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MODERN MATERIAL SOLUTIONS APPLIED IN PEDIATRIC FACILITIES

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Abstract
New tendencies in forming of the health services functional buildings' systems shaped along with the emergence of caring for patient's mental condition in medical sciences. The interior design harmonized with the medical function became an incredibly important feature. This opened up new opportunities for the architecture of health care facilities. A positive architecture's impact on the user's well-being is remarkably important in the case of medical care units for youngest patients. For children contacts with clinics and hospitals implies the stress of separation from family and home environment as well as the fear of medical procedures that cause pain. Properly shaped space allows for the reduction of negative experiences linked with staying in a medical institution. It is worth looking at the contemporary material solutions that allow for the fulfillment of the required sanitary and hygienic standards, enabling at the same time to realize bold visions of pediatric medical facilities' designers.

Streszczenie
Wraz z pojawieniem się w naukach medycznych dbałości o kondycję psychiczną pacjenta ukształtowały się nowe tendencje w formowaniu układów funkcjonalnych budynków służby zdrowia. Bardzo ważną cechą staje się aranżacja wnętrz współgrająca z funkcją medyczną. Otwiera to nowe możliwości dla architektury obiektów ochrony zdrowia. Pozytywny wpływ architektury na samopoczucie użytkownika jest bardzo istotny w przypadku medycznych jednostek zajmujących się opieką nad najmłodszymi pacjentami. Dla dzieci kontakt z przychodniami i szpitalami oznacza stres związany z separacją od rodziny i środowiska domowego oraz strach przed procedurami medycznymi, które powodują ból. Odpowiednio ukształtowana przestrzeń umożliwia redukcję negatywnych przeżyć związanych z przebywaniem w placówce leczniczej. Warto przyjrzeć się architekturze szpitali dla dzieci oraz oferowanym współcześnie rozwiązaniom materiałowym, które umożliwiając spełnienie wymaganych norm higieniczno-sanitarnych, jednocześnie pozwalają na realizację śmiałych wizji projektantów pediatrycznych placówek medycznych.

Keywords: **Architecture; Material solutions; Health care facilities design; Hospital; Pediatrics.**

1. INTRODUCTION: A CHILD IN A HOSPITAL

This paper intends to present contemporary trends in the architecture of medical facilities for the youngest patients. It takes up the subject of spatial organization and material solutions applied in the interiors of such objects. The structure of the text has been divided into two formal parts. The first one elaborates on contemporary design assumptions that designers apply while creating a medical architecture, aiming at it being friendly for a child's perception. The characteristics of the spatial layout zones of the children's hospital including the entrance zone, admission room and registration, waiting room, diagnostic and treatment offices, is presented. This part has been presented as an introduction to considerations on the possibilities of using building materials that currently support

architectural solutions. The second part of the paper presents material solutions that can be used as individual wall barriers arrangement in medical facilities. Moreover, the paper discusses the Polish guidelines for the selection of building materials suitable for interior arrangements of this type of units.

A hospital is a traumatic place for children. Regardless of the situation, whether the youngest patients had prior experiences with staying at a medical facility, or if it is their first visit, the hospital is an environment associated with pain and fear, implying a potential separation from family as well as remoteness from the everyday habitat. The youngest patients are considered to be a difficult group for the staff since their fear of medical procedures causes violent reactions that make it impossible to conduct tests or treatments properly. A prolonged child's hospitalization is detrimental to its mental state and could result in the so-called hospital disease, which significantly impairs its further physical and mental development [1].

A number of studies conducted in the 1970s have proved the existing form of health care architecture to result in an increased stress in children [2]. Not only among the youngest patients do the overwhelming objects' scale, labyrinths of corridors, sterility of rooms, coupled with the dreaded medical technology infrastructure, cause unpleasant associations. Designers of medical units oriented on providing children with medical services currently have the opportunity and the design tools to create a less volatile environment. Research conducted under the popular trend basing the design on the obtained evidence – *evidence-based design* – has proved the properly structured interior design to be able to facilitate children's healing process, reduce stress associated with hospitalization, and thereby indirectly support parents and medical staff [3, 4].

A new, youngest-oriented, architectural design trend correlated with hospitals has been implemented for more than two decades which has been indicated by numerous monograph studies presenting the most famous investments of this type [3, 5, 6]. Objects' masses, material solutions, and spatial arrangements are created to meet children's perception. Designers arranging medical interiors, lobbies, doctor's offices or treatment rooms are aware of the special requirements of the youngest users. The latest medical knowledge in combination with the knowledge of the child's psyche is used to create space in which the process of treating small patients can be conducted most effectively.

