

Incorporation of Medical Equipment Planning in Healthcare Facility Construction Project: A Review

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Abstract

Article Info Volume 82 Page Number: 2087 - 2093 Publication Issue: January-February 2020

Article History Article Received: 14 March 2019 Revised: 27 May 2019 Accepted: 16 October 2019 Publication: 12 January 2020

Keywords: Healthcare Project Management, Medical Equipment Planning, Hospital Construction

the healthcare facility construction a long-lasting success.

Medical equipment planning is important to ensure the right equipment

that fits the right goals is selected, purchased, delivered and

commissioned within the right cost and at a right time in accordance with

the project build programme. However, it is often delayed or worst neglected during the construction of the healthcare facility. This paper hence appraises the incorporation of medical equipment planning in healthcare facility construction project. Via literature review, it is found that maximizing medical equipment planning at the initial stage of the project will contribute to less changes and costly mistakes hence making

1. Introduction

Medical equipment serves as the enabler of efficient and effective healthcare services provided by the healthcare system. Increase in technological dependence on the applicable state-of-the-art medical equipment, which can be in the form of simple equipment, such as laryngoscope or maybe more complex and expensive modalities like Da Vinci robotic surgery, has now become an integral part of every healthcare facilities. Healthcare technology hence is suggested by this paper as the cornerstone of the optimum quality of healthcare delivered through a better access to prevention, diagnosis, therapeutic, treatment, rehabilitation and health education services. As quoted in [1], technology smooths the way for the delivery of the 'human touch', where in this scope, technology refers to medical equipment.

The process of acquiring and incorporating medical equipment itself is a complex activity as it involves few criteria to be fulfilled based on the type of healthcare facility provided by the healthcare providers, whether it is a multi-disciplinary or specialised hospital. Few factors such as availability of the health workforce, location of equipment to be used, type of diseases to be treated in the specific catchment area as well as clinical engineering requirement involving the equipment life cycle to draw up its sustainability plan shall be taken into account to ensure the deployment made will lead to a common goal for every stakeholders involved [2].

However, the importance of ideal planning for medical equipment often delayed or worst neglected during the construction of the healthcare facility [3, 4]. There are also limitations in obtaining articles addressing medical equipment planning in project management using all applicable terms, such as 'project management and clinical engineering' and 'project management and medical equipment', hence showing that the area is underdeveloped [2].

Healthcare facility projects often associated with a complex processes due to the long list requirements set for each processes, such as various stakeholder's needs, wide range of services and functional units, multiple building components and systems, progressive state-ofthe-art healthcare technologies, specialised function, legal and authority regulation requirement, budget limitation



and different financing method [5]. Zooming in to the progressive technology criteria relates back to the needs of having proper incorporation of medical equipment planning into the design and construction processes, which will later contribute to the overall project success.

In general, medical equipment planning can be defined as a specialised process that requires an intelligible understanding of the clinical needs as well as intricate mastery on the equipment life cycle, budgeting, architectural design and building processes [6]. The ultimate goal is to ensure the right equipment that fits the right goals is selected, purchased, delivered and commissioned within the right cost and at a right time in accordance with the project build programme. Medical equipment planning is iterative much like the project design and construction process [7]. Therefore, it requires specialised personnel technically and clinically, to oversee and come out with the right costing, facilities plan and requirement, and specification of the equipment to fit in the anticipated clinical services and focus on details over time throughout the project phases.

Nevertheless, arise a question of at which phase this compound should be initiated within the project timeline. This paper hence aims at appraising the incorporation of medical equipment planning in healthcare facility construction project by providing some insights based on the reviews of the currently available literature on when and how best medical equipment planning shall be incorporated into the healthcare facility construction project.

2. Incorporation of Medical Equipment Planning Into Project Phases

This section elaborates the correlation of medical equipment planning with each phases of project life cycle in healthcare facility construction.

PHASE		PROC	ESS / AC	IIVIIY				
1.	Strategic Plan and	•	Project	concept	and	mission	statement	
Analysis		development						
		•	Assessment of internal and external factors, risk					
		and opportunities						
		Clinical strategic plan						
		•	Feasibility study					
	• Financia				al strategy			
2.	Planning	•	Project delivery team establishment					
		•	Master facility plan					
		Cost projection						
		•	 Regulation and code compliance 					
		•	Project d	lelivery sch	edule			
3.	Design	•	Schemat	ic design				
		•	Simulati	mulation / Mockup – Proof of concept				
		•	Iterative	developme	ent		-	
		•	Final de	sign layout				
4.	Construction	•	Construe	tion docum	entatio	าท		

Table 1: Process or Activity in Healthcare Facility Project. Summarised from [6, 9, 10]

Project Life Cycle

Like any other project, healthcare facility project also undergoes common project life cycle, consisting of analysis, design, build, test and deliver [8]. However, as healthcare facility is often associated with agile environment with high level of complexity, iterative life cycle may benefit more in the success of the desired final product through learning and process improvement. Phases of project life cycle in healthcare facility construction is illustrated in Figure 1.



