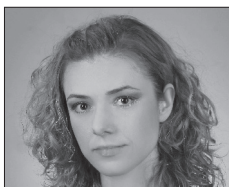


# The health role of smart home bathroom



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The research results summarize the fields of medicine where smart bathroom appliances can create new opportunities to improve user health.

The growing needs and consumption desires of users shaped by the media, concern for health and well-being, and changing lifestyles define new tasks to be fulfilled by the home bathroom. The awareness of the bathroom as a very important space in every home, where most people start and end each day, develops more and more. The existing bathroom functions are expanding. A modern bathroom is no longer a purely hygienic room, while it should meet many new requirements: it is supposed to promote health, relaxation, meditation and psychophysical regeneration. The main role of the bathroom resulting from taking care of personal hygiene is not only associated with cleanliness, but it is indispensably connected with preventive medicine and medical prophylaxis. The bathroom has undeniable health importance, both on the scale of the individual and the whole society. The importance of the health role of the home bathroom is also due to the current social and economic situation around the world caused by the spread of the SARS-COV-2 coronavirus and the COVID-19 pandemic. It results in the lack of sufficient clinical medical care and the need for independent health control, as well as the developing need for medical prophylaxis, protection of immunity and psychophysical condition in the face of public health threats. Public health awareness in the context of medical prophylaxis influences the current trends in the design of modern home bathrooms and their equipment.

## Research purpose, scope and methodology

Social awareness of the need to maintain appropriate conditions of protection and health control in the context of medical prophylaxis is the main problem in the ergonomic design of modern hygiene and sanitation facilities in apartments. The importance of hygiene, health and safety of users determines new solutions and effects in modern bathrooms. Therefore, it was necessary to investigate the health factors in bathroom design on the basis of studies and analyzes of literature and materials from foreign research institutes. The research concerned de-

sign possibilities in the selection of bathroom equipment elements enabling a wide range of comfort as well as supporting and monitoring the health of users. The last step was a tabular list of selected bathroom solutions, indicating their health functions and fields of medicine in which results are expected to improve the health of users. Both the existing and forecast possibilities of implementation, application and use were presented.

## The importance of the health role of the bathroom

The integration of architectural living design solutions to support the health of users is becoming increasingly important in everyday life. A home bathroom is a special place for health care among other home rooms. The amount of time that we spend in bathroom and number of different functions and activities to which bathroom is used, increase along with social changes and technological progress. Contemporary bathroom can be a place of widely understood keeping the body in cleanliness and good psychophysical condition, a place of looking after the beauty, a place of relaxation, fitness, a place with health functions, including those related to medical prophylaxis (therapeutic functions, but also functions enabling control and protection of health without the need for in-patient medical visits) [1].

The modern "healthy bathroom" concept includes the following functions:

- hygienic treatments and activities,
- beauty care and treatments,
- taking care of the health of the body and mind,
- taking care of the psychophysical condition,
- the possibility of fitness exercises,
- the possibility of rest, regeneration, meditation,
- home SPA, "wellness",
- health prophylaxis,
- regular health control and analysis,
- possibility of remote contact and consultation with doctors.

The importance of hygiene, health and safety of users determines new solutions and effects

in modern bathrooms also in the face of public health threats. On the one hand, the impact of technological development, and on the other hand, changes in lifestyle, which generate new needs and expectations of users, significantly improve the functional and aesthetic quality of these rooms. It is important to develop and deepen the state of knowledge in the use of the latest technologies in the design, implementation and use of modern hygiene and sanitation facilities. Research in the field of design possibilities taking into account the health functions and properties of the home bathroom space should concern not only its functional and spatial arrangement and the selection of basic material solutions, but also elements of equipment, devices, sanitary devices, fittings and technical installations.

