



## Medical Facility Management under BIM Paradigm for Hospital Operations Performance in China During COVID-19

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### Abstract

Hospitals operation is becoming a major focusing points on China as there is a huge market because of aging population. The management of healthcare institute is crucial as it contains operational activities that can be harmful to public health such as medical waste as well as medical equipment that has to be maintained timely. In particular with the pandemic COVID-19 situation, the maintenance of the medical equipment is the foundation to ensure the healthcare service can operate functionally. Hence, this research is focusing on how medical facilities are being managed in Chinese healthcare institute as well as to understand whether and how BIM can impact healthcare facility management. A mixed methodology was used to interview facility managers in the province of East China region during COVID-19 period. The result of this research shows that by adopting BIM, the quality and efficiencies of facility management for key hazard assets in hospitals can be improved in principle because of the large amount of asset data and hospitals' information.

**Keywords:** BIM; Healthcare Management; Operation Management; Facility Management, Integration

### 1 Introduction

Poor facility management in healthcare institute will cause multiple problems, for example, delay in diagnosis and treatment, which will end up with medical malpractice. Modern healthcare institutes contain large amount of medical facilities, which demand efficient management to ensure the normal operation of healthcare services. Traditional way of managing these facilities has limitations because these facilities require information coordination and data visualization to assist management team to make sufficient decisions. BIM is playing important role not only in design and construction, but also in facilities and assets management stages (Eastman, 2011). ISO-19650 specified in 2018 has defined Assets Information Requirement (AIR) and Assets Information Model (AIM) to regulate how BIM can be implemented to maintain building operation. BIM have board capacities in facility management, e.g., comprehensive visualized management (Wanigarathna et al., 2019) and can improve the productivity in AEC industries (He, Wang & Ying, 2011). With the situation of pandemic COVID-19, the hospital management in China is becoming more strict, all

medical facilities operation are required to follow rigorous rules for public safety purposes.

There needs to be an efficient solution to manage medical facilities, therefore, adopting BIM paradigm for facility management in healthcare institute can potentially increase its operation performance. It has been studied the impact from BIM to facility operation, which shows the earlier intervention of BIM, the more impact it can have to the later facility management (Deutsch, 2011) Implementation of BIM can significantly increase the resource allocation (Elbeltagi, 2014), hence, BIM has potentials to fill the gap in healthcare facilities management. This researchers explored all kinds of medical facilities in healthcare institute, like what their contribution to the hospital operation is, and what things people need to be aware of during its management. Then, the research concludes how BIM intervention can contribute to these operations from information management aspects.

## 2 BIM and Facility Management in Healthcare

### 2.1 Medical Facility Classification

Modern healthcare institute in China consists of all set of medical equipment, ranging from emergency to outpatient and inpatient. China has large population, which will cause large number of people seeking medical diagnosis and treatment daily. How to efficiently operate the hospital with modern medical facility is always a concerning issue, despite the fact that many solutions are implemented, there is still space for improvement. There comes a demand as to how these facilities need to be managed under modern techniques. Research shows different facilities need to be listed based on their priority and accessibility (Shehata & Rodrigues, 2018). Also, the facility information needs to be well-organized and managed to ensure the normal operation (Holzer, 2016).

With the above situation and criteria, this research goes into classification of medical facilities, and how the medical facilities can be categorized into fixed assets and portable assets (Table 1). Certain large medical devices have high radiation; therefore, need special insulated space to place them. Small size medical equipment is usually together with the out-patients office in order to have prompt action. A case study in Sutter Medical Centre Castro Valley in the United States proves the added value of BIM and Integrated Product Delivery (IPD) to better patients' experience, hence shorter stay at the hospital (Khemlani, 2009).

**Table 1:** Classification of Medical Facilities

<b>Fixed Assets</b>	
Medical Treatment Properties	To take the action as medical treatment and medical examination
Non-Medical Treatment Properties	To assist the operation of healthcare service.
<b>Portable Assets</b>	
Emergency Medical Facilities	To take along with ambulance the action of first aid
Non-Emergency Medical Facilities	To assist the medical service both inside hospital and outside hospital.