The proper, i.e. least stressful, impact of the medical space is influenced by, among others, the access of natural light to rooms, the introduction of green areas within the premises of hospital facilities, as well as the interior design and the associated choice of finishing materials and their coloring, together with the equipment created in accordance with the guidelines of the contemporary art. The quality of the surrounding in which the patient resides affects the course of the healing procedure. Scientific research carried out on hospital wards has proven unmatched interiors to cause anxiety disorders in patients and reduction of the proper immune system functioning, resulting in increased doses of pharmaceuticals [7].

The rooms are designed in a way that allows for a round-the-clock parents' stay – regardless of the patient's age, in order to ensure the sense of security of the youngest. There are special areas in the admission room and in the corridors, which allow families to calmly wait for medical procedures, whereas play areas have lower suspended ceilings. The results of social relations' observations taking place in urban space inspired the implementation of such solutions. Being applied at the hospital, they become an added value [8].

The architecture of hospitals, clinics, and doctors' offices (especially those designed in the period of modernism) is determined by functional requirements. Additionally the aspects of medical technology are evidently the leading, if not the only, factor determining its conception. Nevertheless, designers, with their years of experience and research, are aware of the importance of feelings and emotions experienced by patients in contact with a medical facility. The formula of the formed environment affects the healing process and convalescence. The holistic medicine's approach to healing is currently spread at a much larger scale in pediatric objects, than in different facilities of other medical specialties. *European Charter for Children in Hospital* formed in 1988 by *the British National Association for the Welfare of Children in Hospital – NAWCH* – states: "Children shall have full opportunity for play, recreation and education suited to their age and condition and shall be in an environment designed, furnished, staffed and equipped to meet their needs".

1.1. First impression: facade and entrance zone

A building's facade is the first element to be seen from a long distance. Designers of modern hospitals, with the achievements of building materials' technology, can create original object's coatings of any color

or specific texture, that are also visible at night due to media animation. Such facades have been realized, among others, in London (Richard Desmond Children's Eye Center), Florida (The University of Florida Health Shands Children's Hospital) and also in Parma (The Children's Hospital "Pietro Barilla"). The aforesaid designs are based on additional, double glazed facades using mass-colored glass or metal oxide-coated glass, which incorporate light installations to create projections after dark. Most of these coatings are equipped with an original, colorful facade detail also acting as sun blinds, served by vertical or horizontal so-called *brise soleil*, movable or fixed panels of steel mesh or perforated metal plate [9].

The aesthetics borrowed from kindergartens, playgrounds and department stores, i.e. public facilities that children deal with on daily basis, is introduced also to hospitals and clinics. Transformation of the spatial formula begins already in the outer zone – the entrance area. It is shaped similarly to the public space, which does not arouse any negative connotations in the youngest. The details attracting a child's interest are often used. They include, inter alia, art installations similar to those located on playgrounds. The scale of the main entrance is adapted to children's perception. Canopies above the doors lower the entrance zone and eliminate the intimidation resulting from contact with the monumental mass of the hospital (Fig. 1, 2). Everything is created in such a way as to interest children, distract their attention, and facilitate their entry into the medical world.

1.2. Hospital's activity center: admission room and registration

Additional visual surprises are installed upon entering the hospital, in the main hall, so that the attention of the small patient is not focused exclusively on future examinations and treatments. The search for such solutions resulted in a trend focusing the spatial layout of the hospital on the inner atrium or lobby. In larger objects, a child and its guardians must undergo a registration process within the admission room before they reach the medical zone. The registration point is usually in the lobby – in the space, which resembles the market of a small town. In a metaphorical sense it is a heart of the hospital – its peculiar showcase. It combines various patient-dedicated functions – from administrative issues related to hospitalization to commercial services with shops, pharmacy and restaurants. At the end of the twentieth century many objects were formed in such a way. Hospital's atria are particularly popular in North America. The Hospital for Sick Children building in Toronto is, according to literature, a prototype for such distribution of a medical unit [2]. Drawing inspiration from popular resolutions of public spaces, designers from Zeidler Roberts Partnership

Figure 1.
The main entrance is reminiscent of kindergarten or amusement park – Evelina London Children's Hospital, Londyn 2014, Photography: A. Gębczyńska-Janowicz

Figure 2.
A child-friendly design helps to reduce anxiety in children - Evelina London Children's Hospital, Londyn 2014, Photography: A. Gębczyńska-Janowicz