A wide range of comfort in the modern bathroom is possible thanks to the latest technological achievements. Their operation can be divided into three groups:

- Easy-to-use interface integrating systems and devices that enable the operation and control of many functions and activities performed in the bathroom.
- "Intelligently" working bathroom fittings, accessories, lighting, adjustable equipment elements, easily adapting to the needs of users.
- Innovative bathroom materials, surfaces and finishing elements ensuring an easy-to-clean, hygienic, healthy and safe environment [1].

Optimized use of smart amenities and familiarizing users with the possibilities and ways of operating them in the context of maximizing usability can have social and health effects in the face of aging societies, demographic changes, climate change and threats to safety, health and life [1].

An important aspect is the review and analysis of the available technologically advanced solutions, from which users of different ages and with different physical and mental abilities can choose amenities adequate to their needs, expectations and preferences. First of all, solutions related to health protection, medical con-

tol and health prophylaxis need to be considered. It is also important to indicate the potential for the optimal use of modern technologies and the possibility of processes control, easy flow of information in relation to the external environment (e.g. remote control of devices, remote contact with a doctor). An important issue is to take into account the need for easy and intuitive practical use of smart devices by all users and the possibility of independent, systematic control and protection of health without the need for stationary medical visits, due to the time savings and safety of health care workers and patients [1].

The increase in the global importance of integrating the latest technologies in the field of home bathroom to support the health of users is influenced by:

- changing population profile, aging populations,
- an increasing number of people in need of health care and medical support, of all ages,
- requirements for pro-health aspects that grow with the development of interest in broadly understood well-being,
- the need for comfort, independence, improvement of the quality of life, dignity and respect,
- social awareness and knowledge of the possibilities of technological achievements and the willingness to use them and promote independence, health, well-being and quality of life,
- lifestyle changes, social, cultural, aesthetic changes, fashion, trends, preferences,
- the current social and economic situation around the world, resulting in the need for self-monitoring of health and the developing need for medical prophylaxis, taking care of immunity and psychophysical condition,
- public awareness of the need to maintain appropriate hygiene and health conditions, the importance of which is undeniable, not only in the face of the COVID-19 pandemic caused by the Sars-Cov-2 coronavirus, but also taking into account other diseases.

### **Therapeutic possibilities in the bath and shower**

Contemporary bathing solutions used in bathrooms not only provide a wide range of comfort for hygiene, but also support the health of users thanks to therapeutic and rehabilitation functions.

Innovations in bathtubs and their hydrotherapeutic possibilities include:

- Air baths - a combination of water and air.
- Bubble bath - air flows through the air jets placed in the casing of the bathtub, creating thousands of bubbles in the water, which provide various types of massage.
- Effervescence bath - thousands of tiny champagne like bubbles provide a delicate form of hydromassage.

-Whirlpool bath - water and air mix in the jets and enable a strong, targeted massage.

-Vibracoustic bath - hydrotherapy that combines water and sound vibration in a bathtub (music and vibrations of sound waves). It is a combination of hydrotherapy and music therapy.

-Hydrotherapy in the bathtub can be enriched with chromotherapy and the possibility of heating individual parts of the body through the heated surface of the bath [2].

Hydrotherapy, also known as aquatherapy, is one of the oldest methods of treatment in physiotherapy. It uses the physical and chemical properties of solid, liquid and gaseous water for medicinal purposes. It is recommended both for healthy people to increase the overall immunity of the body or to reduce stress, as well as for people suffering from numerous diseases. Due to the huge variety of treatments and the intensity of the stimulus dose, each user can choose something to suit their needs. Among the many advantages of hydrotherapy, we can distinguish the elimination of pain irritation at the prethreshold stage. The indications for hydrotherapy are: chronic diseases of the musculoskeletal system, heart diseases, cardiovascular diseases, respiratory diseases, gastrointestinal diseases, diseases of reproductive organs, injuries, rehabilitation support, insomnia, neurosis, skin diseases [3].

The latest bath devices and fittings provide greater comfort of use, taking into account the health and therapeutic role of water. Modern rain showers and shower heads can combine the function of hydrotherapy with light therapy, chromotherapy and music therapy. The operation of the different water jets can be integrated with the LED lighting mode that changes color gradually. Connecting the shower to a Bluetooth multimedia device also enables sound therapy. All functions are automatically controlled [4].

