Discussion on Factors Influencing the Performance of Hospital Renovation Engineering - Taking one Medical Center in Taiwan as Example

Wen-Lung Lin, Yan-Chyuan Shiau*, Ting-Chi Lai and Chen-Chung Liu
Department of Construction Management, Chung Hua University
707, WuFu Rd., Sec. 2, Hsinchu 30012, Taiwan
*E-mail: E10216015@chu.edu.tw; *ycshiau@ms22.hinet.net; E10416007@chu.edu.tw; E10416003@chu.edu.tw*

Abstract

The subjects of this study were to investigate the renovation engineering case of four hospital areas in Mackay Memorial Medical Center in Taiwan. The rank of each factor's influencing severity and influencing performance in four stages for hospital renovation engineering was summarized. The factors' severity rank influencing the performance in the four stages were planning and design stage, construction management stage, bidding stage and case acceptance and closing stage. The conclusions and suggestions of this study can be used as reference for future hospital renovation projects.

Keywords: Hospital Building, Hospital Refurbishment Projects, Likert Scale, Questionnaire

1. Introduction

1.1. *Background*

A hospital building is a complex integration of versatile professional disciplines; in addition to general building facilities, the scope includes a steady supply of medical gas (A.V.O) system, fast gas transfer system, safety protection for radiation therapy and nuclear medicine, provision of highly clean air quality of hospital quality (for the OR, supply room, burn center and laboratory), steady medical power supply, safe and clean water supply for the kidney dialysis room, negative pressure ward and positive pressure ward, IT equipment room, medical wastewater treatment plant, movement stream lines of clean objects and contaminated objects, security facilities of psychiatric wards; all the tasks, from refurbishment proposal, planning and design, tender invitation and awarding, construction management, acceptance inspection and case closure, to development of operation procedures, are included in this domain. Therefore, refurbishment of hospital facilities concerns a management science that combines complexity and professionalism.

1.2. *Health care classification in Taiwan*

National health insurance in Taiwan classifies medical care institutes into 4 levels (Fig. 1): Medical Centers of the regional level, regional hospitals of the regional level, local hospitals of the local level and basic health care units of locality level [2].

2. Hospital Refurbishment Project

2.1. *Planning and precautions in hospital constructions*

A hospital is highly professional and widely encompassing medical care installation that takes care of birth, aging, illness and death. There are delivery rooms, nurseries, labs, mortuaries, ORs, out-patient and emergency clinics, kitchens, canteens, post office, bank, barber shop, beauty parlor, sewage treatment plant, incinerator, etc., it is like a small community that requires collaboration of various professionals for achieving its perfection. The Public Construction Commission (PCC) of the Executive Yuan requires that when an entity undergoes a project of public

hospital or health center, reference must be made to "Operation Handbook for Public Buildings of Government Entities" [3] promulgated by PCC, in combination with compliance to medical care requirements, for enhancing engineering quality of the public medical care institutes. PCC has also set forth precautions for carrying out construction projects of public medical care institutes.

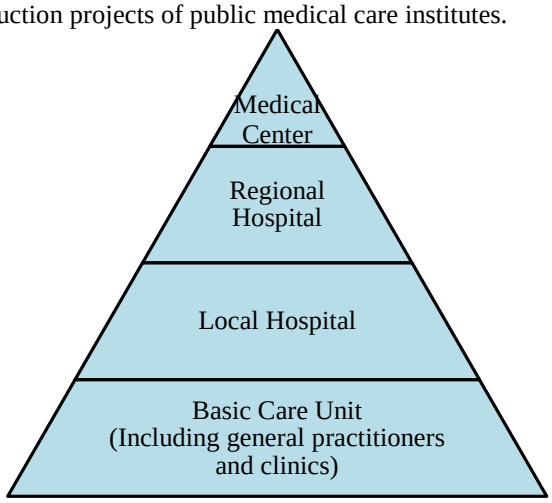

Figure1 Classification of Health Care Institutions

2.2. *A study on the current status of hospital construction management*

Hospitals have the most complicated spatial functionalities of all types of constructions. Via reference documents, theories, and years of personal experience in practicing design and supervision of hospital refurbishments, the author discusses critical constructional phases that affect the refurbishment, aiming to improve the quality of hospital refurbishments. The study compiles and proposes 38 performance affecting factors that may affect the refurbishment. Performance affecting factors are screened via interview and questionnaire given to 8 experts including a supervisor, auditor, labor safety officer, architect, contractor, etc., who have participated in constructions.

3. Investigation and Analysis Against Performance Affecting Factors

The study takes the refurbishment projects of a medical center in Taiwan as case study subject. Four stages of construction life cycle are concluded as Planning and Design, Tender Invitation and Awarding, Construction Management, and Acceptance Inspection or Case Closure. Performance Affecting Factors of Interview results are shown in Tables 1 to 4.