Figure 3.
Bright colors and a jungle theme provide distractions for children during their visit in hospital – an example of interior design, authors: B. Misiejko and B. Konarzewska

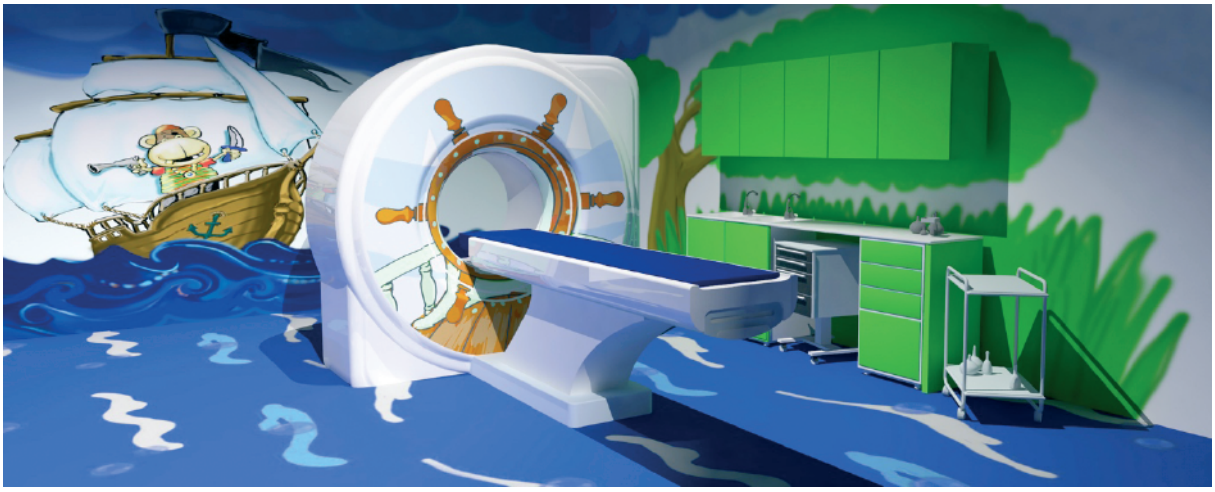

Figure 4.
The new graphic design of the devices – an example of interior design, authors: B. Misiejko and B. Konarzewska

Architects have created a logistical center for the whole facility within the atrium. The ground floor filled with cafes and shops resembles rather a shopping mall than a medical facility.

The children's hospital lobby is usually a few floors high space, well lit by daylight due to its multi-surfaced glass wall barriers. The hanging art installations, as it is in the Children's Mercy Hospital's lobby in Kansas, constitute interesting arrangement elements. Decorations include also elements scaled from the worlds of fairy tales (Arkansas Children's Hospital in Little Rock), interactive color areas and colorful light installations (Children Hospital in Phoenix), as well as a place for artistic performances (Evelina London Children's Hospital). All this aims to create a joyful and interesting environment that will provide children with effective, positive distractions from waiting for medical procedures.

Along with the constant popularity of such spatial solutions, criticism also emerged. The mail pleas concern the lack of children's and youth's participation in the design process. Impressions of future users sometimes diverge from conceptual assumptions. Some young recipients point to the intimidation by the monumental atrium's and lobby's formula as a negative feeling that occurs after getting to the entrance zone of the hospital [2].

The pediatric interior arrangers pay particular attention to the registration point located in the entrance zone. The place's character is increasingly approaching the formula of a hotel's reception desk. By virtue of children, it is modeled in a way to stimulate their interest. It may be shaped in the form of a ship's hull,

a bird nest or other forms that will stimulate child's imagination. *KidsDocs* dental clinic in Berlin is an example of such a solution. Designers from *planbar3* studio proposed an airport terminal styled waiting room. Most of the arrangement elements, starting from the plane's hull-shaped reception desk to ticket-shaped prescriptions were created to divert the attention away from the potentially unpleasant moments awaiting in the doctor's office [10].

1.3. While waiting: waiting room or passages

Another space that requires special attention from the designers is the waiting room. Children with guardians spend there the time before examinations. The unpleasant experiences in the doctor's office are increased by the stress of waiting. It is important that the waiting room's space allows the guardians to calm the impatient patients. However, this place may, through a well-arranged design, resemble a playground. Colorful walls and play corners are most commonly used as a solution for minimizing the medical character. Monitors showing cartoons and digital wall mounted game screens start to emerge together with the development of technology (Fig. 3).

