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Adapting Hospital Interior Architecture Process to Technological Advancement in the Management of Pandemic Cases in Jordan

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Abstract: The COVID-19 outbreak pandemic is currently one of the largest challenges facing the world. The pandemic has had an impact on how hospitals are built, how technology is developed, and how information systems are used. Researchers and practitioners in the field of information systems and technology can aid in the analysis of the COVID-19 pandemic by choosing the most optimal building design to impede and stop virus transmission. This study aims to revise the current COVID-19 Hospital Design process in the Management of Pandemic Cases and suggest a process for the hospital management of pandemic cases that will alleviate current and future pandemics. This study used a mixed approach through personal observations, questionnaire surveys, descriptive statistics, correlations, and regression models. The findings were analyzed and revealed the dimensions that need to be considered and that will need to be up to the standard of leading health organizations. People's perceptions about the state of some selected healthcare centers in Jordan were taken and analyzed. Proposals of new hospital building designs and processes of health facilities were undertaken, which can further strengthen the clinical state in Jordan and handle future cases of a pandemic outbreak, with much emphasis on the current COVID-19 outbreak. Lastly, it is highly recommended that this paper be used as a guideline required to fight against any pandemics or endemics both now and in the future, as it lists comprehensive process guidelines to combat any deadly virus, which are shown in detailed photos and process diagrams.

Keywords: coronavirus (SARS-CoV-2); pandemic; technological advancement; hospital architecture design; design models; design strategies; nanomaterials; interior architecture

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Citation: Alhmoud, S.H.; Çağnan, Ç. Adapting Hospital Interior Architecture Process to Technological Advancement in the Management of Pandemic Cases in Jordan. *Buildings* **2023**, *13*, 2602. https://doi.org/10.3390/buildings13102602

Academic Editors: Jose Cabeza-Lainez, Jose-Manuel Almodovar-Melendo and Pablo La Roche

Received: 29 August 2023
Revised: 6 October 2023
Accepted: 12 October 2023
Published: 15 October 2023

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1. Introduction

The COVID-19 outbreak, which is widespread around the world and in the Jordanian region, is one of the largest challenges trending nowadays. The pandemic has had an impact on how hospitals are built, how technology is developed, and how information systems are used [1,2]. Researchers and practitioners in the field of information systems and technology can aid in the analysis of the COVID-19 pandemic by choosing the most optimal building design to impede and stop virus transmission [3]. Currently, no universally accepted standard response method exists, leading to self-adopted approaches to combat the pandemic. This has made it challenging to determine the number of people affected, treated, or lost. Countries have adapted existing structures, such as hospital buildings and residential facilities, to accommodate COVID-19 patients. However, there were no guidelines for COVID-19 hospital building designs in Jordan during the pandemic [4,5]. This research provides a theoretical overview of the COVID-19 pandemic and technological advancements, evaluating clinical research and physical management. It explores structural hypothesis modeling, data collection, analysis, and clinical investigation hypotheses. The study raises questions about current methods and suggests modern, creative hospital building designs [5]. There is proof that COVID-19 infection and air quality are

tightly associated, and that airborne transmission might happen [6]. According to recent investigations, the indoor aerosol transmission of COVID-19 is a major source of infection, particularly in crowded and poorly ventilated environments [7]. It is crucial to maintain the interior air quality as high as possible in order to stop the spread. This necessitates innovative improvements to the existing indoor and outdoor infrastructure to benefit the locals in even the most densely inhabited places [8]. Additionally, this makes the strategy for creating and building hospitals in the wake of the COVID-19 pandemic more difficult [9]. Post-COVID-19 architecture is ideal for hospital buildings, aiming for a cozy, attractive interior design, requiring a quality structural design for a secure and efficient healthcare institution during critical times.

This study aims to revise the current COVID-19 Hospital Design process in the Management of Pandemic Cases and suggest a process for hospital management of pandemic cases that will alleviate the current and future pandemics.

The essence of this study is to propose a new design process for health facilities that can further strengthen the hold of the nation and put it in better stead when it comes to handling future cases of a pandemic outbreak with much emphasis on the current COVID-19 outbreak. The study also intends to provide a standard procedure that will meet the requirements recommended by leading health organizations around the world, like the World Health Organization (WHO) among others.

The specific objectives of this study are:

- To expatiate ways to go about interior design and implementing medical dispensations in a typical interior hospital process in the management of coronavirus.
- To examine the level of preparedness of healthcare facilities and medical centers in tackling epidemic cases, focusing on the interior.
- Establish a template/blueprint that can be put into use now and in the future, within and beyond the walls of the nation in tackling similar cases to COVID-19 sustainably.
- Develop or reinforce guidelines for entering or having access to such health facilities where cases of COVID-19 are managed.
- Equipping healthcare centers, both existing and model ones, with a process that will base all the necessary facilities needed to aid its proper functioning.

2. Literature Review

2.1. Technological Development and Advancement in Hospitals

Designers, architects, aid suppliers, and researchers have become increasingly concerned about hospital design and healing processes in recent years [10]. A comprehensive review of aid styles has revealed that aid providers have progressed to the point where they have no choice but to develop aid settings [11]. Hospital reconstruction projects worldwide are influenced by technological advancements, improving functionality and wellness. Patients desire assistance with hospital healthcare, companionship, and familiarity. Architectural planning and evidence-based design are secondary, considering past works and findings. This meticulous methodology ensures the quality of staff spaces and specialized projects [12,13]. As a result, it has been stated that a basic and rudimentary association exists between the healthcare facility environment and technology [14,15]. Even though it was put forward due to strong and careful observation, there has been very little substantial evidence to cement this school of thought that there is a profound influence of technology on hospital spaces [16]. The situation is changing in that efforts are now being intensified to design technology and hospital spaces.

2.2. The Ethics of Shared COVID-19 Risks in Ethical Health Technology Assessment and Risk in Vaccine Supply Chain

In a critical review of methodology and guideline approaches by [17], who researched and developed a paradigm for ethical considerations in digital supply chain settings, focusing on the accountability and transparency of cyber risks from IoT systems, and integrating them into COVID-19 hospital infrastructure. Another study by [17] examined the poten-

tial risks of IoT in medical facilities and the ethical implications of shared accountability in healthcare policy. It highlights the challenges of implementing smart manufacturing technology due to cost and lack of cyber capabilities. The research suggests the securing of data in shared facilities, ensuring confidentiality and addressing privacy concerns, and ensuring well-trained healthcare personnel in cyber security and digital technology.

2.3. Interior Indoor Air Quality of Hospitals

The quality of the air is one of the main factors in establishing a healthy interior atmosphere [2,18]. The quality of indoor air can be harmed by pollutants from both external and internal sources, including those brought in by people, animals, machinery, and building materials [19]. Organic gases like volatile organic compounds and inorganic gases like radon and ozone can contaminate indoor air [20]. Additionally, airborne particles including mold, asbestos, and silica dust can contaminate indoor environments [21]. Poor indoor air quality brought on by these indoor air contaminants leads to health problems like asthma, sore throats, shortness of breath, and heart conditions [22]. Along with bronchitis, major illnesses like cancer and chronic lung conditions are also made worse by poor indoor air quality [23]. Additionally, these indoor air pollutants are frequently connected to mental health issues like elevated anxiety, increased violent behavior, deteriorated focus, and mental fatigue [24]. In order to maximize indoor air quality, spatial organization should be considered when constructing a structure. A conceptual design strategy called spatial design takes into account both interior design and service design. People must move between internal and external locations to accomplish this [25]. Designers frequently make choices that encourage social connections based on the sociability and well-being of the inhabitants [26,27]. Additionally, using indoor plants, fresh air, and natural sounds, biophallic design principles are applied to enhance the quality of indoor air. To facilitate a patient's quick recovery and shorter hospital stays, indoor plants and natural sounds are strongly advocated for hospital designs [26]. Since many infectious diseases are brought in by viral types that are comparable to the COVID-19 virus, it can be anticipated that maintaining higher indoor environmental quality can also be effective against them [28,29]. Creative approaches and more durable solutions are needed to reopen a nation since transient conditions like remote jobs and restricted access cannot be maintained.

2.4. Ventilation in Healing Process

According to Garbey [30], patients prefer rooms with windows, which have a more positive effect and reduce stress more effectively than sightings in a city atmosphere. The window allows natural light into the room to reduce diseases as well. In addition, according to Shumaker and Pequegnat [31], as long as the views are interesting, ideally a view of nature conducted a joint laboratory study and discovered that sights of nature result in advanced levels of relaxation. According to Urlich [32], a hospital with a view of nature could decrease the wellness period and enhance adequate resting. He concluded that window views help occupants develop a "perceptual and psychological connection with the outside atmosphere", which can have a significant impact on therapeutic modality and increase the healing environment.

2.5. Setting Dimensions in Hospital and Human Behavior in Pandemic Cases

The physical dimensions were divided into three categories in [33], namely, close conditions, interior conditions, and design. This study looks at people's opinions on healthcare facility spaces in the context of inner design, to support the design expert and make him better understand what the customer wants.

Hospital environments are rapidly changing, with professional and design journals being printed, increasing infection risk due to insufficient ventilation, prolonged indoor stays, high contact rates, and frequently touched surfaces. According to [34], there is one universal truth about hospitals: they are drab, desolate places that do not appear to be well-designed for patients to heal. The furniture is hard-edged and bland, the lighting is

artificial and harsh, and it is not a pleasing environment [35]. The notion of raising the issue of good design to boost healing and good health has recently gained traction in the tending profession [36].

Interior parts influence user behavior, according to [37]. People can respond to the physical environment in one of two ways: by being satisfied or by turning away [38–40]. Approach behavior involves a positive reaction to the environment, prioritizing safety, and security, and minimizing patient exposure, disability, and vulnerability through appropriate finishes, materials, and devices. Inside dimensions that influence user behavior, as described by [41], are within the following section.