Another important aspect that we need to be aware of during the healthcare facility management is the medical waste because of the potential hazards. According to the review of relevant medical regulations, medical equipment can be categorized into hazardous and non-hazardous (Table 2). These hazard facilities will potentially cause contamination in both physical and chemical way, which requires strict regulations during the operation to ensure the public safety. The operation of healthcare facilities require data to be properly recorded and archived. Therefore, the intervention of BIM in healthcare can impact information coordination during the asset management.

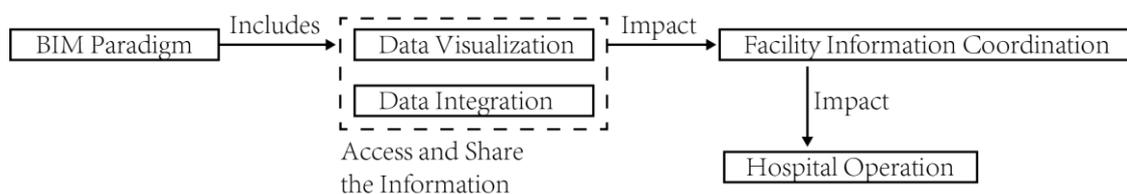
**Table 2:** Potential Hazard of Medical Facilities

Potential Hazards	
Physical Hazards	This contains the radiation, noise, light pollution.
Medical Wastes hazards	This contains the medical residues which have a potential to contaminate the surrounding environment.
No potential Hazard	
Heavy Equipment	Large size facilities, which are not easy to remove, and must be installed in one place.
Light Equipment	Portable device, can be carried anywhere both inside and outside the hospitals.

Ensuring efficient patient diagnosis, treatment, and public safety requires good management of healthcare facilities; however, current researches do not contain any relevant study into healthcare justifying additional reasons of BIM integration besides, capital expenditures and operational expenditures. Henceforth, the intervention of BIM paradigm that could organize and visualize this information in a structural way could enable facilities managers to understand holistically the deployment and the properties of the key hazards as part of the facility operations.

## 2.2 BIM and Medical Facilities Operation

The management of different medical facilities need to consider their difficulties to operate. Due the potential risks, the operation of healthcare facilities requires certain skills, which needs different levels of training. Efficient management of medical facilities provides good treatment qualities, thus will save the life of patient, however the poor facility management will lead to poor treatment due to delay in diagnosis and decision making, and will potentially terminate the life of patient, especially in the emergency situation such as car accident and heart attack. Precedent research has demonstrated that adopting BIM in healthcare system can enhance the information operation coordination, thus can benefit the decision-making progress (Zuo, 2018). The facilities in healthcare institutes require sufficient information coordination to ensure the efficient maintenance, and a previous study shows the use of BIM model can contribute to avoid resource waste and to avoid maintenance mistake (Dixit et al., 2019). Figure 1 shows within BIM paradigm, information coordination in medical facility management can be impacted by data visualization and accessibility, which can impact the hospital operation performance.



**Fig. 1:** BIM Impact on Facility Management

The management of medical facility is an important aspect in hospital operation. Implementation of BIM can enhance facility management performance and those relevant detailed methods have been well researched by many scholars (Shehata & Rodrigues, 2018). Precedent researches have shown that BIM enables optimization and faster operation process in facilities management (Fu, 2018). The relation between BIM and facilities management and offered valuable solutions has also been studied to show its feasibility (Hilal, Maqsood & Abdekhodae, 2019). The outcome of adopting different measurement to investigate facility management have been explored by previous studies, which provides the valuable assessment solutions (Bröchner, 2017). Adopt BIM is a tendency in

Architecture Engineering Construction Operation (AECO) market regardless of time span (Reng, 2018). Talking from these perspectives and considerations, healthcare institute requires efficient resource allocation and management methods to ensure good medical treatment qualities. Regardless BIM having great advantages in managing data and information, its role and impact on healthcare facility management needs to be further investigated.

### 2.3 Management of Medical Facilities with BIM

In modern Chinese hospitals, national and local standards have regulated how medical equipment in hospitals needs to be operated. Precedent researches have been taken into consideration as to how information system can help the management of hospital, which shows the importance of clear and systematic asset information (Cui et al., 2016). Many high-tech medical equipment in Chinese healthcare institutes are imported, hence, it is quite important to know the daily operation and maintenance. With the intervention of BIM and many state-of-art technologies, e.g., Internet of Things (IoT), Near Field Communication (NFC), and Radio Frequency Identification (RFID), many facilities are becoming easier to manage. Some researchers have explored numerous technologies in AECO industries and have verified their impacts during the practical implementations (Wei et al., 2019) BIM paradigm highlights that these technologies need to be implemented by using appropriate methods and process (ISO, 2018a). In addition, improvement of the energy performance of facility management in Chinese public-funded healthcare institutes through integrating BIM has been validated by precedent researches (Wang et al., 2016).