1.4. Treatment process: diagnostic and treatment offices

Medical offices are the hardest space to arrange. The higher the degree of medical services' specialization, the greater the effort that must be made to provide a friendly atmosphere for a child. The graphics on the walls and colorful equipment are the most popular solutions. In offices with advanced medical diagnostic equipment (eg. magnetic resonance, tomograph), where patients spend long periods of time (over an hour), screens with images are mounted on ceilings. An increased attention is paid to the solutions aimed at hiding technical installations and other medical equipment – all as to overcome the feeling of hospital aesthetics. The design of furniture also changes. Chairs in waiting rooms, desks and closets in offices, and also diagnostic devices themselves are designed so that their ergonomics, mass, colors and plastic design of the casing positively affect small patients, maximizing drawing their attention away from the study [11].

An attempt to create a fairy tale world-like space is undoubtedly the most popular concept in such projects. The idea of a complex office interior design includes the aesthetic combination of the building's wall barriers with a dedicated medical device (Fig. 4). A tropical jungle, cosmos, safari, pirates and marine creatures are helpful inspirations. Magnetic resonances and tomographs produced by GE Healthcare are exemplary instances of medical devices designed with consideration for the sensitivity of the youngest patients. Doug Dietz, a medical device designer who had seen an 8-year-old patient's fear of examination in a hospital, made a modification of the device he designed in order to adapt it for a child's perception. The effect of the work has been favorably received by both children and medical staff. As a result, further series of magnetic resonances, tomographs and PET-CT scanners, with a thematic arrangement called: *Pirate Aventure, Coral City Adventure, Jungle Adventure* were developed. The new graphic design of the devices has contributed to the reduction of anesthesia treatments' number prior to advanced imaging diagnostics [12].

2. REQUIREMENTS FOR BUILDING MATERIALS APPLIED IN MEDICAL FACILITIES

Along with changing hospitals' spatial planning designs, the appropriate selection of building materials still plays a key role in medical facilities. The materials should meet hygienic and sanitary standards, have increasingly attractive properties, both durability, physical-mechanical and aesthetic qualities. Finishing materials available on the market allow to achieve the highest standards, while enabling the most elaborate architectural ideas come to life, aiming at the same time at creating a safe and friendly space for small patients.

Ensuring the safety of hospital's or other medical facility's users through architecture depends on three factors: external environment's conditions (air and water quality, natural light, acoustics), correctness of the spatial arrangements, as well as quality and rationality of the equipment's and finishing materials' selection [13]. Medical facilities are subject to specific requirements for planned equipment by virtue of their function, which results from legal regulations and the experience gained in recent decades in the field of healthcare architecture. Minimizing the risk of users' infection as a result of being in a medical facility's environment is one of the priorities in planning new developments. *Healthcare-associated infection* (also known as iatrogenic) is a phenomenon occurring in medical-associated objects and is one of the biggest threats to health and lives of their users.

Medical sciences have dedicated much attention over the last century to prevent the occurrence of health-

care-associated infections. The miasma theory that explained the idea of diseases transfer by means of air in the form of exhalations was a dominant justification of infectious diseases transmission still in the nineteenth century. Therefore, cleaning and ventilating the rooms in which the sick patients stayed were the main precautionary measures [14]. Research in this area has revealed a much broader field of possible ways of infecting the body by pathogens – the factors that cause the disease. Contemporary literature points to several main ways of microorganisms' transmission:

– by contact:
▪ direct transfer of the infectious factor through a person – person contact or person – object contact;
▪ indirect transfer in which a medium occurs between the source of infection and infected person, e.g. an element of medical equipment;
– by airborne contact, when the infected droplets produced while coughing or sneezing are transmitted by air;
– by air, when dust particles infected with bacteria are transferred by air;
– by ingestion, that is when the disease factor is transferred to organism by means of infected liquids and food;
– by a general medium, meaning the spread of pathogens by blood and blood products;
- by vectors, that is the pathogen's transmission by means of animals and insects. [15, 16].

Reduction of healthcare-associated infections can be achieved by making assumptions already on the investment's planning stage and including appropriate solutions in the architectural design. A highly beneficial way involving the principle of the functional-spatial system distinction into the so-called clean paths (i.e. the ones for sterile materials' transfer) and dirty paths (for transferring used elements constituting potential infection sources) is most commonly implemented. In this context it is also crucial to furnish the facility with building materials and equipment that will not constitute mediums of potential pathogens. Finishing materials aspiring to be used in medical facilities are subject to specific requirements ensuring the protection against the possible transfer of infectious factors.

