Recommendations for hospital construction to improve the wireless communication infrastructure environment

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SUMMARY According to a survey by the Japanese government, about 90% of hospitals in Japan have a wireless LAN and about 80% of hospitals have a wireless medical telemetry system. Due to the recent COVID-19 pandemic, the use of other types of wireless communication is also expanding. However, about half of the hospitals have experienced communication failures and other disruptions. The main cause is a lack of signal in certain areas. For wireless LANs, the most common response to a survey was "No connection or difficulty connecting to the wireless LAN". The transfer rate of wireless LANs varies according to the strength of the signal received by the terminal, one of the causes of difficulty in connecting is that a weak (attenuated) signal is reaching the terminal. There are many problems in signal propagation in hospitals. We think that most of them are due to where the antennas are positioned when the radio characteristics of the hospital building components are not carefully taken into consideration in the design phase. In this presentation, we will discuss the construction procedures that should be considered for setting up a wireless communication infrastructure in a large hospital and consider solutions to problems in the operation of information and communication facilities.
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1. Wireless communication in hospitals

According to a survey by the Ministry of Internal Affairs and Communications (MIC) and the Ministry of Health, Labor and Welfare (MHLW) [1], about 90% of hospitals in Japan have a wireless LAN and about 80% of hospitals have a wireless medical telemetry system. Nearly 98% of hospitals now allow (although sometimes only in restricted areas) the use of cellular phones, including smart phones. Due to the recent COVID-19 pandemic, the use of wireless terminals for online medical treatment, online visiting terminals, wireless surveillance cameras, wireless call chimes, etc. is also expanding.

Most of the use of wireless communication in a hospital is for business purposes, such as voice communication, wireless LAN connecting terminals to hospital information system (HIS) servers, medical telemetry systems to monitor patients' vital signs, and nurse call systems connecting inpatients and nurses. In addition, tethering has also been used in recent years for Internet access as a means for inpatients to communicate with and gather information from outside the hospital.

However, about half of the hospitals have experienced communication failures and other disruptions. According to the survey mentioned above [1], the main cause is "lack of signal in certain areas". For wireless LANs, the most common response was "No connection or difficulty connecting to the wireless LAN". The transfer rate of wireless LANs varies according to the strength of the signal received by the terminal. One of the possible causes of difficulty in connecting is that a weak (attenuated) signal is reaching the terminal. As for public cellular phone networks, there are many problems such as "no reception in certain places" or "different reception conditions depending on the carrier". In other words, there are many problems with signal propagation in hospitals. We think that most of them are due to how the antennas are positioned when the radio characteristics of the hospital building components are not carefully taken into consideration.

Especially in large hospitals, it is imperative that an accurate signal be delivered over the required range. Without the signal, patient information cannot be processed. Patient information is also used in hospital wireless communication for business. Therefore, as part of the measures to increase security, there is also a need to protect against the arrival of unwanted signals within the required area and a need to protect from interference from signals originating outside the hospital. Care must be taken to prevent information leakage.

Therefore, we will also discuss the construction procedures that should be considered for setting up a wireless communication infrastructure in a large hospital and consider solutions to problems in the operation of information and communication facilities (especially wireless communication facilities).

2. Features of Hospital Architecture

When comparing current hospital architecture with recently built office buildings, one major difference is the large number of walls and doors in relation to the floor space in hospitals. Most hospital rooms in Japan have four or fewer patients per room, except those for infants. A high occupancy rate is necessary to obtain adequate payment under the medical billing system. According to the standards for the establishment of hospital rooms, the floor space per bed should be at least 6.4 square meters, so the area of a shared hospital room (including the space between beds) is about 30 square meters. It is about 10 square meters for a private room. In most cases, except for rooms for which special fees are charged, the area is kept within this range,

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which has led to an increase in the number of doors and walls in the ward. The only rooms in a hospital building that are allowed take up an unrestricted amount of space are the intensive care unit (ICU), rehabilitation facilities, outpatient lobbies, day rooms in wards, staff stations, and kitchens. Many hospitals are incorporating light courts inside their buildings.