Figure 1: Healthcare Facility Project Life Cycle. Adopted from [6, 9, 10]

To further understand the role of each life cycle, a summary of processes involved is tabulated in Table 1.



	•	Construction risk management
	•	Project execution / construction
	•	Equipment delivery and installation
	•	Pre-commission documentation
5. Commissioning	•	Hand over
	•	Post-occupancy evaluation
	•	Safety review

Where and When to Incorporate the Plan in the Project Phases

Referring to the process or activity schedule, medical equipment planning is generally initiated at the start of the design phase. The conventional approach of having architectural and engineering component to be ready before equipment planning integration does not in line with the real needs of the desired outcome, whereby medical equipment planning shall be in parallel to the overall project sequence [9, 11]. Figure 2 illustrates the overall process of project delivery inclusive of medical equipment planning.



Figure 2: Overall process of project delivery inclusive of medical equipment planning. Adopted from [9]

Ideally, the best incorporation time for medical equipment planning shall begin since the beginning of project concept during strategic analysis. At this stage, the involvement may not require up to detailed specification and mechanical electrical requirements, but more to the understanding of the needed technology, which includes medical equipment, to fit in the clinical and business strategic plan according to the project concept and mission statement. The approach is more of technology assessment to determine how best the technology can support the clinical strategies that will later derive detailed planning of medical equipment [12].

The greatest attention of the detailed incorporation shall then take place during the planning phase before the design stage starts. Based on the technology assessment done in the earlier phase, the type, quantity, budgeting, technical configuration, specification, and space requirement, as well as procurement approach of medical equipment can be derived further as part of the overall concept design and master facility plan hence bringing the best information needed by the project team [12, 13]. While in the design stage, every identified requirement to the end user prior to hand over process to verify its functional and safety requirements and ensure the clinical services can be operated smoothly [6].

3. Approach for Medical Equipment Planning

Medical equipment planning can be considered as mini project management within a bigger scope of the overall healthcare facility construction project. To ensure appropriate deployment of technological innovation with maximum impact of health outcomes via the acquisition and utilisation of medical equipment for the overall project outcome, the planning of medical equipment shall be based on Healthcare Technology Management concept [15]. The components of medical equipment planning is divided into three major areas, planning, procurement and management [9] as shown in Table 2.

Table 2: Components of medical equipment planning [9]

Planni	ng	Procu	irement	Management		
•	Needs	•	Specifi	•	Installati	
assessment		cation		on		
•	Techn	preparation		•	Accepta	
ology		•	Tender	nce		
assessment		preparation		•	Commis	
•	Facilit	•	Tender	sionir	ıg	
y evaluation		issuance		•	User	
•	Budg	• Evalua		training		
eting		tion		•	Equipme	
•	Priorit	• Tender		nt operation		
y setting		award		_		
•		•	Equip			
		ment delivery				

These components shall then be reconciled with the overall project management processes before being distributed among knowledge areas in project management throughout the project life cycle. [2] has identified 34 processes needed to be performed by medical equipment planner as part of the overall process of planning incorporation of which amongst all include the project charter development, health services requirements collection, scope definition based on technological solutions available in the market, schedule management planning and analysis of the cost of ownership of identified technological solutions for budget



planning. The processes developed are based on the knowledge areas identified for project management.

Integration Management

Integration management is the coordination of all project elements in making various processes with regards to medical equipment planning components work together to achieve the goals of the main healthcare facility construction. This knowledge area requires the development of project charter as a generic reference document for a clear understanding of the preliminary roles and responsibilities of the project inclusive of project objectives, deliverables, and appointment of project manager [8].

In medical equipment planning of a healthcare facility construction project, project charter shall be prepared by the medical equipment planner who serves as the project manager during the strategic management and analysis phase once the project concept and mission statement have been identified [6]. Medical equipment scope statement and identification inclusive of medical brief of requirement (MBOR), equipment classification with mechanical and electrical requirement, information and communication technology (ICT) requirement, latest technology evaluation and estimated cost shall be developed during the planning phase based on the assessment done from the initial analysis [16].