Physical parameters must primarily enable the elimination of bacteria and viruses from their surface. Cleaning of the medical equipment's surface is performed on several levels. Four basic risk of infection's categories in particular areas of a medical unit are distinguished in literature:

– low – in administrative spaces;
– notable – in waiting rooms and diagnostic offices;
– high – hospital wards, treatment rooms;
– very high – operating theaters, intensive care units [17].

A suitable pathogen removal process is selected depending on the anticipated risk on infection transfer category in a planned room. In low-category zones it is sufficient to apply the sanitation process (removal of visible dirt). The two subsequent levels require the disinfection of the room's equipment surface (removal of pathogens by chemical or physical means), whereas in the case of the highest risk areas, the sterilization process is required ["a process leading to the destruction of all microorganisms' forms by using physical or chemical means] [18]". The selection of finishing materials in the medical interior must be based on the planned risk of infection's category and the associated pathogen removal activity.

According to the legal provisions functioning in the Polish legislation the materials are required to obtain suitable parameters related to the specificity of the above mentioned environmental conditions. In the current for the article's writing time *regulation of Minister of Health dated June 26, 2012 concerning specific requirements for the rooms and equipment in healthcare institutions* include paragraphs obligating the finishing materials used to cover floors, walls, ceilings and equipment to be resistant to cleaning and disinfection. This criterion must be particularly respected in hygienically demanding rooms, in particular: operating theaters and delivery rooms, bed rooms adapted for delivery, bed rooms in the anesthesiology ward and intensive care units, recovery rooms, burns treatment rooms, and in rooms for collecting and processing blood in the center.

2.1. Material arrangement – examples of solutions

Wall barriers in medical facilities must be covered with a material that will allow for maintaining their surface in a good condition for a long time, having at the same time the parameters enabling to prevent cracks, scratches and the possibility of crushing of the outer coating. All cracks and crushings contribute to the development of bacterial flora, and additionally become a potential source of healthcare-associated infections. The obtained surface should guarantee not only an easy maintenance, but in some rooms also disinfection.

The increasingly common adaptation of medical space to the children's perception resulted in the development of medical facilities' attested interior finishing materials that at the same time meet the

high demands placed by youngest users. The designers overtake in ideas on the structural, color, and graphic design. Bright colors are most commonly used for they expose the accumulating dirt and impurities. The advantage of using white in medical facilities results from the ease of detecting dirt, which is characteristic for a bright color.

In spite of a common belief that color influences the mood of people perceiving the interior, current research does not confirm that the right color palette directly affects changes in the patients' physical health [19]. However, research into the application of colors to hospital facilities conducted over the recent several years have provided new data on this subject. In his studies, Park [20, 21] examined the differentiation in color preferences in healthy and sick children. The stated hypotheses regarding the differentiation of preferences based on age and stage of a disease have not been confirmed, yet there has been a high degree of non-acceptance for white in medical spaces. Other studies [21] indicate that the children choose less vivid colors for the hospital environment, contrary to the modern coloring previously assigned for pediatric facilities. The combination of blue and green, as well as the monochrome use of warm blue, pastel green, bright varieties of warm yellow and orange were the most popular choices among the surveyed children.

Interior coloring plays a key role in the readability of the communication system within the large-scale medical units. Most hospital buildings operate on the base of the corridors system. Complex spatial system of combined medical unit's long pathways causes a spatial disorientation of its users. A visual information system that is based on graphic signs and specially developed colors constitutes an attempt preventing this phenomenon. *The Wayfinding System*, established primarily on the interior's design diversification, makes it easier for users to familiarize with the space, thus saving time for patients and staff [22]. The Evelina London Children's Hospital realized its communication system according to the aforesaid arrangement. The interior design of each of the hospital floors and individual medical units has been adapted to the characteristics of different natural environments: seaside beach, mountains, forests. Small patients are more likely to remember thematic graphics and adapted color palettes than difficult medical terminology assigned to each hospital ward.

2.2. Walls

Materials used on the walls of hospitals and clinics must obtain appropriate certifications that allow them to be used in medical facilities. The aforesaid certifications distinguish different categories of infection's emergence risk in various zones of a medical facility, in which the wall barriers are about to appear. A much higher level of hygienic and sanitary requirements is compulsory in treatment rooms, i.e. where the tissue laceration takes place, in comparison to obligations on the public communication's pathways.