The setting of a room, according to [42,43], is an important part of the healing expertise. The hospital setting and organization should be well monitored to ensure caretaker satisfaction together with caregivers. The way the area is designed or planned, and the colors on the walls and the settings can all contribute to a patient's sense of well-being and safety [44].

2.6. Passive Technology and Nanotechnology

The setting of a room, according to [45,46], is an important part of the healing expertise. The hospital setting and organization should be well monitored to ensure caretaker satisfaction together with caregivers. The way the area is designed or planned, the colors on the walls, and the settings can all contribute to a patient's sense of well-being and safety [44]. Refer to Table 1 for more information regarding the Application of Nanomaterials in Coatings and their Functions.

Table 1. Application of Nanomaterials in Coatings and their Functions [46].

Nanomaterial (Types)	Function	Effect	Industrial Applied
Oxides: - **Titanium dioxide (TiO_2).** - **Iron (II, III) oxide (Fe_3O_4, Fe_2O_3).** - **Silicon dioxide (SiO_2).** - **Chromium (III) oxide (Cr_2O_3).**	- Color effect. - Reproducible paints.	- Prevent crack formation. - Enhanced resistance to fading	- Construction. - Furniture.
- **Organic/inorganic hybrid polymers.** - **Colloidal/nanosilica silica embedded.** - **Silanes, e.g., fluorine compounds.** - **Titanium dioxide (TiO_2).**	- Self-cleaning	- Dirt and water repellant. - Anti-graffiti protection. - Protection against fungi and algae.	- Glass. - Construction (facades)
- **Silicon dioxide (SiO_2).** - **Aluminum oxide (Al_2O_3).**	- Scratch resistance	- Enhanced scratch resistance	- Parquet flooring. - Furniture.
- **Titanium dioxide (TiO_2).** - **Silver (Ag).**	- Photocatalytic effect. - Antimicrobial effect.	- Removal of grease, algae, dirt, bacteria, odorants, fungi, and pollutants. - Transformation of ozone and NOx - Into harmless compounds.	- Wood preservation - Glass - Construction (facades, tiles, noise barriers)
- **Titanium dioxide (TiO_2).**	- Fire retardant	- It creates a layer of carbon foam that works to insulate heat from the wood's surface, followed by a layer of ceramic that resists flames.	- Wood production against fire. - Construction.
- **Titanium dioxide (TiO_2).** - **Zinc oxide (ZnO).** - **Iron oxide pigments.**	- UV protection. - IR absorbing.	- Control of indoor climate. - IR blocking. - Enhanced UV resistance.	- Glass. - Plastics. - Wood preservation. - Construction (facades).

Healthcare design addresses mental and social demands while incorporating biomedical and economic aspects of wellness. Interior architecture incorporates essential com-

ponents throughout the hospital structure, affecting the user and visitor health through finishes and edges [47,48]. In a hospital setting, careful selection of finishing materials is crucial. Nanotechnologies can enhance these features and ensure proper utilization (refer to Table 2). Nano-coating is an environmentally friendly solution for long-term protection against bacteria, mold, and viruses, as well as surface sanitization.

Table 2. Self-sterilizing Properties of Nano-coating.

Features	Environmental Benefits
- Powered by light. - Works with natural, UV, and fluorescent light.	- Improves IAQ (indoor air quality).
- High performance; Long lasting effect.	- Reduces using of toxic chemicals.
- Environmentally friendly; Harmless to human beings and animals.	- Reduces the risk of surface bio-contamination.
- Decomposition of endotoxin and germ body.	- Reduces the time of cleaning and disinfection process.

2.7. Establishing the Basic Relationship between Hospital Design, Technological Development, and Its Environment

The health sector has seen significant progress, aligning with design science and hospital healthcare requirements. The adaptability of design trends reflects stakeholder realization, requiring more effort to strengthen the ongoing work in this field, which is already in motion and evolving [49,50].

2.8. The BREEAM Green Building Assessment Criteria

BREEAM is the world's most widely used sustainability evaluation tool for master planning infrastructure, buildings, and projects. It acknowledges the value of higher-performing assets throughout their lifespan, promoting environmental, social, and economic sustainability. BREEAM-rated developments are environmentally friendly, improve well-being, support natural resource preservation, and make for attractive real estate investments. It promotes innovation and continuous performance improvement, building confidence and value among stakeholders [35]. The rating scores are shown in Table 3 below.

Table 3. BREEAM score rating [51].

BREEAM Rating	% Score
Outstanding	≥85
Excellent	≥70
Very good	≥55
Good	≥45
Pass	>30
Unclassified	<30

2.9. Conceptual Framework

In this paper, the two hypotheses were stated, i.e., H_1 and H_{o0}, which were opposite to each other. These hypotheses were formulated to test the relationship between the variables in this research. He stated that there is no relationship between how pandemic hospitals process new technological advancements and the management of pandemic cases. While, H_1 states the opposite of H_o, the variables of this research were about three in number, which were both grouped in the dependent and independent variables. The independent variable is the pandemic hospital design process, which has dependent variables such as technological advancement and management of pandemic cases. The

pandemic hospital design process will be tested concerning the two dependent variables (technological advancement and management of pandemic cases).

This research focuses on the interior design of a pandemic hospital in Jordan. In the figure above (Figure 1), the conceptual framework of the research is illustrated. Effective pandemic hospital design was the main target of this research, in which nanotechnology was introduced in the interior environment. If it is effective and the required sustainable outcome is achieved, the process will stop. However, if the desired outcome is not achieved, the process will restart. The same process is applied by the government's policy in an effort to achieve effective management of pandemic cases.

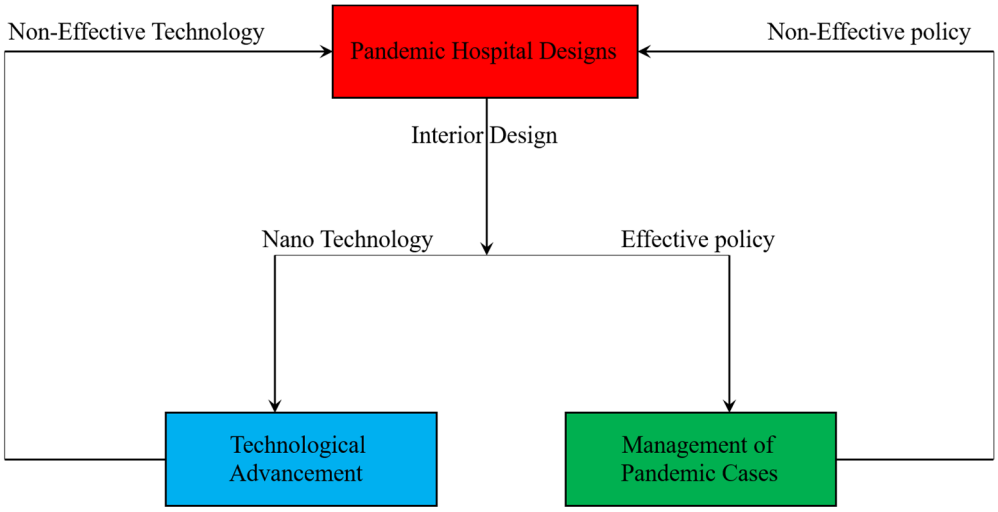

Figure 1. Conceptual Explanation of the Framework.

2.10. Analysis of Nanomaterials in Structural Creation and Improvement with Respect to Sustainability

The broader sense of the terminology presents us with the term "technology", which is the application of matter in a refined way to enable an effective and faster performance at any stage or sector of human activities and existence. The prefix "Nano", on the other hand, means 10-9, i.e., a billionth of a meter. Nanotechnology, therefore, can be defined as the ability to understand, take control of, and manage matter at this level and dimension [52,53].

The construction industry relies on steel, concrete, brick, and timber as major raw materials. Timber is the only natural option, requiring time for preparation. Steel and concrete are reliable but expensive. Concrete is cheaper but requires additional materials like galvanizing, painting, and cathode protection. The production, usage, and demolition of these materials contribute to the depletion of natural materials, making their involvement unsustainable [54,55].

The choice of building material is where nanomaterials come in. Nanotechnology can be used together with native building materials to create structures with a longer life span and excellent functionality. The lower density and higher strength properties of nanomaterials inject a new impulse into the market growth of high-tech [56].

a. Environmental, Social, and Economic benefit

Nanoparticles in housing and construction materials improve performance and sustainability. However, high waste levels, particularly in advanced cities, necessitate an improved waste management plan. Materials should be categorized as recyclable and destroyed, with recycled materials becoming valuable for future construction. Concrete with nanoparticles has improved cognitive strengths [57].

3. Materials and Methods

3.1. Research Design

This paper evaluates existing hospitals and converted buildings for COVID-19 treatment facilities, aiming to create a template for module hospitals for hospital admission and healthcare administration during the pandemic and any unforeseen disease pandemic. A three-phase approach is chosen, and they are listed below:

Section I: Frameworks and Structure.

Section II: Evaluation of the present state of COVID-19 centers (hospitals and makeshift structures) around Jordan with respect to our case studies.

Section III: Exploration of module hospital ramifications with foresight for the upcoming healthcare facility environment and creating blueprints for module hospital designs that can be implemented for effectively tackling pandemic cases of diseases.

The mixed approach and stepwise methodology of evaluation and analysis are crucial for future design-setting studies. Descriptive statistics were used to analyze case studies, ensuring the accuracy and relevance of questionnaire responses. The chosen case studies identified hospital characteristics and design planning for a new module with nanotechnology criteria. This methodology supports past outcomes and quantitative prior findings, streamlining findings and providing a uniform value for a unit of data. In general, results of areas of places taken were unit or section-based to aid evaluation and are either of the 4 headings listed below:

1. Top technology.
2. Reduced technology.
3. Management planning in COVID-19.
4. Structure management.

Justification of the Research Goals

This study aims to fill a knowledge gap in hospital design by focusing on a single aspect of hospital design. It aims to create a blueprint for larger environmental decisions and serve as a template for future hospital planning, considering important factors.