The origins of light therapy go back to the beginnings of medicine, when ancient cultures used the healing properties of sunlight. This natural non-invasive method of therapy is a branch of classical medicine, not just alternative treatment. Currently, we can talk about the renaissance of light therapy. It is influenced by technological progress, the use of light-emitting diodes (LED) and the beneficial health effects of LED light, confirmed by many years of research by NASA and various medical centers, including the Medical College of Wisconsin in Milwaukee in United States. The phenomenon of LED light therapy manifests itself in a huge spectrum of its operation and high efficiency. It is used in general prophylaxis (treatment of all systems and organs) and in convalescence, in dermatology and cosmetology. The application in photorejuvenation (anti-aging) results from the effective counteracting the aging processes. It has an analgesic and anti-inflammatory, anti-depressant and anti-stress effect [5].

### **Tunable White Concept – regulated white light and its support for the human circadian rhythm**

A significant pro-health aspect in bathroom design is the use of tunable LED lighting technology, which is a system of energy-saving cold and warm white light emitting diodes, controlled to allow the color and intensity of light to change from one range to another. The use of Tunable White Concept in the bathroom may result in better control of lighting in the interior, preventing unwanted visual conditions and glare. The influence of the color temperature of light on the circadian rhythm of the human body and the health benefits of maintaining life balance is not without significance. Project activities in this area are aimed at combining regulated lighting with health and well-being - adjustment of light during the day and regulation of circadian rhythms and melatonin production. The lighting control process in the bathroom is based on the imitation of daylight. In the morning, the higher concentration of blue color associated with morning hygiene activities provides stimulating and warning properties that increase attention and concentration, suppress melatonin formation and prepare for all-day activities. In the evening, a warmer color temperature with a lower blue color content accompanying the bath mimics the light of sunset, relaxing and calming the users before going to bed [6].

The research involving the appropriate zoning of LED lighting in the bathroom space (a mirror with integrated LED lighting installed above the sink, a surface-mounted LED luminaire above the toilet, amber LED night lighting, integrated with the handrail at the toilet bowl) was carried out by scientists from the Pacific Northwest National Laboratory in Washington state in United States. Elderly care research suggests that cool color temperatures and brightness can help prevent falls and improve visual acuity, while warmer color temperatures can improve sleep and reduce irritability and anxiety in patients with Alzheimer's disease or dementia in the late evening and at night [7, 8].

The benefits of using Tunable White Concept in the bathroom are as follows:

- regulation of the circadian rhythm,
- improving the quality of sleep and rest,
- efficiency of work and activities during the day,
- ensuring the safety of using the bathroom at night,
- improving visual acuity,
- preventing glare.

### **Interactive health reflecting bathroom mirror**

The possibility of using smart mirror technology in healthcare to predict and monitor aspects of health and disease is an idea that is applicable to the home bathroom space. The basic functions of the smart mirror include the dis-



play of messages, reminders, time, weather, environmental data, traffic data, sports scores, and multimedia entertainment possibilities. Recent research envisages the possibility of monitoring health outside medical facilities by collecting health parameters during the user's routine activities in the bathroom.

The mirror can record and evaluate the following parameters in terms of health:

- the appearance of the face and body, changes in skin characteristics,
- body posture, movement, gestures, facial expressions,
- body temperature, heart rate, blood pressure,
- respiratory frequency,
- emotional states and mood.

All of these parameters are significant health markers, and monitoring it at home promises new possibilities for more accurate and useful diagnostic indicators. Biomedical data can be linked to electronic medical records for sharing with the doctor [9].

