FLEXIBILITY IN HOSPITAL BUILDING AND APPLICATION BY MEANS OF STANDARDIZED MEDICAL ROOM TYPES

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Author biography

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Abstract

This paper presents an approach to standardization of hospital rooms. As hospitals are becoming more complex, the need for quality assurance and validation increases as well. Several sources mention the responsibility of the medical personnel for the quality and safety of the equipment with which patients are treated. The room in which patients are treated can also be seen as part of this responsibility. The hospital currently consists of hundreds of rooms with very little information available on the exact properties and state of rooms. It is thus very hard, both for medical and technical personnel, to gain insight into and be aware of the state of a medical room. This can lead to risks for the patient. In order to give this insight, we paper propose a standardization of medical rooms. Based on the hygiene and electrical safety classes, nine standard room types are defined. Additionally, rooms may have specific 'toppings' for more specialized tasks. This approach allows medical personnel to instantly acquire insight into the capabilities of a room, and the possibility of performing a certain treatment. Furthermore, maintenance requirements are clearer, there is more flexibility in room use, and it is expected that the approach will greatly simplify the planning of hospital construction projects.

Introduction

In the Netherlands, medical personnel are responsible for making sure that the medical devices used meet their specifications. The hospital and especially the medical rooms can also be considered as a medical device [1]. However, the technical specifications of the rooms are not defined clearly.

The allowed medical treatments in a medical room are directly related to the technical specifications of that room. If these specifications are unclear, the medical personnel will not be able to determine which medical treatments are allowed. In the best case the treatment is performed in an over-classified room, costing more than strictly necessary. In the worst case, the medical treatment is performed in an under-classified room, leading to unacceptable patient risks. Furthermore, in case of (re)building a department, the specifications of the rooms needed are unclear.

Although there are a lot of regulations around the room specifications, medical personnel are unable to determine what kind of room they are in, and therefore which treatments are allowed. Experts will only give advice in their own discipline. Disciplines that are often involved are: hygiene, electrical safety, laser safety, radiation safety, occupational health and

safety (OHS). This multitude of disciplines may hamper clear status information on the room.
The hospital hygienist, for example, will specify how clean a certain room must be in order to perform a certain treatment, leading to regulations for the air treatment, but the OHS will also have regulations for the air treatment. Moreover, the electrical safety regulations also state an air humidity range which provides safe working conditions. These regulations might even contradict each other, further obscuring clear status information.
In order to clarify these regulations to the medical personnel, we define standard medical room types. Each medically used room will fit in one of nine standard rooms that base on existing hygiene and electrical safety classifications.
On top of this standard nine room types, additional "toppings" are defined. So, for example, a standard room type with a laser topping will also be suitable for the use of a certain laser. The standard medical room type will have to be depicted in the room including the installed toppings.
This way, the medical personnel will be able to take responsibility for performing the medical treatment in a suitable medical room.

State-of-the-art in Dutch hospitals
Current hospitals in the Netherlands generally recognize the need for a flexible building configuration. The newly built Bernhoven hospital – opened in 2013 – applied the following core principles for the building: flexible, goal-oriented and with a human touch [2]. "Flexibel bouwen" [3] also emphasizes this notion, adding that these principles mainly apply to a polyclinic setting. Technologies such as Building Information Modeling (BIM) are applied to acquire information about the building and to create digital prototypes of the building. This allows for visualization of the building early in the building process, and the assessment of cost and other properties.
To a certain extent, hospitals in the Netherlands are already implementing standardization approaches; for example, by using the same type of blood pressure sensor throughout the hospital, or by using a unified approach to risk management for all hospital technologies. Lean approaches are also increasingly common for tasks such as medical treatment and maintenance planning.
The approach we present here was designed within the ZGT hospitals group. The ZGT consists of one hospital in each of the cities of Almelo and Hengelo in the East of the Netherlands. Combined, these hospitals serve a population of around 300,000 people. The ZGT has recognized the influence that the hospital building has on the medical process. ZGT staff members published a paper [1] and, in cooperation with Twente University, started a PDEng track in Hospital Engineering.

Literature
In literature, standardization and consequent flexibility are seen as two of the main drivers of a lean organization. One of the key principles of the Toyota product development system – which may be seen as the cradle of lean thinking – is 'Utilize rigorous standardization to reduce variation, and create flexibility and predictable outcomes' [6].
When looking at health care and hospitals more specifically, De Neufville et al [7] emphasize the importance of hospital flexibility by discussing future changes in hospital care and the advantages that a flexible layout of functional rooms bring. Several sources in literature acknowledge the possible advantages of standardization within hospitals, mentioning possible gains in quality, cost and safety [8], [9].