3.2. Materials

3.2.1. Identifying Research Variables

The dimension of this research created a path for selecting research from five consistent criteria.

(i) Form of hospitals

The different structures that were used or converted to emergency service units for attending to COVID-19 cases are of varying fundamental types, and their typologies differ immensely between varied specialties. As a result, the proposed module hospital can effectively replace any of the existing temporary hospital conversions.

(ii) Sample location

The proposed pandemic center is located near a general hospital in Jordan, at the empty Princess Rahma Hospital building. Despite the concept being suitable for different locations, providing limited space within densely populated neighborhoods presents challenges. Urban healthcare facilities face expansion and limited ground area issues, while rural areas and suburbs can handle these issues [58]. For the purpose of this study, the prototype implemented is suited to both forms of rural and urban locations.

(iii) Sample City

Irbid was chosen to be the city in which this research was carried out. Flexible designs are usually of varying architecture design, and this necessitated the restriction of the size of the overall sample to which this study is subjected. This study is carried out because the idea of a module hospital is adaptable to different clinical settings all over the world; the

set limit is to ensure that the scope of the research does not become ambiguous; and Jordan, being a nation with a relatively structured healthcare system in the Asian part of the world, can become an important token point.

(iv) Architecture planning flow type

There exist different forms of complex movement in and around a typical hospital, thereby creating a lot of flow. Part of this is the movement of outpatient visitors and non-clinical staff. The scope of this study is limited to the kind that is associated with the sections that are contained in a module hospital, and this centers on quarantine, stabilization, and the entire management practices relating to COVID-19.

(v) Specifications in hospitals

It is good to state that architecture design technologies are as follows.

All the designs and planning space methodology, together with the overall structural systems, are employed in providing the specifications in hospitals [59]. The choice of technological variables that are discussed in this paper are those that are closely related to materials commonly used in interior spaces to take advantage of their properties and high performance, particularly against bacteria.

3.2.2. Factors That Impact Hospital Plans and Models

Hospital design involves a complex process that goes beyond architectural considerations. Factors such as the number of beds, policies, and typological responses influence the appearance of hospitals [60]. Reflective hospital style processes inform the realm of architecture design, focusing on dominant hospital style factors. This process involves small stages that determine healthcare design, highlighting the importance of considering various factors in healthcare environments [61].

3.3. Research Framework: Healthcare Preparation in Hospitals

This research focuses on understanding healthcare settings within the amplitude of architecture using a lone methodology. The methodology is designed to provide solutions to the problems initially set out, while also providing a solid understanding of the present state, factors affecting its position, and the path it takes. While a pinpoint for the future is not possible, evaluating the peculiar threads for the future is a more feasible approach [62].

If this is to be adopted, there is also the need to come up with a sustainable methodology. This is essentially why this research study has tapped into the progressive findings of future studies that are well related to the field of interior architecture and hospital design [63].

The methodology developed by these writers is arrived at through the conceptual framework utilized in business planning. The token points encapsulated in this strategy, functionality and flexibility, depict a sustainable architectural environment design achieved by putting in place a prolonged path of action and strategies.

Strategy can be defined as a set of measurements put in place to arrive at a specific goal [64]. The idea of strategic planning gained headway as a form of analytical method adopted in research around the 1960s, which provides necessary competitive dimensions in a company setting and also aligns the goals and targets of a company in the proper direction [65].

The debate on adaptable hospital design is fueled by the PFI process and fears that innovative facilities may become obsolete within five years [66]. This area investigates the necessity of adaptable hospital layouts for effective building lifespans and the potential for future technological advancements, threatening the National Health Service's acute hospitals.

3.4. Practice-Based Research

According to [67], practice-based research has grown into a qualitative research method, this, in turn, might be defined as a "data collection and analysis technique that

prioritizes words rather than numbers" [68]. Figure 2 depicts the main processes in qualitative research.

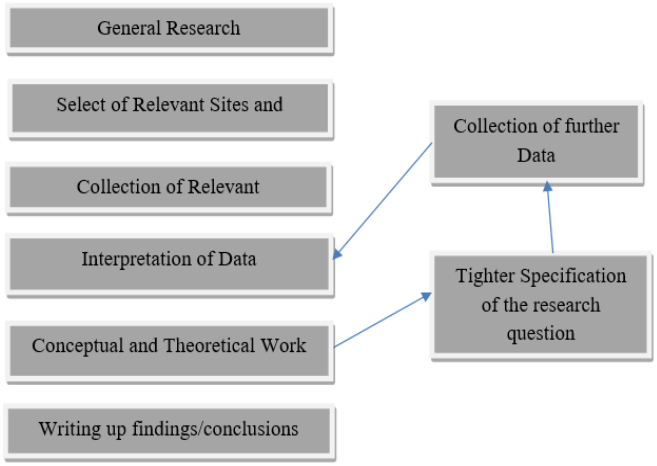

Figure 2. Steps in qualitative research [68].

3.4.1. Research Participants

The questionnaire was used for a national assessment of pandemic preparedness and hospital-building changes. It was short and easy to complete, and respondents found it comfortable to complete at their leisure [68].

The Jordan National Institute for Public Health and the Environment used a database of 68 health organizations and 117 hospitals to conduct a survey on hospital working methods and building changes during the COVID-19 pandemic. The survey was distributed via email, face-to-face, and online. In-depth interviews were suggested as a second approach to collect qualitative data, allowing for reflection on the crisis era and understanding decision-making processes [68].

Online video interviews with hospital building operations specialists aim to understand emergency response during the pandemic and explore future-proofing initiatives, with anonymized and recorded interviews with respondents' approval.

3.4.2. Questionnaire Description "Hospital during COVID-19"

The survey focused on working habits during the COVID-19 pandemic, divided into four sections. It included in-depth interviews with respondents about the pandemic response, working processes, institution characteristics, and pandemic readiness. The survey also discussed adjustments made to buildings and new initiatives emerging due to the pandemic. The following sections are explained in further detail:

The sections that included context-related questions about a pandemic response are as follows.

I. General information:

The purpose of the questions regarding the respondents is to obtain non-identifiable data that help to characterize them.

II. Outcomes measures:

A. Working Methodologies—COVID-19 Operations

- Cohort nursing and non-cohort nursing are two different types of nursing.
- Capacity approach: Outplacement of patients.
- Distinguished locations: facilities committed 100% to COVID and non-COVID care.

B. Characteristics of the hospital (objectives outcome measures)

- Number of beds.
- Number of ICUs.
- Number of single-patient rooms.

C. Pandemic preparedness (Subjective outcome measures)

- Pandemic preparedness 1st wave.
- Pandemic preparedness 2nd wave.
- Pandemic preparedness British variant—3rd wave

III. Measures are taken during the pandemic

These variables influence outcome measures and are classified into three main categories composed of eight or nine interventions.

- Building interventions.
- Technical interventions.
- Staff services.

IV. Future overview

This section aims to reflect on the future necessity of future-proofing healthcare facilities for a virus like COVID-19.

The survey results are expected to give an overview of Jordanian hospital measurements. The findings look at the association between emergency response metrics and hospital spatial factors such as building year, hospital type, and population density. Furthermore, the survey's final questions are planned to provide a preliminary summary of which components should be addressed in future hospital design.

3.4.3. Interview Protocol

The interview's participants and questions were chosen based on the survey's previously collected data. The goal of the seminars was to learn more about the emergency response context and decision-making process. The purpose was to reflect on the crisis period and analyze the major challenges and lessons acquired during each organization's experience. The interview process was created with four primary subjects in mind, as stated in Table 4.

Table 4. Main Interview Topics.

- Prepare for a crisis in the context
- During the emergency reaction, strategies and procedures were developed
- Logistics alterations
- Facilities' long-term prospects

3.4.4. Processing Data

SPSS 28—2021 software is recommended for the display and descriptive analysis of the data collected in the questionnaire. To detect patterns and illustrate the data obtained in the survey, timelines, and histograms are employed. There were no additional statistical analyses performed; hence, the survey analyses should be regarded as qualitative.

Because little is known about the studied phenomena, an explorative inductive approach (shown in Figure 3) was utilized to analyze the interviews. This method entails examining data with little or no prior theory, structure, or framework, and using interview data to answer research questions, allowing for interpretation [69].

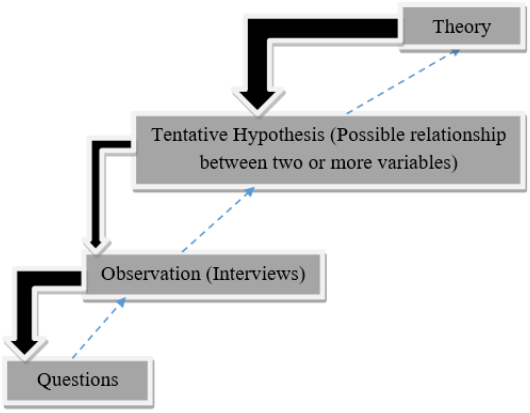

Figure 3. The structure of an inductive method [70].

All English interviews were transcribed and labeled using the ATLAS program after each interview session. Through the thematic content analysis technique, this tool was utilized to manage and assist in the analysis of the obtained data. The key methods for analyzing the transcripts are identifying themes, categories, and relationships between variables of interest in the research, and developing tentative hypotheses and recommendations for future hospital design open thematic coding [69].

A student of French by the name of Godet 1990 [70] came up with a novel 'strategic prospective' model titled "la perspective", which makes a unique distinction between the laid down way out in pieces of literature and the plan setting itself [70]. The idea behind the initiative is to recognize all the possible influencing factors of the near future, ensuring that they are well adjusted for as long as they can be (see Table 5 below) [65].

Table 5. Five for Strategy of Management [71].