### Smart toilet - personal health assistant

The concept of "smart toilet" is being developed with clear health implications for the population due to its diagnostic capabilities. The device can also provide early warning of virus or bacterial outbreaks. The "Precise Health Toilet" can detect many symptoms of the disease by automatically analyzing urine and feces. The main goal is to design a toilet where urine and feces can be collected and analyzed, and the results can be consulted remotely with a doctor. The challenge is to use technology that is simple, cheap and safe for the user and has an embedded data protection system - a recognition system - to match users to their specific data [10, 11]. The smart toilet is part of the technology for continuous health monitoring, which also includes Internet of Things (IoT) devices for everyday wear, such as smart watches. "Everyone uses the bathroom and toilet — there's really no avoiding it — and that enhances its value as a disease-detecting device." [12]. A solution in the form of an additional element that can be easily integrated into any toilet bowl is desirable. Diagnostic data can be automatically taken from the sample, sent to a secure, cloud-based storage system, and then forwarded to the clinician.

Projected disease detection with "smart toilet":

- White blood cell counts, constant blood contamination, protein levels and more can be indicative of a variety of diseases (e.g. infections, bladder cancer, kidney failure).
- The detection of a variety of disease markers in urine and feces, including certain cancers such as colorectal cancer or urological cancer, is particularly important in the genetic predisposition to certain conditions such as irritable bowel syndrome, prostate cancer or kidney failure.

**Tab. 1. List of smart bathroom appliances with their health functions and medical fields where their use and health effects are expected (Author's work)**

Type of equipment and technology	Health functions	The field of medicine where the control and protection of users' health is expected
Bathing equipment (bathtub, shower)	Physiotherapy - Hydrotherapy, Light therapy, Chromotherapy, Music therapy, Hydro massage, Therapeutic massage, Heat treatment	General preventive medicine, Public health, Rehabilitation, Rheumatology, Orthopedics, Traumatology, Neurology, Cardiology, Pulmonology, Gastroenterology, Gynecology and Obstetrics, Dermatology and Cosmetology, Psychiatry, Geriatrics
Tunable White Light Concept	Supporting the human circadian rhythm	General preventive medicine, Public health, Neurology, Ophthalmology, Geriatrics, Psychiatry
Interactive mirror	Health monitoring based on physiological changes, Digital detection of disease biomarkers, Telemedicine, remote medical care, Control of the general psychophysical condition	General preventive medicine, Public health, Dermatology, Ophthalmology, Rehabilitation, Orthopedics, Cardiology, Neurology, Endocrinology, Geriatrics, Psychiatry, Oncology
„Smart” toilet	Automatic analysis of urine and feces, Constant health monitoring, Digital detection of disease biomarkers, Individualization of tests (according to genetic predisposition), Telemedicine, remote medical care	General preventive medicine, Public health, Urology, Gastroenterology, Endocrinology, Diabetology, Oncology, Gynecology and Obstetrics, Geriatrics

- Individualization of tests, e.g. urine monitoring with particular emphasis on glucose for people with diabetes, blood monitoring for people with a predisposition to bladder or kidney cancer is extremely important in preventive healthcare [13].

### Conclusion

The optimized use of smart amenities in the home bathroom in the context of preventive health care and familiarizing users with the possibilities and methods of their operation can bring social effects in the face of safety, health and life threats and the growing need for additional support and medical care. Research on the possibility of using modern technologies and bathroom devices in medical prophylaxis indicate their significant potential in the field of constant health monitoring, diagnostics and telemedicine.

The wide scope of application is important especially due to the increasing number of people requiring permanent or temporary healthcare, regardless of age. This is due to the current social and economic situation around the

world, resulting from the spread of the Sars-Cov-2 coronavirus causing the COVID-19 disease, resulting in the need for self-monitoring and remote medical care, as well as the growing need for prevention and special care for immunity and psychophysical condition.

Meeting the requirements regarding the health-promoting aspects of the human material environment, in the context of broadly understood well-being, should be treated as a superior determinant and goal not only in the design of contemporary bathrooms, but entire buildings and interior architecture.