Table 1. Performance Affecting Factors at Planning and Design Stage

No.	Performance Affecting Factor	Expert								Total
		1	2	3	4	5	6	7	8	
A1	Unclear investigation of function requirements of the user unit (such as power system, air-conditioning system, etc.)	✓	✓	✓	✓	✓	✓	✓	✓	8
A2	Only CAD plotted drawings of the refurbished area are provided without actual survey of the site.	✓	✓	✓	✓	✓	✓		✓	7
A3	The user unit cannot fully comprehend the design drawing, and no sufficient communication has been made.	✓	✓	✓	✓		✓		✓	6
A4	Dimensions and space for handling movement of medical care facilities are not sufficiently considered in the planning.	✓	✓	✓	✓		✓		✓	6
A5	Drawings are not plotted for integration (such as architecture system, E&M System, air-conditioning system, gas transfer system, etc.).	✓	✓	✓	✓		✓	✓	✓	7
A6	Elevators are not located based on classified transfer of contaminated objects, wastes and relevant recycling resources.	✓	✓	✓	✓		✓		✓	6
A7	Poor design of soundproof materials of special clinic rooms or inspection units, affecting examination results (e.g., hearing examination, language therapy, consultation room).	✓	✓	✓	✓		✓		✓	6
A8	UPS system for medical care facilities not isolated from that for IT system, therefore causing interferences.	✓	✓	✓	✓		✓		✓	6
A9	Space for maintenance access of facilities not considered.		✓	✓	✓		✓		✓	5
A10	Improper material design and poor material quality causing maintenance difficulties.	✓	✓	✓	✓		✓	✓	✓	7
A11	No integrated planning given for treatment plant and space for infective wastewater and general wastewater.	✓	✓	✓	✓		✓		✓	6
	Number of pros for inclusion	10	11	11	11	2	11	3	11	

Table 2 Performance Affecting Factors at Tender Invitation and Awarding Stage

No.	Performance Affecting Factor	Expert								Total
		1	2	3	4	5	6	7	8	
B1	Drawings of tender invitation document not fully cross-checked.	✓	✓	✓	✓		✓	✓	✓	7
B2	Improper definition of supplier qualification.	✓	✓	✓	✓	✓	✓	✓	✓	8
B3	Tenderer qualification not fully ratified prior to tender open.	✓	✓	✓	✓		✓		✓	6
B4	Inconsistencies in tender documents, drawings and specifications.	✓	✓	✓	✓		✓		✓	6
B5	Unclear inspection standards for work items, materials and facilities in tender documents.	✓	✓	✓	✓		✓		✓	6
B6	Irrational construction period.	✓	✓	✓	✓		✓		✓	6
B7	Improper price for work items.	✓	✓	✓	✓		✓		✓	6
	Number of pros for inclusion	7	7	7	7	1	7	2	7	

Table 3 Performance Affecting Factors at Construction Management Stage

No.	Performance Affecting Factor	Expert								Total
		1	2	3	4	5	6	7	8	
C1	Improper quality supervision of the project executive entity.	✓	✓	✓	✓		✓	✓	✓	7
C2	Lack of experience of outsourced supervisor; lack of experience in supervising medical care constructions.	✓	✓	✓	✓	✓	✓	✓	✓	8
C3	Supervising unit fails to implement construction review plan and quality plan.	✓	✓	✓	✓		✓		✓	6
C4	Contractor autonomous inspection not fully implemented.	✓	✓		✓	✓	✓		✓	6
C5	Contractor defect follow-up and remedial/preventive measures not fully implemented.	✓	✓	✓	✓	✓	✓		✓	7
C6	Review and plotting of pipeline systems not carried out prior to construction, resulting in disordered pipelines that affect spatial usage of the hospital.	✓	✓	✓	✓	✓	✓	✓	✓	8
C7	Pipelines are not identified with color code and flow direction.	✓	✓	✓	✓		✓		✓	6
C8	Air-conditioning ducts not sealed, resulting in contamination inside the duct.	✓	✓	✓	✓		✓		✓	6
C9	Emergency plugs not color coded for discriminating from general ones.	✓	✓	✓	✓		✓		✓	6
C10	Pipelines go through internal walls in the ceiling of isolated ward, damaging air-tightness of the isolated ward.	✓	✓	✓	✓		✓		✓	6
C11	Proper sealant not provided at openings where pipeline goes across fire zones.	✓	✓	✓	✓		✓		✓	6
C12	Improper location or lack of cleaning openings and vents of sewers and drainage pipelines.	✓	✓	✓	✓		✓		✓	6
C13	Insufficient firefighting facilities on the construction site.	✓	✓	✓	✓		✓		✓	6
C14	Excessive number of supporting suppliers resulting in interfacing difficulties that affect general completion date of the project.	✓	✓	✓	✓	✓	✓		✓	7
C15	Slow design change process that severely affects construction progress.	✓	✓	✓	✓	✓	✓		✓	7
C16	Failure to control critical path operation resulting in lag of construction progress and lacking an effective countermeasure.	✓	✓	✓	✓		✓	✓	✓	7
	Number of pros for inclusion	16	16	15	16	6	16	4	16	