Strategies	Strategy Description	Relevance to Thesis
Plan	Forward planning progressive action	Relevant
Pattern	A view at actions of the past and pointing out a correlation	
Perspective	How management depicts the goals of the establishment	
Position	Correspondence in the architect's environment	Irrelevant
Ploy	Correspondence in the architect of direct competitors	

Against, planning centralizes on concentrating objectives with solid bases around the immediate future to discover a fulfilled future perspective. As suggested by Godet, the concept of planning is largely narrowly carved for establishing long-term strategies. Based on this study, a research layout design methodology well suited for exploring typical hospitals in managing epidemic cases such as COVID-19 was selected.

In contrast to this, the typology that was utilized in this research is by the duo of [72], with its core revolving around a backtracking flexible design and regional planning in a comprehensive module. One of the essential reasons why this methodology was favored for adoption is because of its 5 phases of experimentation that exist, where there is one that allows for forecasting future eventualities.

By contrast, the need to develop a future-oriented methodology is arrived at as a form of necessity through the visual evaluation (units/square meters (sqm)) of the healthcare environment. This has subsequently led to the research in this case to develop a working module that seems from that of [73]'s 'Prospective'. This methodology was arrived at

with the idea of contributing largely to the pool of knowledge in interior architecture and general hospital design. As well as implementing a sustainable template for the successful management of COVID-19 and any other unforeseen pandemic disease of nature.

3.5. Evaluating the Impact of Technology as a Major Determinant in Hospital Design Planning

Technology has been at the forefront of development witnessed in the health industry and planning has a role in the architecture design of hospital structures and other components. However, there are scant research works that explore the relationship concerning Jordan and, if there at all, they are not readily available. Spatial requirements are gradually addressed with every new hospital plan that is implemented, factoring in the need to actively involve technological advancements; technology's impact in shaping the hospital environment is still quantitatively unexamined.

3.5.1. Investigating the Likely Implications of the Introduction Module Hospitals for Future Pandemic Disease Treatments and Associated Hospital Spaces

The literature review lacks empirical work on the future implications of module hospitals, making it crucial to analyze their impact on future hospital space. The COVID-19 case teaches us the importance of proactive planning to secure lives and properties. A scenario approach visualizes the impact of module hospital models on hospital space, leading to research on future hospital design remedies using nanomaterial planning solutions.

3.5.2. Evaluation of the Need for Flexible Hospital Design Solutions

This research aims to explore smart healthcare design solutions for pandemic cases like COVID-19. It uses data from the research to design a new module for COVID-19 treatment and management. The study provides recommendations for future architecture design planning strategies and a new module with criteria guidance, highlighting the need for a smart healthcare system.

3.6. Quantitative Framework: Case Study Sample

In the first part of the study, a sample of functional COVID-19 centers in Jordan were identified and selected to be the case studies and they include;

i. Irbid Hospital.
ii. Zarga Hospital.
iii. Ma'an Hospital.
iv. Prince Hamzat Hospital.

Together with these, hotels and other precious residential and non-design buildings that were converted to COVID-19 holding and quarantine facilities were also turned in.

The case study aims to quantify the nature of hospitals in Jordan and the effort that has been put forward in tackling the effect of COVID-19 in society. There is a need to evaluate Jordanian hospitals that are built over a long period of time and still exist and are as functional as those of this generation in a bid to grasp their inherent capability to respond to cases pandemic cases. The choice of case studies also made it possible to pinpoint several hospital characteristics and hospital design planning for the new module with the criteria of nanotechnology.

Three inquiries are asked for each Jordan hospital case study.

(i) How well are hospitals in Jordan faring in the battle against COVID-19, and the position in tackling another unforeseen pandemic case and essentially determine if there is any need to put the use of module hospitals into full swing?
(ii) Is technology growth rightly and supposedly measured and quantified?
(iii) What are the trends and relationships that are manifested in one way or another between high and low-tech areas?

3.7. Data Collection

The study collected data from various sources, including government officials, non-governmental agencies, health workers, and patients of hospitals, to understand how hospitals coped with the pandemic and apply lessons for future projects. It aimed to establish a basis for implementing model hospitals and prioritize their use in housing and caring for COVID-19 cases and other unforeseen pandemic cases.

3.8. Description of Case Study

Case Study 1: Coronavirus Field Hospital Ma'an

The Ma'an Hospital is located in Ma'an, Jordan, beside the Ma'an Government Hospital. The hospital covers an area of 4400 square meters, with a capacity of 48 intensive care beds, and 198 regular beds. Figure 4 shows the map of the Ma'an Hospital with a hospital photo, and Table 6 presents an indoor description of the Ma'an Hospital.



Figure 4. Map of the Ma'an Hospital and Hospital Photo.

Table 6. Indoor Description of the Ma'an Hospital.

	
A. A sample multi-bedroom ward	B. A sample patient ward
	
C. A four-bedroom patient ward	D. A laterally placed four-bedroom ward

Case Study 2: Coronavirus Field Hospital Zarga

The Zarga Hospital is located in Amman, Jordan, beside the Prince Hashim Bin Al Hussein Government Hospital. The hospital, established on a 5200-square-meter plot of land, was directly implemented by the Military Works and Housing Directorate within 14 days and was equipped with all necessary equipment with a capacity of 300 beds. Figure 5 shows the map of the Zarga Hospital with a hospital photo, and Table 7 presents an interior view of the Zarga Hospital.



Figure 5. Map of the Zarga Hospital and Hospital Photo.

Table 7. Interior View of the Zarga Hospital.

	
A: Passage linking patient wards	B: A multi-bedroom patient ward
	
C: A sample Intensive Care Unit (Unit)	

Case Study 3: Coronavirus Field Hospital Prince Hamza

Prince Hamza Hospital is located in Amman, Jordan, a short distance from the Cairo Amman Bank Cab. The hospital was built in 30 days on the premises of Prince Hamzah Hospital with a capacity of 408 beds, including 84 intensive care beds. The hospital covers an area of 5200 square meters. Figure 6 shows the map of the Prince Hamza Hospital with a hospital photo, and Table 8 presents an indoor description of the Prince Hamza.



Figure 6. Map of the Prince Hamza Hospital and Hospital Photo.

Table 8. Indoor Description of the Prince Hamza.

	
A: A life support unit	B: Picture of a multi-bed patient ward showing the walkway in between
	
C: A typical multi-bed patient ward partitioned with wooden extensions	D: A compartmentalized patient ward

Case Study 4: Coronavirus Field Hospital Irbid

Irbid Hospital is located in Irbid, Ar-Ramtha, Jordan, beside King Abdullah University Hospital. Upon arrival at the field hospital, established on the grounds of the Royal Medical Services' Prince Rashid bin El Hassan Hospital, King Abdullah was received by the Chairman of the Joint Chiefs of Staff Maj. Gen. Yousef Hneiti toured the hospital. The field hospital, covering an area of 4650 square meters, has a 300-bed capacity, including 48 intensive care unit beds and 18 intermediate care beds ready to be converted into ICU beds. Figure 7 shows the map of the Irbid Hospital with a hospital photo, and Table 9 interior demonstration of the Irbid Hospital.



Figure 7. Map of the Irbid Hospital and Hospital Photo.

Table 9. Interior Demonstration of the Irbid Hospital.

	
A: A multi-bedroom patient ward	B: Picture of a multi-bed patient ward showing the walkway in between

The scores below in Table 10 represent the level at which each institution incorporates the guidelines of design planning to provide an easily adaptable model that requires little time and resources in its establishment while not defeating its purpose. The essence of this study is to qualify the abstract and genuine opinions of people about the state of major Coronavirus Field Hospitals in Jordan and propose new processes and designs of facilities that can further strengthen the hold of the nation and put it in better stead when it comes to handling future cases of a pandemic outbreak, with much emphasis on the current COVID-19 outbreak.

Table 10. Evaluation of Case Studies According to BREEAM Criteria.

Criteria	Coronavirus Field Hospital Irbid	Coronavirus Field Hospital Prince Hamza	Coronavirus Field Hospital Zarga	Coronavirus Field Hospital Ma'an
Indoor Air Quality and Coronavirus	+	−	−	+
Thermal Comfort and Cross Ventilation	−	−	−	+
Visual Comfort and Indoor Lighting	−	+	−	−
Quality of Outdoor Space	−	+	+	+
Silica Nanoparticles	*	*	*	*
Tatiana Nanoparticles	*	*	*	*
Carbon Nanotubes	*	*	*	*
Aluminum Oxide Nanoparticles	*	*	*	*
Clay Nanoparticles	*	*	*	*

Table 10. *Cont.*

Criteria	Coronavirus Field Hospital Irbid	Coronavirus Field Hospital Prince Hamza	Coronavirus Field Hospital Zarga	Coronavirus Field Hospital Ma'an
Iron oxide Nanoparticles	*	*	*	*
Copper Nanoparticles	*	*	*	*
Indoor Environmental Quality	+	+	+	+
Accessibility	−	+	−	+
Suitability for Conversion	+	−	+	+
Acoustic Comfort	−	+	+	+
Ease of Cleaning and Maintenance	−	−	−	−
Environmental Impact of Construction Site and Process	+	+	−	+
Fire Prevention	++	+	+	+
Infection Control	+	+	+	+
Technological Advancement	−	−	−	−
Physical Atmosphere	+	+	+	+
Emotional Responses in Healthcare	+	++	+	++
Ventilation in Healing Process	−	+	−	+
Human Factors in Internal Setting and Sensing Environment	−	−	−	−
Prevent the Spread and Formation of Bacteria	*	*	*	*

The table above shows the evaluation of 4 hospitals according to the BREEAM criteria as explained in the literature review: excellent (++), very good (+), poor (−), and not existing (*).

Building contractors in Jordan have put significant effort into installing modern features for a quarantine-essential building, ensuring necessary features are in place.