On the basis of the conducted research, great possibilities of using light and LED lighting technology in pro-health architectural design were noticed. The action of infrared light radiation and visible light of different colors can induce health-promoting reactions in the human body. On the other hand, the action of ultraviolet light with a specific wavelength can be used safely for human health in disinfecting and fighting pathogens, including coronaviruses, which is of great importance in the face of the current Sars-CoV-2 coronavirus and the Covid-19 pandemic. For this reason, research into the use of

light in design holds great potential for "healthy architecture".

## Findings

The research results summarize the fields of medicine where smart bathroom appliances provide opportunities to improve user health. They indicate both existing and forecast effects of the application.

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**Abstract:** Social health awareness in the context of medical prophylaxis influences the current trends in the design of modern domestic bathrooms. The importance of the health role of the modern bathroom also results from the current social and economic situation around the world, resulting in the need for independent health control and the developing need for medical prophylaxis, taking care of immunity and psychophysical condition in the face of public health threats. Therefore, it was necessary to investigate the health factors in bathroom design based on research and analysis of literature and materials from foreign research institutes. The study concerned design possibilities in the selection of bathroom equipment elements enabling a wide range of comfort and supporting and monitoring the health of bathroom users. The research included a review and analysis of technologically advanced solutions, intelligent solutions, including Internet of Things (IoT) technologies, ensuring health prophylaxis in the home bathroom. The potential for the use of innovative technologies and the possibility of process control, easy flow of information in relation to the external environment (e.g. remote contact with a doctor) was indicated. The need for easy and intuitive use of intelligent devices was taken into account, as well as the possibility of independent, systematic control and protection of health without the need for stationary medical visits, with a view to time and safety of healthcare professionals and patients. The research results summarize the fields of medicine where smart bathroom appliances can create new opportunities to improve user health.

**Keywords:** smart bathroom, innovation, Internet of Things, health care

**Streszczenie:** ZDROWOTNA ROLA INTELI-GENTNEJ ŁAZIENKI DOMOWEJ. Społeczna świadomość zdrowotna w kontekście profilaktyki medycznej wpływa na aktualne tendencje w projektowaniu nowoczesnych łazienek domowych. Znaczenie zdrowotnej roli współczesnej łazienki wynika również z aktualnej sytuacji społecznej i gospodarczej na całym świecie, skutkującej koniecznością samodzielnej kontroli zdrowia oraz rozwijającą się potrzebą profilaktyki medycznej, dbania o odporność, a także kondycję psychofizyczną w obliczu zagrożeń zdrowia publicznego. W związku z tym konieczne było zbadanie czynników zdrowotnych w projektowaniu łazienek na podstawie badań oraz analiz literatury i materiałów pochodzących z zagranicznych instytutów badawczych. Badania dotyczyły możliwości projektowych w zakresie doboru elementów wyposażenia łazienkowego umożliwiających szeroki zakres komfortu oraz wspierania i monitorowania zdrowia użytkowników łazienek. Badania obejmowały przegląd oraz analizę rozwiązań zaawansowanych technologicznie, rozwiązań inteligentnych, w tym technologii internetu rzeczy (IoT), zapewniających profilaktykę zdrowotną w warunkach domowej łazienki. Wskazany został potencjał wykorzystania innowacyjnych technologii i możliwości sterowania procesami, łatwego przepływu informacji w odniesieniu do środowiska zewnętrznego (np. zdalny kontakt z lekarzem). Uwzględniono potrzebę łatwego, a także i intuicyjnego wykorzystania inteligentnych urządzeń oraz możliwości samodzielnej, systematycznej kontroli i ochrony zdrowia bez konieczności stacjonarnych wizyt lekarskich, mając na uwadze czas oraz bezpieczeństwo pracowników służby zdrowia i pacjentów. Wyniki badań obejmują zestawienie dziedzin medycyny, w których inteligentne urządzenia łazienkowe mogą stworzyć nowe możliwości w zakresie poprawy zdrowia użytkowników.

**Słowa kluczowe:** inteligentna łazienka, innowacyjność, internet rzeczy, ochrona zdrowia

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