The second criterion taken into consideration is the material's resistance to mechanical damage resulting from, among others, the transport by hospital carts and the increased user traffic. Any cracks and scratches of the building materials result in lowering of the hygienic and sanitary standards. For this purpose, the durable protection of walls in areas where damages may occur is implemented – mainly on communication routes and in rooms of hospitalization. Handrails and wall bumper guards on the corners are popular solutions. However, they rapidly break down if made of low-quality plastics as a result of an intensive use. More durable solution is to cover the walls with flat strips of hard materials or steel, or a full floor coverage up to a height of 110 cm with homogeneous lining or Corian panels. The last solution has an additional hygienic and sanitary advantage resulting from a jointless material transition from the wall to the floor covering.

Full panels of plastics such as: PP, LDPE, and HDPE combined in the thermoforming process are also gaining their popularity. They can be easily cut and shaped. What is more, they occur in a variety of colors with durability achieved at the stage of production due to the in-mass coloring process.

Filament fiberglass wallpapers as well meet high hygienic-sanitary and durability standards obligatory for hospital areas. This tensile, brushing-resistant material has special anti-bacterial properties. The unique method of impregnating wallpaper rolls with adhesive already at the production stage allows for their quick installation and a unitary adhesion to the surface, as well as the full tightness. Fiberglass wallpapers, such as the ones in the Systexx system, are varied – different types are designed for communication pathways and administrative rooms, while others for diagnostic rooms or doctors' offices. What is particularly important for children-oriented projects, is the possibility to cover them with photographic wallpapers.

The previously mentioned solid surface material – Corian, consisting in 2/3 of minerals and in 1/3 of acrylic resin, has gained popularity in medical institutions due to its durability (no discoloration, no loss of physicochemical characteristics due to prolonged

Figure 5.
The glass wall with fixed graphics, 2016, Photography: A. Gębczyńska-Janowicz

Figure 6.
The ceiling art above hospital patient bed, 2016, Photography: A. Gębczyńska-Janowicz

use), non-porosity and the jointless connection. For the sake of its elasticity at forming shapes it is also used to make worktops and wash basins.

Stainless steel is a specific material that is particularly applicable in the case of high sanitary hygiene. Not only is it used in production of medical furniture, doors, window frames and surgical scrubs, but also in entire systems of wall and ceiling panels utilized primarily in operating theaters. Stainless steel is resistant to corrosion, mechanical damage, easy to clean and resistant to disinfectants. The possibility of the panels' powder coating in any color from the RAL color chart, as well as distinguishing the surfaces onto matt, semi-gloss or gloss, resulted in the designed operating theaters not having to be unified, regardless of the demanding technological standards. Depending on the designer's intentions they may vary, affecting thus the well-being of both patients and staff. An increased protection against pathogenic outbreaks is obtained by an additional antibacterial coating with silver ions.

Antimicrobial copper is a material less commonly used in touch surfaces' coatings in medical facilities. Clinical trials have multiple times documented its bacteriostatic and bactericidal properties [23]. Copper alloy surfaces not only reduce microbial growth, but also effectively reduce it (removal of bacterial contamination by 90% within a few hours) [24].

Glass is also the ever more often used material in the architecture of medical facilities. It meets hygienic and sanitary requirements due to the new possibilities offered by modern technologies: bonding, bonding in tight sets or invisible coating covering. In comparison to other coatings traditionally used in wall barriers, it has better acoustic and thermal properties. Furthermore, it can also have self-cleaning, antireflection and absorption properties. The glass increasingly emerging not only on the facades, but also in the hospital interiors. Glass panels are especially recommended for operating theaters where the highest hygienic and sanitary requirements are applied. Limited resistance to mechanical damage, assembly limitations and the mirror reflection effect are, however, the unquestionable disadvantages.

Glass wall barriers with fixed graphics are incredibly popular in medical spaces, for they are enabling the interior to be more attractive (Fig. 5, 6). Examples of special graphic solutions can be found at Emma

Children's Hospital Amsterdam. The visual system was designed by Stag Gubbels.

Colorful graphics on the walls of the clinic and pediatric hospitals is a permanent phenomenon. The wall barriers covered with wallpapers, photographic wallpapers or stickers are still yet more popular than in-mass colored or silkscreen covered glass. The purpose for decorating walls or ceilings in this way is the lower cost along with the possibility for more frequent arrangement modifications.

Due to the achievements of material engineering traditional wall coatings, such as paint coatings, offer new, better properties. Paint coatings used in hospitals in addition to their mechanical abrasion resistance and chemical resistance now also have bactericidal and antifungal properties. The use of active silver nanoparticles ensures the decomposition of microorganisms coming into contact with the surface. As a result, a photocatalytic reaction emerges, in which the harmful substances decompose, contributing not only to the cleanliness of the surface, but also to the maintenance of adequate air hygiene. The initial use a special non-flammable wallpaper as a primer is necessary in case of application in aseptic rooms.