Table 11 above compares the assessments of the four pandemic centers, i.e., Ma'an, Zarga, Irbid, and the Prince Hamza COVID-19 pandemic hospitals. There is a lesson to be learned from these case studies that will be taken into consideration in the new proposal for the pandemic design process of the health centers required in this paper. Natural interior lighting was poor in all four hospitals. The first case study used here was the Ma'an COVID-19 pandemic center located at Ma'an Hospital in Jordan; this hospital was rated as having poor natural interior lighting and ventilation because the building has no windows in the patient rooms. In order to have cross-ventilation and enough lighting in the interior building, each patient's room must have at least one window (according to BREAM criteria). Likewise, the capacity of the building, when compared with the overall population, must be at least 2000 patients to tackle the pandemic situation in a country, according to the World Health Organization (WHO) and the American Organization for Nursing Leadership [72,74,75]. There are 12 governorates and regions in Jordan with a total population of 10 million, 116 hospitals with a total of more than 14,000 beds, and 650 ICU beds. This gives an average of 121 hospital beds per each of the 116 hospitals in Jordan [36]. Therefore, these four hospitals do not have adequate existing hospital bed capacity for patients to overcome the pandemic situation in the country. In terms of accessibility, the Ma'an, Prince Hamza, and Irbid hospitals have good accessibility within their interiors, while Zarga has poor accessibility. Only Zarga and Irbid have good interior circulations, while the rest are rated as fair. Lastly, all four case studies were rated fair in terms of the functionality of the overall structure of the hospitals. These and more elements and factors were the ones that were taken into consideration in the new proposed hospital building

that is present in the results; solutions to all of these problems would be shown above, while alleviation would be the last option when a problem was found and could not be solved. The overall assessment of all the buildings falls under unclassified in the BREAM assessment table.

Table 11. Comparison Assessment between the Four (4) Case Studies.

S/N	Case Study	Lighting	Accessibility	Circulation	Capacity	Ventilation	Functionality
1.	Coronavirus Field Hospital Ma'an	-	F	+	-	-	F
2.	Coronavirus Field Hospital Zarga	-	-	F	-	-	F
3.	Coronavirus Field Hospital Prince Hamza	-	F	+	-	-	F
4.	Coronavirus Field Hospital Irbid	-	F	F	-	-	F

4. Data Analysis and the Hospital Interior Design Process with 3D Proposed Module Design for New and Improved Jordan Hospital

The widespread coronavirus has reignited discussion about the importance of an environment wrapper in the control of infection. The various components of the structure that separate the interior of the environment from the periphery of the building envelope are currently treated as a hermetically sealed box. Structures that are "leaky" are sufficiently tight to reduce energy consumption rates. Opening a window is an easy way to get rid of polluted air and give room for a fresh one in case of a pandemic.

Smart buildings involve using and incorporating technological advancements into their designs to help lift such spaces above infection of any kind. Not just any form of building will find it particularly important to adhere to the principles of smart buildings concerning the functionality of these buildings such as hospital building infrastructure [73,76,77]. In the construction of buildings and the renovation of existing ones, most especially hospitals, which are meant to house people and provide wellness conditions for them, the buildings should be built to control their temperature, airflow, and light. A building's ability to manage its usage and how it will operate and function should always be the priority when designing a healthcare facility. Starting from energy usage, this should be significantly less than what it produces [75,78]. The heating, ventilation, and air conditioning system harnesses its energy from nature; rather than tightening up the building, preventing outer air from gaining access, the constructing protector was revealed for the structure to "associate with as well as act in return to its natural world in order to encourage effectiveness and mental balance" [78,79].

This paper explores potential upgrades and advancements in hospital facilities, particularly in response to the COVID-19 pandemic, to aid in the fight against illness. The study focuses on hospital designs that consider necessary components and adapt to different regions. The study emphasizes the importance of adaptability and flexibility in healthcare facilities, as machines now perform more activity than ever before. It also explores ways to encourage well-being and quick recovery from depression. The paper also incorporates various fields of architecture, including healthcare research, technological research, and social research, to create a comprehensive COVID-19 pandemic center. The results suggest a clear relationship between the healthcare environment and technology, with the revolution in space occurring concurrently with advancements in architecture. The matchbox-on-a-nanomaterial model, a new module process for interior architectural design, emphasizes the importance of advancements in technology and architectural planning, including biotechnology and nanotechnology, in adapting future hospital and healthcare facilities to better manage unforeseen pandemic cases.

4.1. Results and Discussion

Questionnaire Analysis of Stakeholders Socio-Demographic Data

Figure 8 below shows the Likert-scale questionnaire results of participants to the items of this questionnaire that were used to analyze previous Jordanian hospitals and assist in remodelling a new and improved architectural interior structure for the Jordanian.

A. Module Hospital Assessment Questionnaire

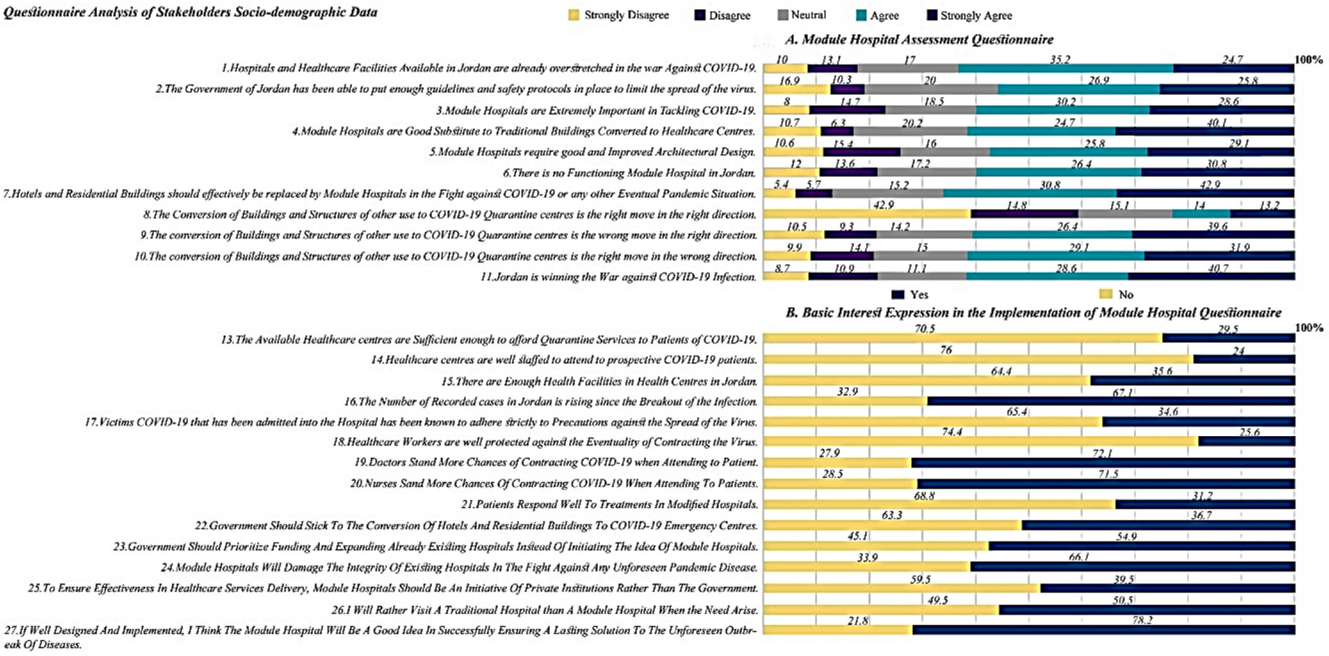

Figure 8. Likert-scale questionnaire results.

i. Hospitals and Healthcare Facilities Available in Jordan are already overstretched in the war Against COVID-19.

Forty-five (45) respondents strongly agreed that hospitals and healthcare facilities available in Jordan are already overstretched in the war against COVID-19, which represented 24.7% of the total sample, and sixty-four (64) respondents agreed that hospitals and healthcare facilities available in Jordan are already overstretched in the war against COVID-19, which represented 35.2% of the total sample. While 24 respondents disagreed that hospitals and healthcare facilities available in Jordan are already overstretched in the war against COVID-19, representing 13.1% of the total sample, 18 respondents who represented 10% of the total sample strongly disagreed that hospitals and healthcare facilities available in Jordan are already overstretched in the war against COVID-19 (Figure 8). Therefore, a majority of the respondents agree that all the hospitals in Jordan were overstretched.

ii. The Government of Jordan has been able to put enough guidelines and safety protocols in place to limit the spread of the virus.

Forty-seven (47) strongly agreed that the Government of Jordan was able to put enough guidelines and safety protocols in place to limit the spread of the virus. Whereas 49 respondents, who represented 26.9% of the total sample, agreed that the Government of Jordan was able to put enough guidelines and safety protocols in place to limit the spread of the virus. However, 19 respondents disagreed that the Government of Jordan was able to put enough guidelines and safety protocols in place to limit the spread of the virus; they represented 10.3% of the total sample; in addition, 31 respondents strongly disagreed that the Government of Jordan was able to put enough guidelines and safety protocols in place to limit the spread of the virus, which represented 16.9% of the total sample (Figure 8). There was a tie, in this regard, because equal numbers of respondents

agreed to this question and disagreed at the same time; this might be due to a lack of awareness that makes people unsure of the governmental activities in the country.

iii. Module Hospitals are Extremely Important in Tackling COVID-19.

Fifty-two (52) respondents who represented 28.6% of the total sample strongly agreed that the module hospitals are extremely important in tackling COVID-19, and fifty-five (55) respondents agreed that the module hospitals are extremely important in tackling COVID-19, which represented 30.2% of the total sample. However, 27 respondents who represented 14.7% of the total sample disagreed that the module hospitals are extremely important in tackling COVID-19, and 14 respondents who represented 8% of the total sample strongly disagreed with this (Figure 8). The module hospitals were strongly supported by the majority of the respondents.

iv. Module Hospitals are Good Substitutes for Traditional Buildings Converted to Healthcare Centers.

