THE INFLUENCE OF ARCHITECTURAL DESIGN OF THE SURGICAL SUITE ON THE TRANSMISSION OF INFECTION IN HOSPITALS

ANALYTICAL STUDY OF SPACES AND TRAFFIC FLOW IN EGYPTIAN HEALTHCARE FACILITIES

BY

Hoda Khaled Zakaria Alkashef

A Thesis Submitted to the
Faculty of Engineering at Cairo University
in Partial Fulfillment of the
Requirements for the Degree of
MASTER OF SCIENCE
in
Architectural Engineering

FACULTY OF ENGINEERING, CAIRO UNIVERSITY
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Under the Supervision of

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Title of Thesis:

The Influence of Architectural Design of the Surgical Suite on the Transmission of Infections in Hospitals, Analytical Study of Spaces and Traffic Flow in Egyptian Healthcare Facilities

Key Words:

Design of spaces; acquisition of infection; traffic flow; surgical suite; spread of infections

Summary:

Healthcare associated infections constitute a serious health risk worldwide. This emerged the need to study the diverse aspects that could limit the spread of these infections especially in the surgical suite. The architectural design of the surgical suite plays an important role in the acquisition of these infections. This study focuses on the design of spaces, zoning, and traffic flow for the surgical suite of general hospitals. The aim of this study is to investigate to which limit can the architectural design of the surgical suite affect the transmission of healthcare associated infections. And in order to reach this target, the study analyzed the effect of the design of spaces, zoning, and traffic flow on the spread of infections. Infection control regulations related to the design of spaces, zoning, and traffic flow were gathered from the diverse resources. A design assessment checklist was created based on previous literature. This checklist is to be used by architects during the design process to measure the degree of the architectural design compliance with infection control regulations. It is an easy to use template that highlights areas of deficiencies need improvement. This checklist was tested through its implementation in an Egyptian case study in a way that promotes the design's creativity and avoids directing architects to specific design alternative.

Acknowledgement

I would like to express my sincere gratitude for my advisors Professor Hammam and Professor Mohamed for their continuous support, patience, and motivation during my research work. Besides, I would like to thank my friends for their endless help and support. Last but not the least, I would to thank my parents, my brother, and my aunt for their everlasting motivation and support.

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List of Abbreviations

WHO:	World Health Organization
CDC:	The Centers for Disease Control
IFIC:	International Federation of Infection Control
HAIs:	Healthcare Associated Infections
SSIs:	Surgical Site Infections
BSC:	Central Line Associated Bloodstream Infections
CA-UTI:	Catheter Associated Urinary Tract Infections
VAP:	Ventilator Associated Pneumonia
MRSA:	Methicillin Resistant Staphylococcus Aureus
MASH:	Mobile Army Surgery Hospital
PACS:	Picture Archive and Communication System
AIDS:	Acquired Immune Deficiency Syndrome
MRI:	Magnetic Resonance Imaging
CT:	Computed Tomography
FGI:	Facility Guidelines Institute
JCI:	Joint Commission Institute
CSSD:	Central Sterile and Supply Department
TSSU:	Theatre Sterile and Supply Unit
OR:	Operating Room
AORN:	American Organization of Perioperative Registered Nurses
AGV:	Automated Guided Vehicles
ICRA	Infection Control Risk Assessment
HVAC	Heating, Ventilation, and Air Conditioning

Introduction

Healthcare-associated infections constitute a public health threat worldwide that cause morbidity and mortality to patients in healthcare facilities [1]. Around "one in twenty-five hospital patients have at least one healthcare-associated infection" [2]. In Egypt, 15% of surgical and intensive care patients are in the risk of having hospital-acquired infections as estimated by the World Health Organization [3]. A serious problem that studies have addressed since the mid of the 20th century. These showed the role of the built environment on preventing these infections [4].

Healthcare-associated infections occur due to "the imbalance between the classical triad of epidemiology; agent, host, and environment" [5]. These three elements constitute the chain of transmission of infections that the breaking of this chain could avert infection from occurring. Contamination issues in healthcare facilities especially in the surgical suite should be carefully dealt with by all disciplines in order to control infection. The architectural design of the surgical suite constitutes an essential part of these contamination issues.

The design of spaces and their interrelationships and the design of traffic patterns within the surgical suite are the core of this research work. These design elements should comply with multiple standards that are based on surgical, disease prevention, and architectural practices. Such aspects and others will be deeply investigated to provide a thorough knowledge of the effect of the architectural design on the incidence of acquiring infection. So, design considerations affecting infection control measures are to be extracted while taking into account current and future advancements in surgical practices. Further, a design assessment checklist that evaluates the compliance of the architectural design with infection control regulations is to be created in a trial to reach an answer to the research problem.

Research Problem

Infection control is a vital aspect in healthcare facilities nowadays. Further, the design of hospitals is shifted toward meeting infection control regulations [6]. However; some hospitals in Egypt have major problems in prohibiting the transmission of infections. In some cases, these hospitals are the source of infection to healthy people. This might occur due to the cross intersection between clean and dirty flow, the improper separation between clean and soiled activities, the inadequate design of spaces, the inappropriate allocation of spaces, and other reasons that affect the spread of infections.