Antibacterial coatings are used not only in the form of paint coatings, but also as invisible, thin layers applied on the walls, as well as floors, equipment and furnishings. Previous methods of their production and application (most commonly applied by spraying with use of argon plasma) unfortunately cause them to be heterogeneous and easily subjected to scratching due to e.g. abrasion. Among new types of antimicrobial coatings that are still being developed, titanium and copper oxides nanolayers (TiO2/Cu), applied by a physical vapour deposition of thin layers (PVD), based on high-power impulse magnetron sputtering (HiPIMS) deserve a particular attention. This method ensures greater initial adhesion of the surface even before the deposition of the coating, and the possibility of depositing thin layers of high density microstructure.

2.3. Floors

Similarly as in the case of other wall barriers, floor materials must meet aseptic requirements depending on the degree of hygienic and sanitary risk present in a medical facility. In addition, the issues of a slippage risk, abrasion resistance (which is associated with quality's reduction), reverberation's dampening, and the phenomenon of reflection appear.

Floors in medical treatment rooms must be covered with a material that allows for easy hygiene maintenance and is resistant to detergents and disinfectants. Mechanical durability while maintaining the flexibility of the surface is equally important, therefore it is recommended to use non-penetrative, non-absorbent, and non-toxic materials with high abrasion resistance. The load-bearing capacity due to the weight of installed equipment as well as the abrasion and mechanical impact resistance must still be obtained while maintaining the surface flexibility. In rooms with advanced medical equipment the issue of protection against agents harmful to health also emerges. Materials that allow, among others, the conduction of static charges or shielding from X-rays and electromagnetic fields are applied. In order to equalize the electrical potential between the building's elements and the apparatus, they should have the ability to discharge electrical charges from the surface to the electroconductive adhesive layer. Differences in electrical potentials change the indications of the apparatus and can be dangerous for patients. Floors in radiological rooms should additionally protect against ionizing radiation, hence in the layers (directly in the concrete coating layer or under it, on construction) the protective lead or barite-concrete coatings need to be installed.

The selection of floor coverings should take into account the characteristics of the users due to the specificity of the discussed objects. The floor can constitute a cause of accidents both as a result of slippage and injuries caused by falling onto a hard material. In the research carried out so far [25] rare healthcare related guidelines were pointed out in comparison to, for example, playgrounds.

The intended acoustics of the room remains a crucial aspect in choosing a flooring material. In waiting rooms where the noise associated with children's activity should not distract the staff and other users, this criterion is particularly important.

Jointless finishings are preferably applied in case of floors used in medical facilities. In places where joints are used, their tightness should be optimized as they shall be non-penetrative and chemicals resistant.

A junction of the floor with a vertical panel is a location of special attention in room finishings. As a result of poor performance and subsequent use the dirt can easily accumulate in such areas. For this purpose, it is recommended to perform cove formers that improve the cleaning and disinfecting processes. Roundings of ceramic moulders in the case of ceramic tiles or upstands of 10-15 cm, of the same material as the floor, are widely applied.

Solid vinyl floorings laid out in sheets or rolls are the most common solution in hospitals. Their use is permitted in each of the hospital's zones: entry, laboratories, operating theaters, and intensive care rooms. Homogeneous vinyl covering with pre-applied polyurethane layers is the dominant variant of such floor coverings. A special composite cork layer can be used especially in the children's wards to improve its warmth absorbency and bump acoustics. A special attention needs to be paid to the joints and their proper protection when laying PVC.

Rubber floors are also used in hospitals, especially in high traffic areas, for they are extremely resistant to abrasion and dents, and therefore have a longer lifespan than other types of floor coverings. Since the surface of such a floor is very dense and closed, there is no need to coat it with additional protective layers. Rubber floor has a very good antislip and sound dampening properties, as well as a high degree of fire resistance and what is more, it does not emit harmful, toxic substances. It may have antistatic discharge or conductive properties.

Resin floors, used among other jointless hospital floors, are characterized by a high chemical resistance (they can be washed with aggressive detergents) and mechanical resistance, while eliminating the problem of joints and bacteria that accumulate in them. Quartz sand is added to epoxy resin in order to strengthen the resin flooring in high traffic areas. Specialized solutions for resin floors are also used for operating theaters and recovery rooms with specialized equipment (such floors collect electrical charges and discharge them to ground).