Seventy-three (73) respondents who represented 40.1% of the total sample strongly agreed that module hospitals are a good substitute for traditional buildings converted to healthcare centers, and forty-five (45) respondents who represented 24.7% of the total sample agreed that the module hospitals are a good substitute for traditional buildings converted to healthcare centers. While 11 respondents who represented 6.3% of the total sample disagreed that module hospitals are a good substitute for traditional buildings converted to healthcare centers. Finally, 19 respondents who represented 10.7% of the total sample strongly disagreed (Figure 8). A higher number of responses were given to strongly agree that module hospitals are a good substitute for traditional buildings converted to healthcare centers.

v. Module Hospitals require good and Improved Architectural Design.

Fifty-three (53) respondents who represented 29.1% of the total sample strongly agreed that the module hospitals require good and improved architectural design, and forty-seven (47) respondents who represented 25.8% of the total sample agreed that the module hospitals require good and improved architectural design. However, 28 respondents who represented 15.4% of the total sample disagreed that the module hospitals require good and improved architectural design; in addition, 19 respondents, which represented 10.6% of the total sample, strongly disagreed (Figure 8). The majority of the respondents strongly agreed that module hospitals require good and improved architectural design.

vi. There is no Functioning Module Hospital in Jordan.

Fifty-six (56) respondents who represented 30.8% of the total sample strongly agreed that there is no functioning module hospital in Jordan; in addition, forty-eight (48) respondents who represented 26.4% of the total sample agreed that there is no functioning module hospital in Jordan. However, there were 25 respondents, who represented 13.6% of the total sample and disagreed that there is no functioning module hospital in Jordan, and 21 respondents who represented 12% of the total sample strongly disagreed (Figure 8). Most of the respondents strongly agreed that there is no functioning module hospital in Jordan.

vii. Hotels and Residential Buildings should effectively be replaced by Module Hospitals in the Fight against COVID-19 or any other Eventual Pandemic Situation.

Seventy-eight (78) respondents who represented 42.9% of the total sample strongly agreed that hotels and residential buildings should effectively be replaced by module hospitals in the fight against COVID-19 or any other eventual pandemic situation, and fifty-six (56) respondents who represented 30.8% of the total sample agreed that hotels and residential buildings should effectively be replaced by module hospitals in the fight against COVID-19 or any other eventual pandemic situation. However, 10 respondents who represented 5.7% of the total sample disagreed that hotels and residential buildings should effectively be replaced by module hospitals in the fight against COVID-19 or any other eventual pandemic situation, and 9 respondents who represented 5.4% of the total sample strongly disagreed (Figure 8). The majority of the respondents strongly agree that

hotels and residential buildings should effectively be replaced by module hospitals in the fight against COVID-19 or any other eventual pandemic situation.

viii. The Conversion of Buildings and Structures of other use to COVID-19 Quarantine centers is the right move in the right direction.

A total of 24 respondents who represented 13.2% of the total sample strongly agreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the right move in the right direction, and 25 respondents who represented 14% of the total sample agreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the right move in the right direction. However, 27 respondents who represented 14.8% of the total sample disagreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the right move in the right direction, and 78 respondents who represented 42.9% of the total sample strongly disagreed (Figure 8). There are higher numbers of responses from the participants who strongly disagreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the right move in the right direction.

ix. The conversion of Buildings and Structures of other use to COVID-19 Quarantine centers is the wrong move in the right direction.

A total of 72 respondents who represented 39.6% of the total sample strongly agreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the wrong move in the right direction, and 48 respondents who represented nearly 26.4% of the total sample agreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the wrong move in the right direction. In addition, 17 respondents who represented 9.3% of the total sample disagreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the wrong move in the right direction. However, 19 respondents who represented 10.5% of the total sample (Figure 8). Here, the majority of the respondents strongly disagreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the wrong move in the right direction.

x. The conversion of Buildings and Structures of other use to COVID-19 Quarantine centers is the right move in the wrong direction.

There were 58 respondents representing 31.9% of the total sample who strongly agreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the right move in the wrong direction, and 53 respondents who represented 29.1% of the total sample agreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the right move in the wrong direction. However, 26 respondents who represented 14.1% of the total sample disagreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the right move in the wrong direction, and 18 respondents who represented 9.9% strongly disagreed (Figure 8). A higher population sample strongly disagreed that the conversion of buildings and structures of other use to COVID-19 quarantine centers is the right move in the wrong direction.

xi. Jordan is winning the War against COVID-19 Infection.

Seventy-four (74) respondents who represented 40.7% of the total sample strongly agreed that Jordan is winning the war against COVID-19 infection, and forty-three (43) respondents who represented 28.6% of the total sample agreed that Jordan is winning the war against COVID-19 infection. Twenty respondents who represented 10.9% of the total sample disagree that Jordan is winning the war against COVID-19 infection. Finally, 16 respondents who represented 8.7% of the total sample strongly disagreed that Jordan is winning the war against COVID-19 infection (Figure 8). Therefore, a majority of the respondents strongly agree that Jordan is winning the war against the current pandemic.

B. Basic Interest Expression in the Implementation of Module Hospital Questionnaire

i. The Available Healthcare centers are Sufficient enough to afford Quarantine Services for Patients with COVID-19.

Fifty-four (54) respondents who represented 29.5% of the total sample implied yes that the available healthcare centers are sufficient enough to afford quarantine services to patients with COVID-19, and ninety-two (92) respondents who represented 70.5% of the total sample do not agree that the available healthcare centers are sufficient enough to afford quarantine services to patients with COVID-19 (Figure 8). The respondents say the available healthcare centers are not sufficient enough to afford quarantine services for patients with COVID-19.

ii. Healthcare centers are well staffed to attend to prospective COVID-19 patients.

Forty-four (44) respondents who represented 24% of the total sample agreed that the healthcare centers are well-enough staffed to attend to prospective COVID-19 patients, and one hundred and thirty-eight (138) respondents who represented 76.0% of the total sample do not agree (Figure 8). Therefore, there are not enough adequate healthcare center staff to attend to prospective COVID-19 patients.

iii. There are Enough Health Facilities in Health Centers in Jordan.

Sixty-five (65) respondents who represented 35.6% of the total sample agreed that there are enough health facilities in health centers in Jordan, and one hundred and seventeen (117) respondents who represented 64.4% of the total sample do not agree that there are enough health facilities in health centers in Jordan (Figure 8). There are not enough health facilities in health centers in Jordan, the majority of the respondents say.

iv. The Number of Recorded cases in Jordan has been rising since the Breakout of the Infection.

One hundred and twenty-two (122) respondents who represented 67.1% of the total sample agreed that the number of recorded cases in Jordan has been rising since the breakout of the infection, and 32.9% of the total sample, which corresponded to sixty (60) respondents, disagrees with this (Figure 8). The number of recorded COVID-19 cases in Jordan has been rising since the breakout of the infection.

v. Victims with COVID-19 who were admitted to Hospital were known to adhere strictly to Precautions against the Spread of the Virus.

A total of 63 respondents, who represented 34.6% of the total sample, agreed that victims with COVID-19 who were admitted to hospital were known to adhere strictly to precautions against the spread of the virus, and 119 respondents, who represented 65.4% of the total sample, agreed that victims with COVID-19 who were admitted to hospital were known to adhere strictly to precautions against the spread of the virus (Figure 8). Therefore, victims of COVID-19 who were admitted to hospital were not known to adhere strictly to precautions against the spread of the virus.

vi. Healthcare Workers are well protected against the Eventuality of Contracting the Virus.

A total of 46 respondents who represented 25.6% of the total sample agreed that healthcare workers are well protected against the eventuality of contracting the virus, and 136 respondents who represented 74.4% of the total sample do not agree that healthcare workers are well protected against the eventuality of contracting the virus (Figure 8). High responses were given to the statement that healthcare workers are not well protected against the eventuality of contracting the virus.

vii. Doctors Stand More Chances of Contracting COVID-19 When Attending to Patients.

One hundred and thirty-one (131) respondents who represented 72.1% of the total sample agreed that doctors stand more chance of contracting COVID-19 when attending to patients, whereas fifty-one (51) respondents who represented 27.9% of the total sample do not agree that doctors stand more chance of contracting COVID-19 when attending to patient (Figure 8). Therefore, the research calls for doctors to be extra careful when attending to patients with communicable diseases like COVID-19 to alleviate the spread.

viii. Nurses Sand More Chances of Contracting COVID-19 When Attending to Patients.

One hundred and thirty (130) respondents who represented 71.5% of the total sample agreed that nurses stand more chance of contracting COVID-19 when attending to patients. However, there were 52 respondents representing 28.5% of the total sample who disagreed that nurses stand more chance of contracting COVID-19 when attending to patients (Figure 8). However, the respondents say nurses stand more chance of contracting COVID-19 when attending to patients.

ix. Patients Respond Well to Treatments in Modified Hospitals.

A total of 57 respondents who represented 31.2% of the total sample agreed that patients respond well to treatments in modified hospitals; in addition, 125 respondents who represented 68.8% of the total sample do not agree that patients respond well to treatments in modified hospitals (Figure 8). Therefore, patients do not respond well to treatments in modified hospitals.

x. Government Should Stick to the Conversion of Hotels and Residential Buildings to COVID-19 Emergency Centers.

A total of 36.7% of the total sample, which corresponded to 67 respondents out of the 182 respondents, agreed that the Government should stick to the conversion of hotels and residential buildings to COVID-19 emergency centers; in addition, 115 respondents who represented 63.3% of the total sample do not agree that the Government should stick to the conversion of hotels and residential buildings (Figure 8). Therefore, a majority of the people do not think that the Government should stick to the conversion of hotels and residential buildings to COVID-19 emergency centers.

xi. Government Should Prioritize Funding and Expand Already Existing Hospitals Instead of Initiating the Idea of Module Hospitals.

One hundred (100) respondents who represented 54.9% of the total sample strongly agreed that the Government should prioritize funding and expand already existing hospitals instead of initiating the idea of module hospitals, and eighty-two (82) respondents who represented 45.1% of the total sample (Figure 8) do not agree that the Government should prioritize funding and expand already existing hospitals instead of initiating the idea of module hospitals.

xii. Module Hospitals Will Damage the Integrity of Existing Hospitals in the Fight Against Any Unforeseen Pandemic Disease.