The management of medical facilities need to comply with relevant criteria, and well-coordinated information that can improve the facility operation performance. Medical facilities are healthcare assets, due to their complexities and large numbers, they demand the intervention of information management in modern hospitals. BIM has strong capability in managing building asset information because the operational performance of building assets relies on the action taken by facilities management team (Fraser, Gunawan, & Goh, 2013). The powerful information integration capability from BIM can help medical team to have better coordination to make efficient decisions. Application of BIM will enable management of the building asset information from life-cycle perspective (Andersen & Findsen, 2019). Adopting BIM can reduce certain risks and avoid fatal error because it has strong visualization capabilities to increase the management performance (Cheng, 2017). Hence, modern Chinese hospitals can improve medical operation from the increased building asset management.

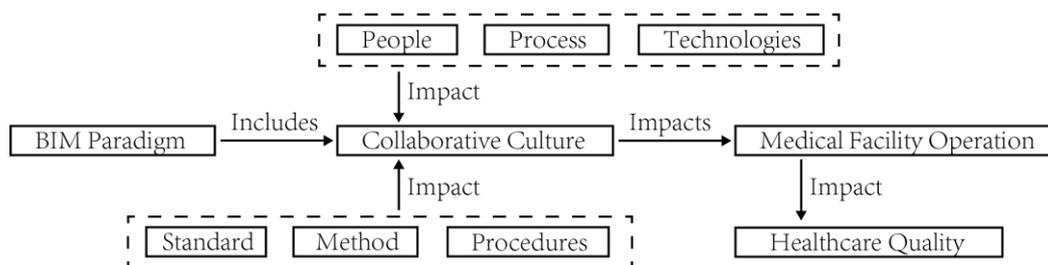


Fig. 2: BIM Impact on Healthcare

Furthermore, the development of a collaboration culture allows better integration of the overall management performance (Kapogiannis, Fernando & Alkhard, 2021). Figure 2 shows the impact from collaborative culture to facility management in healthcare institutes, the collaborative culture is not only impacted by people, process, and technologies, but also by standard method and

procedures. Hence, under BIM paradigm, it is widely accepted for its strength in collaborative management, and its role on information coordination has been well-recognized, therefore, precedent researches are considering BIM as a system that helps to clarify the process and development in AECO industry (Gholizadeh, Esmaeili & Goodrum, 2018), then its role is to support efficiency on hospital building operation and to prevent operational difficulties (Sijtsema, Gluch & Sezer, 2019). Therefore, the discussion of secondary data shows if facilities management in healthcare institutes fully adopt BIM in their medical equipment operation, it should enable a range of benefits that might impact patient experience and an efficient way to manage their resources. Section 3 of this paper has discussed the analysis of primary data to measure the feasibility of taking features of BIM into hospital management.

### **3 Potential Application of BIM in Healthcare in China**

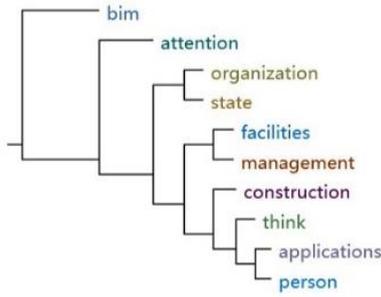
#### **3.1 Research Methodology**

The research uses mixed method approach. In total researchers received samples from 9 facility managers from 9 different hospitals in the East China region, therefore, the research is limited in lack of generalization. However, considering COVID -19 phase where the region was in lockdown and had limited access, the research is being considered as a preliminary and feasibility study. From this perspective, structured interviews took place followed by surveys, which were used to learn the opinion of facility managers in relation to the current status of asset management systems in Chinese hospitals, which reviews the potential of BIM integration in China retrospectively.