While at the construction phase, clear direction on the procurement, delivery, and installation of medical equipment shall be ready for execution [6]. At this phase, some change controls may be applied to the project activities subject to the clinical needs in terms of equipment selection or maybe change in installation requirements in line with the processes highlighted in [8]. The final stage of the integration area will then involve project completion at each phase of medical equipment planning and the project as a whole.

Scope Management

Project scope in medical equipment planning of a healthcare facility construction project refers to the features or functions of the equipment needed for the identified clinical services to be provided as well as the work required to deliver the specified equipment, hence the medical equipment planning team know the deliverables and problems to be solved. In [8], there are six processes involved. Applying these processes into medical equipment planning, the scope management will involve the following:

i. Process planning and scope management creation particularly for medical equipment.

ii. Stakeholders requirement for clinical and administrative areas collection.

iii. Scope definition based on detailed project description of medical equipment planning.

iv. Division of smaller task using work breakdown structure (WBS) for each component in medical equipment planning.

v. Scope verification from the stakeholders.

vi. Scope control according to the actual and approved scope.

Schedule Management

Schedule management is the key to the completion of a project on time [8]. Hence, in this case, the project schedule will provide a detailed plan on how and when the needed medical equipment in a healthcare facility construction project to be identified, purchased, delivered, installed and commissioned to ensure a smooth process of the overall project completion as per the defined project scope. Every duration allocated for each process must correlate back to the available resources in place. Project schedule also serves as a tool for performance reporting.

Cost Management

Cost management can be a huge challenge in medical equipment planning of a healthcare facility construction project as the equipment is often associated with expensive value for its complexity. Hence, cost estimation shall be done during the initial planning stage once the needed equipment is identified for budgeting exercise [16]. Preliminary budgeting based on space programme and project concept shall be developed even earlier to assist in the overall project financial approval. The challenge in the cost control may happen during the

identification of medical equipment needed to fit the clinical requirement as clinical users may expect the latest state-of-the-art technology to be deployed at their area [17]. Therefore, here comes the importance of technology assessment to ensure a proper selection of equipment is made without adding up burden in the overall cost.

The total cost of ownership of the identified equipment shall also be taken into account during the technology assessment and selection to ensure best value of technology is deployed not just for the acquisition cost, but also the upcoming operational cost throughout the equipment life cycle in a healthcare facility construction project [11]. Cost containment in medical equipment does not only refer to the purchase cost, yet it also includes the delivery, storage, and installation of the equipment. Thus, it is important for the team to monitor the progress of the overall project as any delays may further increase the initial cost estimation.

Quality Management

Management of the healthcare facility construction project and its deliverables fall under quality management. Therefore, in medical equipment planning, for every identified equipment, it should completely align with the clinical service needs, environment requirement, special governmental constraint, and legal and regulatory



requisites with collaborative engagement between the stakeholders [8]. These elements will be the project requirements and quality standards while the compliance level must be monitored, documented and continuously improved accordingly throughout the project phase using the tools or techniques set for quality measurement in the organisation.

Resource Management

Resources in project management comprise of physical and team resources required to deliver the works [8]. Physical resources in a healthcare facility construction project apparently refer to material, equipment, machinery, infrastructure, and facilities to ensure successful completion of medical equipment delivery and installation. In terms of team resources, the needs depend on the size of the overall construction project. A smaller project scale may only require one medical equipment planner for overall project phases, while bigger project scale may need a team comprises of biomedical engineers and administrator to technically assist team leader for the overall planning.

By having a team, the team leader must know the skills and competency level of each member and provide guidance and assigned specific duties to each individual. Task distribution may be divided into different key clinical areas, such as emergency, operating theatre, critical care areas, oncology and imaging for less complex planning, better focus and empowerment via specialisation [11]. A few other influencing elements must also be considered by the team leader to retain and improve team satisfaction and motivation, such as the working environment, stakeholders communication, internal and external policies, and organisational management.

Communication Management

Bridge development in exchanging information between diverse stakeholders internally or externally reflects the function of communication management. Challenges in communication must be identified as well, for example, different language used and team geographical location or time zone. Clear and concise communication, be it via meeting, emails or any other approach or use of technology is crucial as it will impact project execution or outcome.