A total of 120 respondents who represented 66.1% of the total sample agreed that module hospitals will serve the integrity of existing hospitals in the fight against any unforeseen pandemic disease, and 62 respondents who represented 33.9% of the total sample do not agree that the module hospitals will damage the integrity of existing hospitals in the fight against any unforeseen pandemic disease (Figure 8). The respondents say in the majority that the module hospitals will not damage the integrity of existing hospitals in the fight against any unforeseen pandemic disease.

xiii. To Ensure Effectiveness in Healthcare Services Delivery, Module Hospitals Should Be An Initiative of Private Institutions Rather Than the Government.

Seventy-two (72) respondents who represented 39.5% of the total sample agreed to ensure effectiveness in healthcare services delivery, module hospitals should be an initiative of private institutions rather than the government, and one hundred and ten (110) respondents who represented nearly 59.5% of the total sample do not agree (Figure 8). Most of the respondents agree that to ensure effectiveness in healthcare services delivery, module hospitals should be an initiative of private institutions rather than the government.

xiv. I Would Rather Visit A Traditional Hospital than A Module Hospital When the Need Arises.

There were 92 respondents representing 50.5% of the total sample who agreed that they would rather visit a traditional hospital than a module hospital when the need arose, and

90 respondents who represented 49.5% of the total sample did not agree that they would rather visit a traditional hospital than a module hospital when the need arose (Figure 8).

xv. If Well Designed and Implemented, I Think the Module Hospital Will Be A Good Idea in Successfully Ensuring A Lasting Solution to the Unforeseen Outbreak of Diseases.

One hundred and forty-two (142) respondents who represented 78.2% of the total sample agreed that if well designed and implemented, then the module hospital would be a good idea to successfully ensure a lasting solution to the unforeseen outbreak of diseases, and forty-two (42) respondents who represented 21.8% of the total sample did not agree (Figure 8). The majority of the participants say if well designed and implemented, then the module hospital would be a good idea in successfully ensuring a lasting solution to the unforeseen outbreak of diseases.

4.2. Test of Hypotheses

4.2.1. Test of Hypothesis H_o

There is no relationship between the management of pandemic cases and the new technological advancement of the pandemic hospital process.

As shown in the above table (Table 12**)**, the findings in the model summary show that independent variables (the new technological advancement of pandemic hospital processes) predicted the dependent variable (the number of pandemic cases) by 79%. This gives the notion that the independent variables were of high significance. On the other hand, other factors that are beyond the scope of this study can predict pandemic cases by 21%.

Table 12. Table Model Summary of Pandemic cases.

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate
Pandemic cases	0.89 [a]	0.79	0.79	0.914

Predictors: New technological advancements in the pandemic hospital process. [a] Dependent Variable: Technological advancement and management of pandemic cases.

4.2.2. ANOVA

Results of $p < 0.01$ indicate that the model is well defined since the p-value is less than 0.05 at a 95% confidence level. Thus, the results indicate that the findings can be used to make a conclusive statement since the model is fit. Moreover, it indicates that the pandemic hospital process significantly predicts technological advancement and the management of pandemic cases. Furthermore, the significant F indicates that for the relationship (373.38), $p < 0.001$ stands for the entire and all-important prediction of the independent variables to the dependent variable. It can be seen that the result is highly acceptable ($p < 0.001$) (see Table 13).

Table 13. Table Model Summary of Regression.

Model		Sum of Squares	Df	Mean Square	F	Sig.
1	Regression	1247.98	4	312.00	373.38	0.00 [b]
	Residual	330.06	395	0.84		
	Total	1578.04	399			

[b] Predictors: (Constant), Pandemic hospital process as the independent variable.

4.3. Hospital Building Processes

The global pandemic has become more frequent due to ozone layer depletion, which has increased atmospheric temperature, making it more conducive to disease growth. To adapt to unforeseen disease outbreaks, hospitals and healthcare facilities need to be flexible and adaptable. Traditional construction models often reduce floor space, but the

coronavirus necessitated swift construction to manage the outbreak. In Jordan, converting spacious settings into pandemic management zones could be a better alternative. This would involve reconfiguring entrance spaces, upgrading ICUs, and improving isolation wards. Other designs should be considered based on the ground and the nature of the cases to be managed.

4.3.1. Interior Design Process and 3D Proposed Module Design

Data analysis once again has proven to be a fundamental tool in the analysis and prediction of events. All qualitative and quantitative data were gathered, and case study hospitals were analyzed to develop a new and improved hospital interior design process for Jordan. The new model is not limited to COVID-19 prevention alone but rather supports all areas of improving healthcare for the country, including enhanced building plans with all aspects of enhanced technological features, such as nano-antibacterial self-cleaning, nano-self-sterilizing, air-purifying wall coatings, etc. Finally, special thanks to all participants, the Ministry of Health of Jordan, and all other supporters of the study.

Building Research Establishment Environmental Assessment Method (BREAM) criteria were, however, considered in the process of designing the proposed building. The overall proposal designs emphasize the natural sustainable features, disabled persons, and less capacitated persons.

In the picture above (Figure 9), special care should be given to pandemic disasters, the safety of all the staff, and the patients within the hospital, making sure all the features required to win the fight against the COVID-19 virus are considered. These features are explained in Figure 10 showing the process the pandemic hospital design. Natural ventilation in the patients' rooms; incorporation of greenery within and outside the hospital; the required average number of patients' capacity; isolation of the patients by making one patient per room; and a respiratory ventilation machine for patients with breathing difficulties. An article titled, "Adapting hospital capacity to meet changing demands during the COVID-19 pandemic", written by Ruth McCabe, stated that the number of hospital beds must be greater than 1550 in order to fight any kind of pandemic, and this is approved by the National Hospital Service (NHS) in England [77].

The image below presents the process that interior pandemic hospital management and design processes follow. These processes focus on the interior of the hospital building while stating the necessary steps to follow in order to fight any kind of pandemic, current or future. Technological advancement indicates the need to incorporate the technical, mechanical, and advanced interior features of the hospital building. Nanotechnology was chosen to be within the interior walls of the hospital because of its superior effects. The nanotechnology process is explained in detail in below. The other technological aspect involved in the hospital process was the machinery that will help run the hospital successfully. These machines may involve any mechanical and electronic devices used in the hospital, like oxygen mechanisms, ventilators, electric generators, uninterrupted power supplies (UPS), safety alarms, smoke sensors, HVAC, etc.

Effective policymaking is a necessary process that has to be created and followed carefully in order to successfully combat pandemics in Jordan. These policies are a set of guidelines and principles that will be applied in the interior parts of the pandemic building. These guidelines must be proposed to sustain the exercise of intensive-care professionals throughout the pandemic, in addition to encouraging the growth of national policies, which must be authorized by hospitals' governing institutions or related local government authorities. These findings are also in line with Stephen Warrillow's research in 2020 [77].

Figure 11 below shows the proposed COVID-19 hospital isolation center; it also shows the nine floors in the building, the greenery in the surroundings, the footpaths, and the windows for cross ventilation. The building was designed with greenery to support the natural cooling and good exchange of respiration within the hospital. The plants will absorb the carbon monoxide exhaled by both the patients and the hospital staff while giving out oxygen. However, they help cool down the hospital's surroundings by absorbing the sun's

heat and protecting the building from direct sunlight. The importance of using greenery was adopted from BREEAM green building criteria in this hospital building proposal.