When considering the propagation of radio waves, the materials used for these walls, doors, floors, and other structures become an issue. If metal is used, it is obvious that radio waves will be reflected. Ordinary glass and plasterboard, which is often used for ceilings, are known to conduct radio waves. The steel in reinforced concrete reflects radio waves. The concrete itself allows radio waves to pass through, but attenuates them according to the amount of moisture it contains. Recent years have seen an increase in hospital buildings that have adopted the "deck plate method" for constructing floors. It can reduce the amount of concrete used by laying corrugated steel plates. A problem is that it is difficult for the hospital staff to know each of the construction material used.

One of the reasons for the problem of "no signals reception in certain areas" is that wireless communication facilities are designed without sufficient consideration of these building materials.

3. Stages and Problems in Hospital Construction

When constructing a hospital, the larger the scale, the more complicated the procedures and processes become. The process starts with the "design", followed by the construction of the "foundation then the frame of the building. The interior infrastructure is then added, such as air conditioning, electricity, water supply, drainage, and communications systems, followed by the preparation of the interior fixtures and finally the installation of medical and medical support equipment. Design can be divided into basic design and detailed design. In most cases, after completion of the interior work the delivery of equipment is done after several inspections, with confirmation based on the Building Standards Law, fire department inspection, and health department confirmation.

Much depends on the number of floors of the hospital building. In the case of mid- and high-rise buildings, each process is contracted separately and they do not proceed in parallel. The framing work on the upper floors may be ongoing while the interior work is being done on the already framed lower floors. In addition, the design of the location of some rooms or the purpose of room usage may change frequently, mainly at the request of the hospital. In addition, in Japan the distinction between "equipment" and "fixtures" can be confusing, especially in the area of information and communication technology (ICT). For example, nurse call systems are categorized as "equipment" because they are similar to telephones, while medical telemetry systems and LANs (including wireless LANs) are often treated as "equipment". In any case, when the installation of ICT equipment is carried out, the construction of the building frame and the interior work may have been completed.

The biggest problem with this kind of construction procedure is that there is too little sharing of information among persons involved in these stages. Even when information is shared, it is often only in the form of drawings. In some cases, design changes that occur in hospital wards during the construction process are not properly shared. As a result, necessary information about the material of walls, doors, and floors is not properly communicated. Sometimes the correct location of the antennas cannot be determined due to the lack of information in the design. This also includes a lack of information about radio wave propagation. As a result, it makes impossible to simulate correct electromagnetic wave propagation, which in turn causes problems in their propagation. In many cases, hospital staff are not allowed to enter the building until after the completion of the inspection. This is problematic because it is difficult to determine if the antenna location is correct just by looking at the architectural drawings.

Care must also be taken when a hospital building is renovated. For example, when a multi-bed room is converted to a private room, new wall is inserted. If the use of a room changes as a result of a major renovation, the new wall material may be different than the original. Radio wave propagation may change depending on the material of these new walls.

4. Possible Solutions

In order to solve these problems, it is important that hospitals carefully plan for the introduction of wireless communication from an early stage and have it taken into account during the design stage. The person in charge of ICT facilities should share information with the building constructor and the supplier of wireless communication facilities, and should be involved in the basic design of antenna locations, taking into account any design changes that may occur during the construction process.

In addition, during the ICT system design process, it is necessary to collect as much information as possible on the materials of walls, doors, floors, and other structures and to conduct electromagnetic field propagation simulations. This makes it possible to visualize the range of radio waves, which helps their evaluation by hospital staff.

Wireless medical telemetry systems (WMTS) may have a leaky coaxial cable as an antenna. In this case, it is necessary to insure in the design stage that the cable does not come into contact with metal. Therefore, the specific selection of the medical telemetry system should be made at an early stage [2]. Fig.1 shows a flowchart of recommendations for the installation and management of WMTS and details of the sharing to be done. Fig. 2 shows the points to be considered for setting WMTS antennas during construction [2].