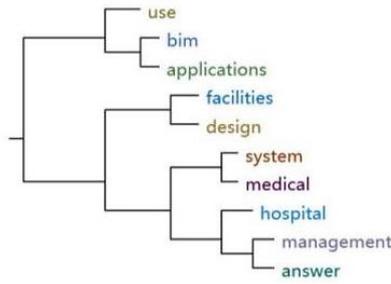
#### **3.2 Qualitative Data Analysis-Understanding Facilities Managers Perception on BIM Integration**

Considering a brief introduction on BIM and its benefits, for the first question in relation why BIM might help facilities management in Chinese hospitals, the word counts from the interview data shows that “Hospital”, “Use”, and “Design” have top frequencies (0.90%, 0.89%, and 0.87%). However, on the question of which factors should be used prior BIM integration, data shows “Think (28 times)” and “Reason (20 times)” have top frequencies. That means that it is mandatory to explore how BIM could be better utilized to understand the reasoning behind (business case) justifying the investment. As part of the reasoning the interviewees highlighted the importance of “Design (57 times)” and “Management (46 times).” These two words reflect BIM having potential in design stage within the hospital operation stages.

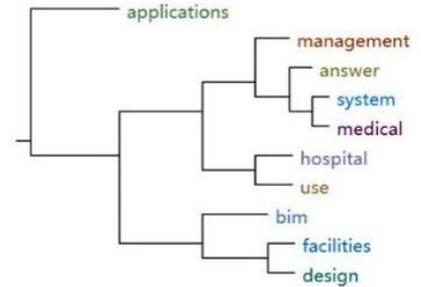
According to interview data, healthcare management is categorized into four parts: Finance, Treatment, Logistic, and Procurement. For the healthcare information, it goes into: Patient, Medicine, and Facilities. These functions and information are equally important to make healthcare institute running properly. The interview data shows in current Chinese hospital, there is already an information management solution being implemented, which uses a software named Tute, and its role is to manage the medical and patient information. The potential advantage of BIM is to improve the information coordination in healthcare management because BIM has great advantages in facilities management that can improve medical treatment performance. This happens because of technology inclusion. The major concern of an interviewee toward BIM implementation in healthcare management is focusing on whether this can increase the information coordination compared with current technical solutions.



**Fig. 3:** Macro Perspective



**Fig. 4:** Medium Perspective



**Fig. 5:** Micro Perspective

To further explore the interrelations, this research uses NVivo to make clustering analysis from macro to micro perspective (Figure 3 to Figure 5). The macro perspective is focusing on the overall impacts from BIM. Figure 3 shows the role of BIM has the leading position to the entire hospital operation. The entire procedure is driven by people, process and technology under BIM criteria. The medium perspective is focusing on the impact from BIM to medical treatment. Figure 4 shows the role of BIM is assisting facilities management to make the healthcare services, which acts as tools to manage all the relevant information. Figure 5 shows the role of BIM in micro perspective. In this scenario, BIM is guiding the design of healthcare facilities, which is impacting the overall healthcare operation and management.

From the above data analysis, it can be concluded that the implementation of BIM in Chinese hospitals is: a) Acting as a leading power, to provide process and assign tasks to the entire project. b) Acting as tool to solve certain issues, driven by demand. c) Acting a solution to address certain group of problems and manage a range of tasks.

### 3.3 Quantitative Data Analysis-Potential BIM Integrated System Intervention

To measure whether BIM is a possible solution to improve healthcare services, a quantitative survey has been taken to analyze people's attitude towards the way healthcare facility management needs to be in the future. For understanding whether information management is required in a hospital, data shows despite the fact that there are 75% of people having certain degree of expectation towards the future healthcare management, still 50% of people have no idea what kind of system needs to be adopted. There are 37.5% people who think integrated system will be adopted in hospitals in the future and 12.5% people think other system will be adopted. The interview also goes into the satisfaction of current healthcare management. The data shows that 75% of people are satisfied with current management solutions.

There are certain barriers to promoting BIM in healthcare service, according to the statistics, there are over 60% of people who think adopting BIM will increase costs. Also, the understanding of BIM is another concern, the result shows that 50% of people have never heard about BIM, while only 12.5% of people understand BIM very well. The rest 37.5% of people have just briefly heard about BIM. Moreover, the interview goes to investigate how people think that BIM can be integrated with medical facilities management, results show that 50% of people think BIM will never be integrated with healthcare facilities and 12.5% of people provide no answer, there are 37.5% of people who think BIM has great potential to make intervention.

