (11 structures) Hs are equipped with automated control systems to prevent excessive bleeding of the cooling towers, in order to minimize the consumption of water. In 77% (28 structures), moreover, a return of condensed steam system in the boiler for reuse is also provided.

In order to reduce the consumption of water in Hs, the possibility of replacing the water-cooling units with air-cooling has been also investigated; in about 58% of cases (21 facilities) this intervention has been planned. Finally, 75% of respondents (27 facilities) consider it cost-effective to invest in technologies to reduce water consumption.

The answers on preventive measures to reduce water consumption in Hs showed that only 2 out of 36 facilities (approximately 5%) ensured a double water supply in new buildings. Similarly, only 2 Hs have installed water-saving showerheads.

Most Hs, however, have adopted systems of flow control on the taps: about 28% reported the presence of flow reducer and about 8% of opening sensors for taps. Other preventive measures in Hs include: the pres-

ence of retrofit toilet flushing to obtain systems with low power consumption (about 25%), the installation of flow reducers on the terminals (about 6%) and an automatic purge system for the treatment of boilers (about 17%).

Attitude and practice toward reuse of greywater and/or rainwater in hospital

The reuse of water, at least for those Hs that filled in the questionnaire, is not yet a common practical implementation. Actually, only 4 of Hs enrolled in the study (11%) reuse water; the reuse concerns rainwater for irrigation purposes and for fire service.

Although 86% of the interviewed support the reuse of greywater in hospitals, 38.7% of them believe that it could cause infections in immunosuppressed patients or, in general, could contain infected material, could cause incidental exchange of drinking water with reused water. Among 14% of HTOs contrary to reuse water, the reasons for the disagreement are mainly due to the high cost of water treatment.

Factors related to the attitude to reduce wastewater within the hospital

Finally, in order to evaluate if the perception that recognition from HTOs that wastewater could be minimized within their structures could be related to best practices, χ^2 test or Fisher's exact test were used. The analysis also showed an association between the attitude to reduce wastewater within the structure and:

- the knowledge of volume of water consumed for *type of consumption* ($p = 0.022$);
- the implementation of preventive measures to reduce water consumption ($p = 0.001$);
- the possibility of replacing equipment for water cooling with the one for air cooling ($p < 0.0001$).
- No association was observed between type of hospital (HC of HF) and attitude and practices toward wastewater reduction.

CONCLUSION

This preliminary investigation offers several hints. First of all, the instrument used has provided useful information for the analysis of water consumption in Hs. Among these, the most striking, not only because it is inconsistent with the findings of Verlicchi *et al.* [14], but also because it is the main object of the study, is the correlation observed between the daily consumption of water in the structure (expressed in m^3) and the H's size (expressed as beds number). Obviously, these are preliminary conclusions because they regard a sample of Hs of Lombardy Region only. It will be necessary to verify whether this correlation will be confirmed when the survey will be extended to the whole country.

Considering the water consumption by type of use, the percentage distribution observed in our study is similar to that observed in other studies performed in Australia [6] and in Florida [22], where ablutions are the most relevant type of consumption.

Although in every H there is an Energy manager, as prescribed by law in Italy (Law 10/1991), analysing the responses to the questionnaires, it was noted that not in all Hs the HTOs interviewed was able to provide data about water consumption. This lack of information is surprising considering that about 90% of hospitals have flow meters. It is also true that this could arise from the contractual terms and conditions for the supply of water, often of a lump sum, which the individual HT or Health Care Trust (HCT) subscribes with authorities responsible for the provision of the same. The lack of attention to this problem may also result from the low cost of water supply in Italy, if compared with other European countries [36].

In many structures, although the HTOs believe it is important to reduce the water wastage, few control systems and/or preventive measures are used to reduce the consumption. Among the measures used only flow reducers on taps and retrofit toilet discharge systems are commonly used, but apparently they are not enough to reduce the consumption of such complex structures which are characterized by a variety of activities involving high consumption.

HTOs showed a high awareness of the poor attitude of the staff to reduce consumption, but this is not reflected in effective initiatives aimed at improving the management of water resources. Similar results were observed in a previous study aimed at investigating on energy consumption in Italian hospitals [12].

Finally, although the majority of the interviewers is favourable to reuse greywater, this is performed only in 11% of Hs involved in the survey. This happens for several reasons: first because most of Hs are old [37] and their water plants are not designed to spare the water; second, because of the belief that the reuse of greywater can lead to risk of infection for all users of the facilities; third, because they believe the reuse of water to be too expensive.

Downstream of the above considerations, it is assumed not only a lack of awareness of health personnel, but also of HTOs and of Energy managers regarding the use and saving of water. For this reason, it will be of interest to perform this investigation at national level and also to produce recommendations in order to reduce the water wastage and promote a safe reuse of this resource also in other health care facilities.

In fact, as argued by Brown *et al.* [15], health systems and health professionals should not underestimate their potential influence on sustainability actions [38]. In Italy some Hs are already taking steps to minimize their environmental impact [39], but it should be a priority for all the health system, like already occurred in other countries [40].

Conflict of interest statement

There are no potential conflicts of interest or any financial or personal relationships with other people or organizations that could inappropriately bias conduct and findings of this study.

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