A simple example that can be used in medical equipment planning of a healthcare facility construction project may be the selection of Magnetic Resonance Imaging (MRI) bore size. A stakeholder is responsible to communicate their requirement to have a bigger bore size to cater big sizes patients [18], based on patient demographic data to the planning team so that the specification and site requirement for MRI can be designed accordingly. If this information was not channelled in the right method, the planner will proceed with the normal bore size MRI in order to reduce the equipment cost hence creating limitation in type of patient coverage later on. Another sample may be infection control requirement for a specific area such as operating theatre. If it was found out by the infection control team that the medical equipment installed does not properly follow the standard of clean and dirty area, it must be highlighted straight away to avoid noncompliance that will cause further troubles in the future [19].

Risk Management

Everything done is associated with risk. The same concept applies to project management, where every single process will have its own risk [8]. Therefore, identification of risk level is needed in pursuit of project completion as risk will emerge continuously throughout the lifetime of the project. Hence, medical equipment planning team in a healthcare facility construction project must be aware of every risk associated with each process in the identified component, whether it is an individual project risk or overall project risk.

For instance, late issuance of purchase order for equipment acquisition will possess a risk of late delivery leading to overall project delay that will incur more cost and time [6]. Safety risk, for example, will appear mostly during equipment installation especially when it comes to huge and complex equipment such as imaging modalities. Injuries may happen anytime hence what is the plan and contingency measure created for such incident to reduce the risk threshold.

Procurement Management

Procurement management often involves agreement in the form of contract, purchase order or service level agreement between buyer and seller [8]. In medical equipment planning, it is more on the approach or strategy selected to acquire the technology between the healthcare facility and equipment principal or distributor. Medical equipment planner must understand the procurement policies and processes in the organisation [6], such as the limits of approval, open or closed tender requirement, evaluation processes for selection and contract requirement. Some purchases may come with a contract for the overall medical equipment lifecycle that covers the maintenance management of the equipment. Procurement management is also crucial for the planner to specify clearly technical requirements for each medical equipment in a healthcare facility construction project as per the clinical needs while still being in compliance with the necessary law and regulation.

Stakeholder Management

Stakeholders in project management are internal or external parties or individuals who directly or indirectly affected by the project works or outcome. Some stakeholders may have the ability to influence the project [8]. Therefore, once project charter is approved,



stakeholders must straight away be identified and engaged appropriately and iteratively throughout the project phase.

In medical equipment planning of a healthcare facility construction project, close engagement with internal stakeholders, such as clinical users, organisation management team, finance, and procurement team, is needed during the early stage of project analysis to understand the overall needs of medical equipment based on the planned clinical services to be provided, financial capability and internal policies related to procurement process [6]. Externally, the stakeholders may comprise of equipment principals or distributors, construction team, local authorities, architects and funding agencies. Effective communication and routine updates shall be planned and maintained properly at every phase so that all these stakeholders are satisfied and aligned with the main objectives.

4. Importance of Medical Equipment Planning in Healthcare Facility Construction

Medical equipment undoubtedly is an integral component of healthcare delivery. Generally, the cost of medical equipment in a healthcare facility construction project is about 20% of the overall project cost making it be one of the major parts in the project planning process [4, 16]. Maximising medical equipment planning during the initial stage of the project will later help to reduce changes throughout the whole project phases as well as avoiding costly mistakes [11, 14]. Identification, selection and integration of medical equipment with detailed requirements into the architectural and engineering are vital to avoid delayed decision making on the selection that will further impact the project schedule. [20] conducted a survey to identify delay factors for hospital projects in Vietnam and listed medical equipment as one of the contributing factors in the sense of late or slow delivery, lack of design and construction specification, change in specification during construction and obsolete equipment. Meanwhile, [17] highlighted some design issues to allow late scope lock-in of medical equipment selection to allow the latest technology deployment, hence causing the final design of the room to be postponed as long as possible. Apart from that, earlier incorporation of medical equipment planning in a healthcare facility construction project also contributes to the ability of the whole project to meet its patient safety objectives [21].

5. Conclusion

In this paper, it has been noted that medical equipment planning incorporation in the healthcare facility construction project shall be initiated at the earliest phase of the overall project initiation and in concert with the architectural and engineering design. The components of medical equipment planning shall be reconciled with the processes involved for the overall project management via the task distribution according to the key knowledge areas. The importance of having the incorporation in place is of course to ensure the right equipment that fits the right goals is selected, purchased, delivered and commissioned within the right cost and at a right time in accordance with the projects build programme hence leading to a successful completion of the overall project outcome and meeting the original set mission.

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