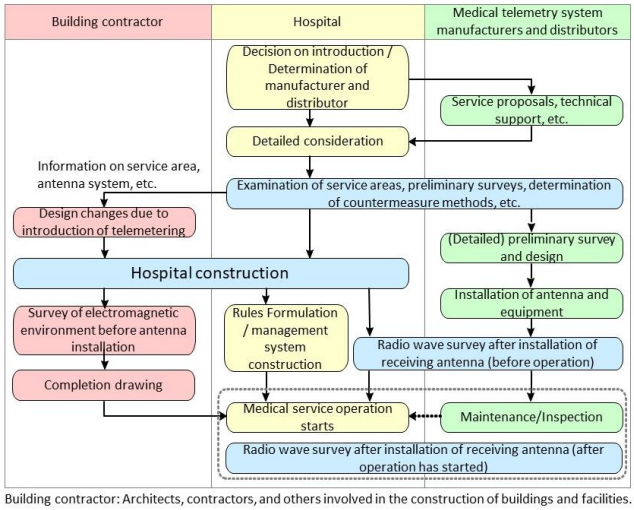

Fig. 1 A flowchart of recommended WMTS installation and management and details of the sharing to be done [2]

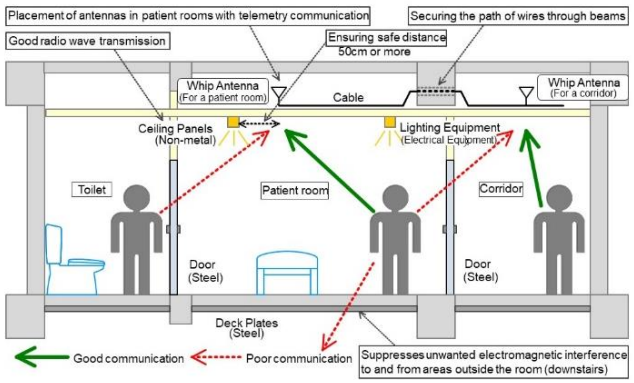

Fig. 2 Points to be considered when installing WMTS antennas [2]

If any renovations or installation of new metal products are planned in areas where wireless LANs are used, electromagnetic field propagation simulations should be conducted in advance. Alternatively, a survey of signal propagation (a site survey) should be conducted after the renovation or installation. A signal propagation survey for can be done using a transmitter and a special mode built in to the receiver of WMTS. Most WMTS receivers have a mode that shows the strength of received signals. The recommended C/N (Carrier to Noise) ratio is at least 30 dB. A simple signal propagation survey for Wireless LAN can be done using freeware on a smartphone, such as “Wi-Fi Analyzer”.
Based on the results, the need for addition or relocation of antennas should be considered.

5. Future Prospects

On July 30, 2021, the Electromagnetic Compatibility Conference Japan (EMCC) published a revised version of "A Guide for Safe and Secure Use of Radio Waves in Medical Institutions" [3] in cooperation with MIC and MHLW. The Architectural Institute of Japan (AIJ) published "Guidelines and descriptions for building planning considering the use of radio wave equipment in medical institutions - For Wireless medical telemetry systems -" [2] on September 25, 2021, as an environmental standard in cooperation with MIC and the EMCC's "Committee for Radio Use Promotion in Medical Institutions" and the Healthcare Engineering Association of Japan's "Radio Communication and Electromagnetic Environment Research Committee (ad-hoc)" The main targets of the EMCC guide are WMTS, Wireless LAN, and cellular phone use in hospitals. The AIJ guidelines are specific to WMTS.
In this way, guidance on how to build a foundation for the safe and secure use of radio waves in hospitals is being prepared in Japan. The use of wireless communication in large modern hospitals is essential for quick and accurate information sharing. In order to promote the development and application of information and communication in our field, it is necessary to continue to raise awareness of these infrastructure possibilities and problems and to provide a better environment for their use.

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