Problem definition

In Dutch hospitals, a typical department consists of both medical and non-medical rooms. No clear specification of the requirements of the room are shown in the room or on the outside of the room, therefore the medical personnel is unable to verify whether the room is suitable for the specific medical treatment they planned to perform. The fact that the naming looks identical (treatment room dermatology versus treatment room ENT) does not guarantee a room with equal technical specifications.
Assuming that design specifications are known, the permitted medical treatments can be defined. In order to be permitted to do the medical treatments some parameters need to be monitored. In the operating room, for example, a screen displays values such as: the pressures of medical gasses; air temperature; the relative air humidity. While active readings of the parameters can be done, the limits of the parameters are often unknown. Another problem is that not all parameters can be measured in real time [4]. The health care inspectorate in The Netherlands already obliges medical personnel to check whether medical devices meet their specification before use [5]. As the hospital and its medical rooms can be considered as medical devices [1], it is thus mandatory to be able to determine their current state. Although it is very important to verify that the medical room meets design specifications at the time of use, this paper is restricted to the design criteria and the permitted medical treatments.
When departments are upgraded or rebuilt, a clear technical specification of the desired rooms is often missing. This can lead to over-classified or under-classified rooms. Over-classified rooms cost more than strictly necessary, as they provide more facilities than required. Under-classified rooms on the other hand provide insufficient facilities, leading to unsafe situations while costing both time and money.
With a lack of clarity comes the disadvantage that when new rooms are created – for example by building a new hospital wing or renovating part of the hospital – there is little design information available. As a result new medical rooms are designed almost from scratch. Expensive medical rooms are built for each separate department, resulting in relatively low occupancy rates.
In summary, three key problems are defined:

- medical personnel need to be able to see to which regulations the medical room was built to or, more specifically; which medical treatments can be performed in the room.
- In order to increase the occupancy rate, we like to be able to share rooms among different departments.
- when departments are upgraded or rebuilt, a clear overview of the specifications of the required rooms is essential.

Approach taken
To be able to deal with the three problems defined above, only the medical rooms are of interest. So rooms such as offices, hallways and storage rooms are outside the scope of this project. However, since the scope includes medical rooms throughout the entire hospital, both technical and medical information is needed to be able to determine whether the rooms meet specification and thus whether they are not either over- or under-classified. A multidisciplinary team was set up to collect all this information. This team included the first three authors of this paper, medical personnel, a building manager, and a coordinator of construction projects.
After investigating standards, laws, guidelines and recommendations, it turned out that a lot of these standards, laws, guidelines and recommendations are intended for very specific situations that do not occur in all medical rooms. For example, there are guidelines for safe working with medical lasers [edit RIVM lasers], while in most medical rooms a laser will never be used. Hygiene and electrical safety on the other hand, apply to all medical rooms.

Therefore a standard grouping of medical rooms can be made with the hygiene class and the electrical safety class as a basis.

Proposition

To better define the variety of different rooms in the hospital and create a smarter and simpler system, a room standardization approach is proposed.

As stated before, the hygiene and electrical classes are the bases for standardizing the medical rooms. The electrical safety classes go from K0 / S0 to K3/ S3 [NEN 1010] the higher the number the deeper into the patients body the medical personnel is allowed to go. The S means that the room was built before 2007 after which the technically more strikt K class is introduced. Medically the same kind of treatments are allowed as long as they are numeral equal.

Hygiene classes H2 till H5 apply to medically used rooms, the higher the number the more strict the hygiene regulations become. The division into hygiene class is not straightforward. It depends on 6 parameters:

- Size of the incision
- Depth of the incision
- Duration of the treatment
- Implementation of materials foreign to the body
- Opening of sterile cavities
- The impact of a wound infection for the patient.

The hygiene class is determined by a hospital hygienist.

Taking the common factor of allowing deeper entry into the patient's body, a sensible combination of the hygiene and electrical safety classes can be made, as shown in Table 1. As can be seen not all possible combinations exists. The medical treatments determine which combinations are possible.

Table 1: Overview of standard medical rooms

Medical Room	Hygiene class	Electrical safety class
I	H2	K0 / S0
H	H2	K1 / S1
G	H3	K1 / S1
F	H2	K2 / S2
E	H3	K2 / S2
D	H2	K3 / S3
C	H3	K3 / S3
B	H4	K3 / S3
A	H5	K3 / S3

Supplementing these nine standard rooms are possible specific adaptations that are required in only a few cases. These include properties such as radiation shielding or the aforementioned availability of provisions for laser application.

In order for the medical personnel to be able to work with these medical rooms, all there treatments need to be rated. The medical personnel explains how the treatment is executed and the hospital hygienist and electrical safety expert determine in which medical room the treatment can be performed. At the entrance of the medical rooms, the room classification will need to be shown (see figure 1).

Figure 1: room classification

<table>
<tr><td rowspan="4">Medical room type

E</td><td>Laser safety class
L1</td></tr>
<tr><td>Radiation class:
R2</td></tr>
<tr><td>Hygiene class:
H3</td></tr>
<tr><td>Electrical class:
K2</td></tr>
</table>

The medical personnel can directly see which medical room type they are in, and can therefore look up which medical treatments are allowed and the technical staff can also see which regulations apply to the room.

Future extensions

The proposed approach provides an approach which is validated by input from several experts in the field, like medical personnel, a hospital hygienist and a electrical safety expert. To confirm that the proposed approach will actually work and delivers the predicted advantages, field trials will be preformed at two pilot departments.

Extensions can be added to the current model. As a result of research done in parallel to the research presented in this paper [4] there are several possible directions:

- extension of the medical rooms with real-time information.
- analysis of specific technologies using the medical rooms approach. This could entail hospital infrastructure related systems such as air conditioning systems. By extending to more specific systems a general requirements overview of all rooms (both medical and non-medical) is formed.

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