With the quantitative data analysis from the primary interview and questionnaire data, it can be

concluded that: a) Integrated information system is needed for healthcare service development. b) BIM needs to minimize its costs during the implementation. c) The advantages of BIM need to be better promoted and educated.

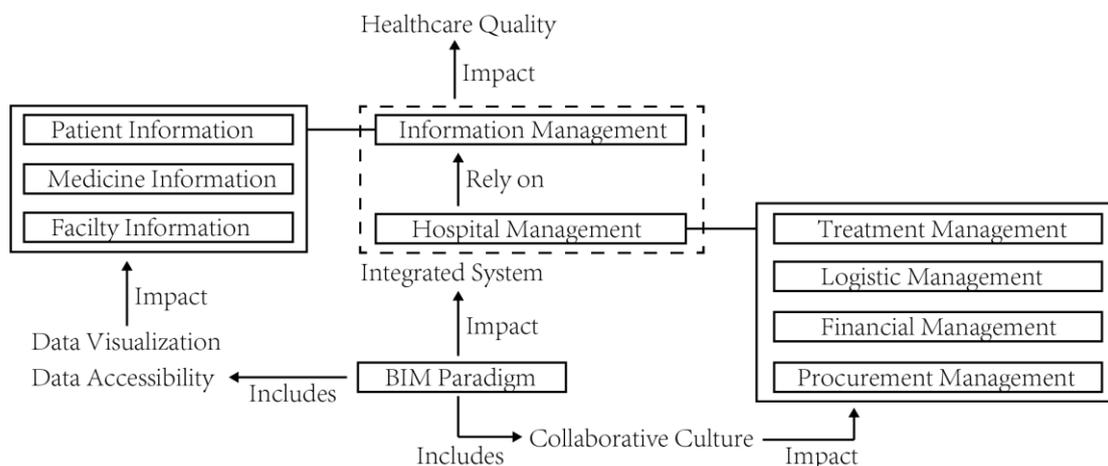
#### 4 Conclusion, Limitations, and Future Research

This research has clarified that it is possible to integrate BIM into healthcare facilities/asset management based on primary and secondary data analysis. The collaborative culture from BIM paradigm can impact information coordination in medical facility management, thus to further impact on medical treatment quality and the enhance hospital operation performance. Considering the fast growth of designing integrated solution for the AECO sector, then hospital buildings have to integrate BIM paradigm in a way to solve critical problems such as equipment operation and waste disposal, so that the treatment quality and public responsibility can be assured. According to the findings from primary data, the demand from information to hospital management is listed in Table 3, thus, there is a high demand to use the strength of BIM to access and visualize healthcare data, which particularly can fill the gap in facility information and treatment management.

**Table 3:** Demand from Information to Hospital Management

	Finance Management	Logistic Management	Treatment Management	Procurement Management
Patient Information			Yes	
Medicine Information			Yes	
Facility Information	Yes	Yes	Yes	Yes

The research identifies the demand of hospital operation from the outstanding, and the findings shows different medical facilities need to be accommodated with diagnosis and treatment to ensure patients can mitigate the suffering. The research also identifies the potential hazard generated by medical facility operation need to be properly managed to respond to public liability. The research highlights the strength of BIM, compares its advantages from AECO disciplines regarding building operation management, reiterates its potential role in healthcare facility management. The findings show the facility information is highly linked with treatment management as facility rely on finance, logistic, treatment, and procurement, while treatments rely on patient, medicine, and facility information. (Figure 6) shows under BIM paradigm, it can have impact on developing an improved integrated system to increase the coordination of above information, thus, the performance of hospital management can be enhanced.



**Fig. 6:** Research Findings

However, the findings from this research is limited in sample quantity and diversity, therefore, it does not comprehensively cover all the situations in the country. Due to the medical resources not being evenly distributed, some areas still operated in a very traditional way, which is lack of digitization to manage healthcare services. Thus, how BIM can impact these area's hospitals is still waiting to be investigated. Furthermore, the research is standing from AECO asset information perspective, which has limited focus on how medical services are operated, hence, it may cause some bias regarding whether BIM can contribute to medical information management. This research is a preliminary study to measure the feasibility of using BIM in hospital management. The future research will go deep into medical diagnosis and treatment in healthcare institutes, to take in-depth exploration with medical professionals to examine how those characteristics in BIM can impact on healthcare service.

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