The matter of using carpets in medical facilities remains debatable. In Poland it is generally excluded due to the statutory requirement to use materials enabling disinfection. In England and in the United States, however, carpets are permitted, but only in the low infection risk zones. An unquestionable disadvantage of carpets is to keep the material in aseptic conditions, yet on the other hand its damping properties are a huge advantage [3].

The floors of hospitals and clinics are often designed in a way that leads the patient and the parent in individual offices and rooms. Different room colors are already indicated on the floor in the corridor, even before the entrance door. Most frequently smooth, wavy lines appearing on the floor, break the monotony of communication pathways. Various zones appearing on the route: waiting rooms, children's corner and entrances to the offices, are indicated and distinguished by colors or shapes on the floor.

2.4. Ceiling

The ceiling should be easily cleaned, and in particular cases also disinfected. A suspended ceiling is the most common solution as it allows to cover, but also to access a number of technical infrastructure's traction: air conditioning, ventilation or fire protection systems. Its usage results in obtaining a homogeneous surface, which makes it easy to keep the ceiling clean. Suspended ceilings for rooms with a high degree of sanitary care should be made as a hygienic, with full, airtight surfaces, dustproof, resistant to mechanical and surface damages to the material. Suspended installations and dynamically diversified suspended ceilings level the hospital's character while improving acoustics at the same time – particularly in the lobby.

Suspended ceilings in medical facilities vary in terms of technical characteristics depending on whether they are used for operating theaters, magnetic resonance rooms, hospital corridors or rooms not subject to disinfection.

Specialized ceiling tiles of rock wool and metal plates belong to the most popular solutions on the market. Metal plates are more often used in operating

Figure 7.
The LED Skylight as innovative ceiling finishing in treatment rooms in hospital, 2016, Photography: A. Gębczyńska-Janowicz

theaters, where the risk of infection is certainly high. Similarly to the aluminum grate on which they are attached, the plates have plastic attachment clips and silicone sealing joints, due to which they are hermetic and resistant to difficult conditions. Regular mineral panels are used in non-demanding rooms in terms of high hygienic rigidity. They provide excellent acoustic conditions by minimizing noises and enabling the patients to have adequate resting and convalescence conditions. Such panels are smooth, laminated with glass fiber veneer. Mineral plates are additionally coated with antibacterial paint.

Rock wool ceiling tiles are designed for both high-risk medical rooms and for rooms that have to meet the standard hygienic and sanitary requirements. Due to the material used, the tiles have the highest fire resistance class and covering them with a special washable film that tightly seals the entire module, makes them durable and resistant to aggressive detergents and disinfectants.

A particular attention should be put onto LCD, LED or OLED displays among other innovative ceiling finishings appearing in treatment rooms or patient's room. (Fig. 7). They become a part of a new design approach (Ambient Experience Solutions) of light-focused environments in which Philips, among others, is involved.

These spaces not only bring a small patient into the original, illuminating environment, but also encourage to its co-creation [26]. Designs using this technology have been realized at the Winter Park Memorial Hospital in Florida, Advocate Lutheran General Hospital in Chicago and the Charité Universitätsmedizin in Berlin. In the first two cases, a unique resonance room illumination project that moves its users into an imaginary world, distracting thus the small patients from the study itself, has been developed. The advantage that such projects have over static graphics emerges from the fact that they can dynamically change and their users can contribute in their creation. The project in Berlin, in contrast, involves illuminated panels over patients' beds enabling them to control color and intensity of light, as well as the appearance of images, to effectively support patients' recovery, stimulating their moods and encouraging them to play with available applications, such as mobile phones-dedicated.

3. CONCLUSIONS

High requirements for pediatric units have resulted in the development of finishing materials that meet both hygienic and sanitary obligations, and are aesthetically pleasing to the youngest users. A trend towards a holistic approach to the design of pediatric institutions is visible, basing at the same time, the creation on overall health-promoting environments where art and architecture play a major role. Exceptional lighting projects or overall spatial arrangements equipped with small architecture and large-scale elements are usually inspired by a fairy tale world that is close to a child's perception. The design trends inspired by the natural environment are also popular among the buildings, facades, lobbies, and corridors designs, as well as the selection of finishing materials. It is visible from the outdoor gardens and green atria, to decorative elements in the animals and plants environment, appearing in the form of graphics on all the wall barriers. All this aims at creating a complex, multisensory environment that supports small patients, their families, and staff, creating the best possible experience, and contributing to the promotion of positive memories.

The appropriate material arrangement of the children-dedicated medical interiors not only guarantees the hygienic and sanitary conditions, but through the positive influence on the child's psyche it also supports both the patient's family and the caring medical staff.

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