Table 4 Performance Affecting Factors at Acceptance Inspection or Case Closure Stage

No.	Performance Affecting Factor	Expert								Total
		1	2	3	4	5	6	7	8	
D1	Failure to set up SOPs for functional test run, tests, random tests, etc.	✓	✓	✓	✓		✓	✓	✓	7
D2	Failure to provide equipment training for the hospital ADM and medical care staff.	✓	✓	✓	✓		✓		✓	6
D3	Failure to perform an integrated system test.	✓	✓	✓	✓		✓	✓	✓	7
D4	Excessive improvement deadline for acceptance inspection.	✓	✓	✓	✓	✓	✓	✓	✓	8
	Number of pros for inclusion	4	4	4	4	1	4	3	4	

4. Results

Analysis of Expert Opinion Survey is carried out mainly by using a questionnaire based on 5-point Likert Scale with the above construction Performance Affecting Factors identified by experts. Experts curve and ranking of Performance Affecting Factors are developed for hospital refurbishment projects. The study summarizes interview and questionnaire results against 4 hospital locations as shown in Table 5. The study also compiles frequent defects seen in the refurbishing works and concludes construction Performance Affecting Factors and improve-

ment suggestions for providing valued references to practices of clients.

Table 5. Statistics of severities of Performance Affecting Factors in respective stages.

Study Subject	Stage 1	Stage 2	Stage 3	Stage 4
Taipei General Hospital	4	3	2	1
Tamsui Branch	2	1	4	3
Taitong Branch	4	3	2	1
Hsinchu Branch	4	1	3	2
Total	14	8	11	7

5. Conclusions

Via review of reference documents, study of actual construction cases, questionnaires, and integration of expert opinions, the study compiles problems in the current execution of refurbishment as follows:

- After discussing with user units at the planning and design stage, drawings have not been fully verified, resulting in confusion in the acceptance inspection, or awkwardness of modification or re-do. Respective systems were not integrated during system design, resulting in construction difficulties and subsequently design changes.
- Tender information was only available at the hospital website and bulletin boards within the hospital, suppliers were unable to acquire information from other resources, resulting in insufficient number of tenderers, which in turn resulted in failure of tender and prolonged time for contracting.
- The person-in-charge failed to demand exact compliance to specifications, such as materials not submitted for approval prior to construction, failure to implement inspection procedures at respective stages, etc.
- Excessive deadline for improving defects.

After analyzing properties of respective hospital areas and problems encountered during for carrying out works, the most severe Performance Affecting Factors at respective stages are as follows:

- Planning and Design Stage: Poor communication with relevant units, differences in demands and design, unclear investigation of function requirements of the user unit (such as power system, air-conditioning system, etc.).
- Tender Invitation and Awarding Stage: Inconsistencies in tender documents, drawings and specifications. Lack of price analysis against singular work items.
- Construction Management Stage: Contractor autonomous inspection not fully implemented. Insufficient quality supervision of the implementation entity.
- Acceptance Inspection or Case Closure Stage: Excessive improvement deadline for acceptance inspection. Failure to abide by SOPs for functional test run, tests, random tests, etc.
- Severity Ranking of Performance Affecting Factors of these 4 stages is: Tender Invitation and Awarding Stage, Construction Management Stage, Tender Invitation and Awarding Stage, and Acceptance Inspection or Case Closure Stage.

Comprehensive suggestions proposed by the study addressing the above problems are as follows:

- Strengthen communication skills of the staff at the Planning and Design Stage. Suggest setting up a communication platform for the execution unit and user unit, members of which include medical care personnel, first-line operators and heads of units. Special considerations must be given to movement streamline of the medical care, medical care facilities, and subjects requiring the service, so as to avoid differences during the acceptance inspection, and to prevent from affecting quality of medical care services.
- Tender of project must be carried out more openly with more channels. Suggest that a contractor database be established to ensure number of participating contractors and that a contractor assessment system be established for quality enhancement.
- Explicit construction specifications must be set forth at the Construction Management Stage. Suggest that the person in charge of the project demand construction quality based on contractual requirements, and that a construction inspection team must be organized.
- Set up SOPs for Acceptance Inspection.

6. References

1. Likert, R. A Technique for the Measurement of Attitudes, Archives of Psychology, 140, (1932) 1–55.
2. 2015 statistics of medical care institutes, Ministry of Health and Welfare, website http://r.search.yahoo.com.
3. Operation Handbook for Public Buildings of Government Entities, PCC, the Executive Yuan, https://www.pcc.gov.tw