Controlling the occurrence of infection is highly required in the surgical suite, where invasive procedures are performed. So, the architectural design of the operating unit should carefully meet infection control regulations, where in fact it is sometime not met. For this reason, this study aims to fill in the gap in the knowledge of the design of the major spaces in the surgical suite, their interrelationships, and the traffic flow among the suite's spaces. This is to be studied in relation to the infection control aspect for the aim of alleviating the incidence of infection through the design. Such complicated issue cannot be solved by following a single intervention, it requires integrated solutions that the architectural design is one of these factors [7].

Research Objectives and Significance

Hygiene principals greatly affect the design of the surgical suite that should be the utmost clean zone at any healthcare facility. Designing spaces to sufficiently accommodate activities performed inside while maintaining cleanliness levels is one of the focus elements of this research. The other elements are the thorough study of spaces' adjacencies and traffic flow. These deep investigations aid to fill in the gaps in the knowledge in order to reach the research's objectives, which are as follows:

- Studying and analyzing the influence of the architectural design of spaces, their interrelationships, and the design of traffic flow on the spread of infections in the surgical suite.
- Gathering infection control regulations that are related to the architectural design of spaces and traffic flow in the surgical suite from the diverse guidelines, standards, codes, and published journal articles.
- Creating a design checklist for the surgical suite that could primarily assess the degree of the architectural design's compliance with infection control regulations.

Research Questions, Hypotheses, and Variables

Based on the research problem of having improper designed surgical suites in some Egyptian hospitals, the main research question emerges. It is to which limit can the architectural design of the surgical suite affect the transmission of infections? From this main question, other secondary questions are initiated based on the study's focus design elements. These secondary questions are as follows:

- What are the zones of the surgical suite?
- What are the main zones that compose the operating room?
- How should the operating room's zones be arranged to facilitate activities performed without exposing patients and personnel to the risk of infection?
- How should the fixed imaging equipment be configured within the surgical setting inside the operating room?
- What are the infection control design pre-cautions that should be considered while designing operating rooms?
- Where should anesthesia be performed within the surgical suite and how this affects the incidence of infection?
- Where should the staff changing facilities be located within the suite?
- How should the staff changing facilities be designed to mitigate the spread of infections?
- Should the staff lounge be attached to the staff changing facilities and how this affects the acquisition of infection?
- Where should the scrub area be located in the suite?
- What are the design precautions to reduce the spread of infections from the scrub area?
- Where should pre-and post-operative care areas be located in the suite and how this affects acquiring infections?
- How designing hand hygiene facilities affects the prevalence of infection within the suite?
- What are design precautions for patients, personnel, and materials flow patterns to reduce the spread of infections?
- How should spaces of the surgical suite be arranged to mitigate the prevalence of infection?

These questions and others are to be investigated in relation to infection control aspects.

As mentioned above, solving infection control problems in healthcare facilities require a set of procedures and precautions that the architectural design is part of it. This study assumes that the architectural design of the surgical suite specifically; spaces, zoning, and traffic flow affect the acquisition of infection. And as design complies with standards including infection control regulations as the spread of infections are mitigated. This hypothesis is based on the fact that the physical environment plays a role in controlling the spread of hospital-acquired infections [8]. Where 30% to 70% of these infections can be avoided in case infection control regulations are achieved [9].

This research is to be conducted on general non-specialized hospitals with the assumption of some research variables. These are the location of the surgical suite within the facility, sizes of spaces contained in the surgical suite, the architectural design of these spaces, the interrelationship between these spaces, and circulation inside and in between these spaces. Each of these elements can individually affect the transmission of infections. For example, the improper positioning of the operating unit within the healthcare facility can increase the number of microorganisms causing infection inside the suite. Also, placing clean or dirty areas inside dirty or clean zones respectively can contaminate clean spaces or zones.

Methodology

Due to the interdisciplinary nature of this study, two main streams are to be basically studied and analyzed; epidemiology and architecture. First, the epidemiology stream focuses on understanding all scientific parameters of infection; its definition, sources, transmission, routes, occurrence, and the most popular hospital infections. Second, the architectural stream focuses on understanding the architectural design of the surgical suite; its development, events and trends affecting its design, and its current practices. Accordingly, the relationship between these two streams is to be studied and analyzed in depth to understand how far can the architectural design of spaces, zoning, and traffic flow affect the incidence rate of healthcare-associated infections in the surgical suite. Furthermore, infection control regulations related to the architectural focus elements of this research are to be extracted from the latest diverse standards, codes, guidelines, and published articles. From the above-collected and analyzed regulations, a design checklist is to be developed to assess the architectural design degree of compliance with infection control regulations. Then, a case study is to be implemented on the checklist to verify and test it. Finally, analyzes of major findings are to be done to identify the research's recommendations (Fig. 1).

Data to be utilized throughout this study is be precisely selected to suit the research problem. Data is to be traced from its origin taking into consideration the latest technological, medical, and architectural trends related to the research's focus areas. For instance, statistics are to be mainly obtained from the WHO (World Health Organization) and CDC (Centers for Disease Control and Prevention) organizations; infection control regulations are to be mainly obtained from the IFIC (International Federation of Infection Control) organization and international infection control guidelines; and architectural design regulations are to be basically gathered from the most recent international guidelines for the design of healthcare facilities and the latest journal articles that directly or indirectly address the research's focus elements. These selected data types aim to cover both the theoretical and practical bases of surgical practices, infection control regulations, and architectural design practices that influence the incidence of infection.