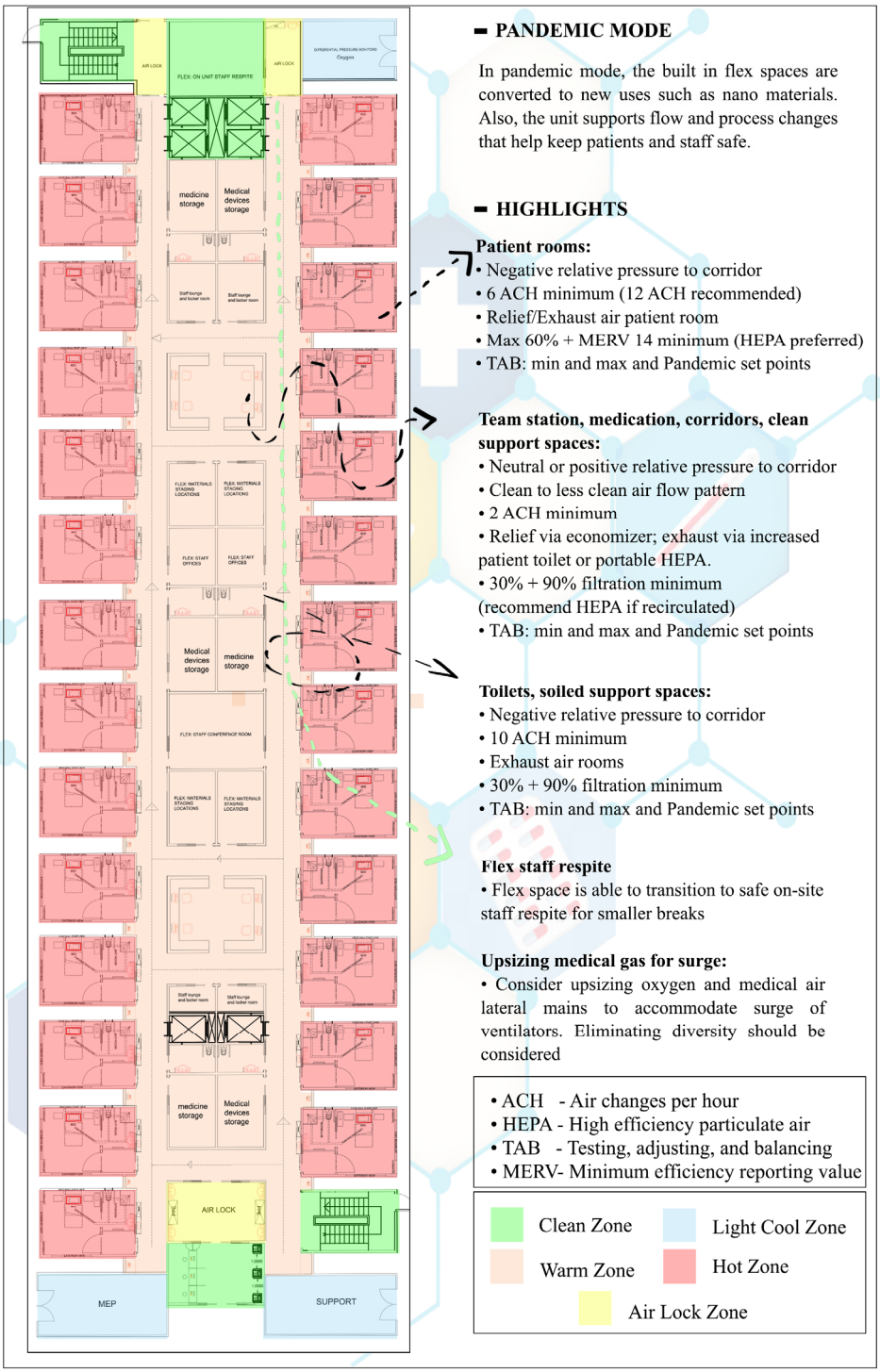

Figure 9. Three-dimensional Model Plan for Jordan Hospital Design.



Figure 10. The Interior Pandemic Hospital Design Process.



Figure 11. The surroundings of the 3D Model for Pandemic Hospitals.

The picture above (Figure 12) shows the space between the blocks of the pandemic hospital building. It shows the passageway along with some plants that reduce the impact of the sun penetrating the building interior through the openings. It also protects the building walls from heat, which keeps the interior cool even at night when the exterior walls are cooling.

This sort of plan depicts a typical hospital model, which serves as a template that is adopted in arriving at the 3D designs in this research work. This is a comprehensive model that pays attention to details in selecting every component of the hospital room, including the passageways for effective circulation. Nanotechnology is employed to include a touch of modern-day advancement, ranging from its applications on tiles, healing vents, water closets, walls, curtains, and upholstery. The implementation of simplicity in the circulation within the interior of the building makes it easy for both the patients and staff to move freely and identify the facilities they require easily. In this design, there are four elevators, i.e., two on each axis: two closer to the main entrance and two at the end of the hospital. These elevators can be used by both the disabled and both staff and patients. However, there are two emergency staircases in this design.

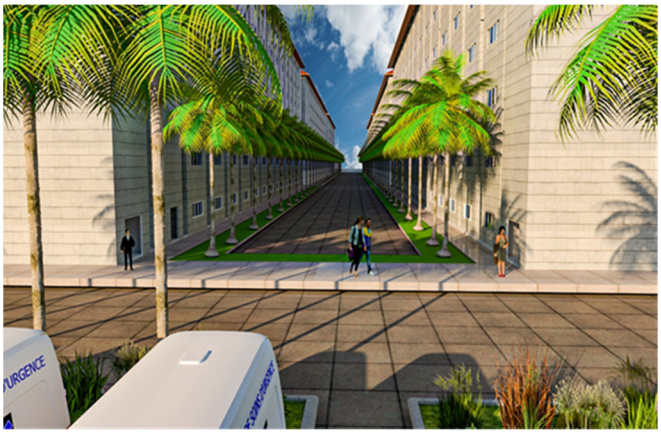

Figure 12. The Spaces between the Blocks of the Hospital Building.

The 3D plan in Figure 13 is properly explained in the figure below. There are a total of seven external doors in every block in this hospital; some of these doors are connected to the interior and some are not. Doors like the main entrance, the alternative entrance, and the two emergency exits are connected to the interior of the building. While all the service doors only have access to the machines that were placed for utility, supply, and maintenance purposes, such situations usually arise from time to time. Most of these machines require these doors for servicing, maintaining, and the provision of the materials required for the machine to operate properly. The main entrance, as shown in Figure 14, is facing the parking area of the hospital compound. This door has a sensor to open and close electronically, but it gives access to the reception area first, where patients are first registered and admitted if the need arises. The next room after the entrance door is the airlock room, which prevents the interior air from coming to the exterior. With this, the virus will be contained within the building, and the prevention of its spread will be strong. Also, in the airlock room are hazmat suits, face masks, hand gloves, a hand wash basin, and detergent that the visitors, patients, and staff must wear before entering the hospital. There are 27 patients' rooms per floor, as shown in Figure 13, and each patient's room was designed in such a way that it would not keep the virus for a long period. This is because the virus does not perform well in a hot environment [79–81]. Therefore, the patient's room did not have any cooling device like an air conditioner or HVAC; rather, a natural cross-ventilation was devised in the patient's room. A detailed explanation of the 3D plan design was shown in Figure 14 below.

This cross-ventilation was achieved by having one window on two different walls of the room (refer to Figure 15). This is even more sustainable in terms of cost savings and electric consumption when operating the hospital [80,82].

The HVAC, however, exists in the building, but at a controlled rate of temperature that is not more than or less than 24–26 °C. The HVAC exists in the passage and all other rooms within the middle-centered rooms. Because the rooms lack natural ventilation, the interior core will be uninhabitable for both staff and patients. There is no HVAC in the patient rooms, as mentioned earlier.

The patient's room is shown in Figure 15, which shows that the room is divided into two portions. The small portion is a small entrance for cleaning up and disinfecting before and after coming into contact with the patient. The bigger portion is the patient's room, well equipped with several machines that will aid quick recovery and be easily accessible by the patients and the staff. These machines were oxygen machines, ventilators to support people with breathing issues, intensive care devices to support patients in critical conditions, chargers for the defibrillator paddles, etc. As mentioned earlier, there are windows in the room for cross-ventilation. However, the room contains a personal toilet for the patient and a device that will lift patients in a critical condition and take them to the toilet automatically.



Figure 13. The 3D plan of the building.

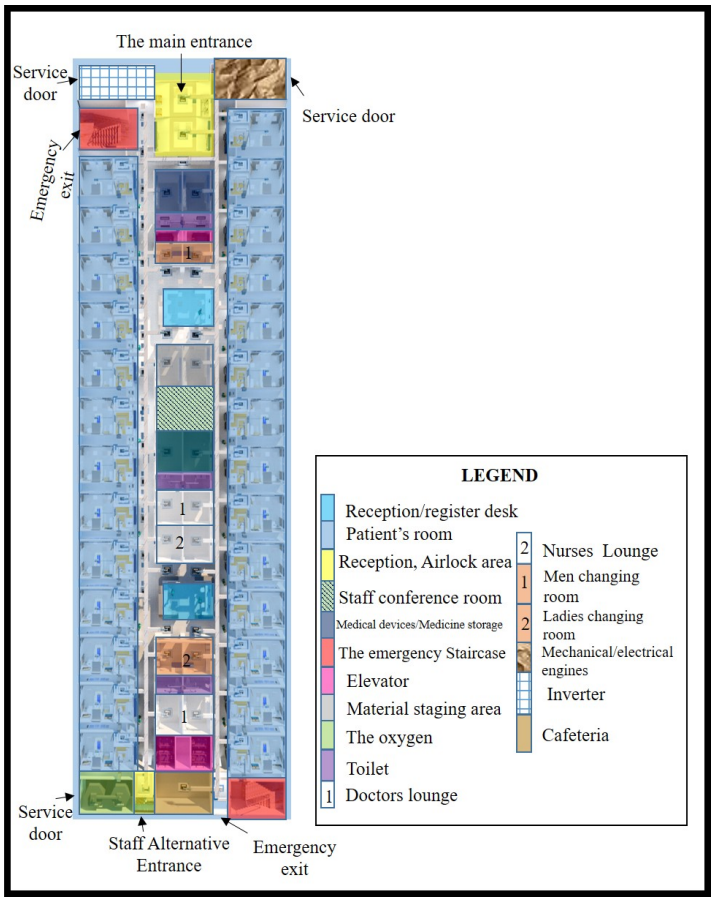

Figure 14. A detailed explanation of the 3D plan design.

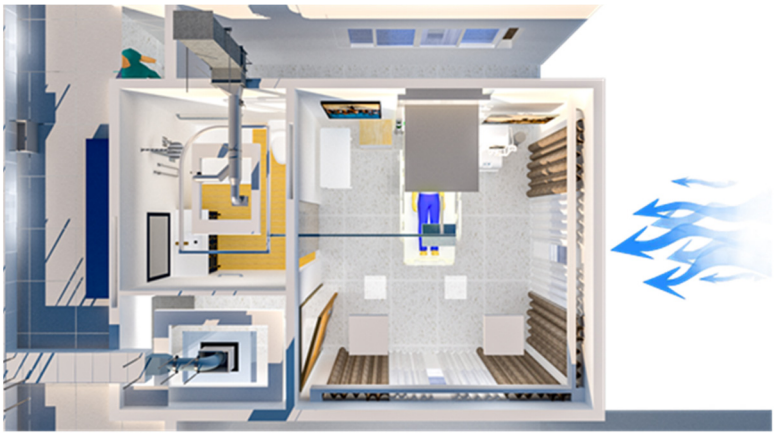

Figure 15. The structure of the patient's room.

In this model, there were about three hospital registration desks, one at the main entrance and the other two at the center of the building. As shown in Figure 16, this is an example of how the inside of a hospital registration desk looks. In this registration desk, patients who had been discharged, died, or were in critical condition will be recorded and documented. The registration desk at the entrance was for patients who were admitted for the first time. However, the registration desk will always have nurses in case of emergencies that arise from existing patients in the hospital.



Figure 16. The Hospital Registration Desk.

In this hallway shown in Figure 17, the computer is placed beside the door of every patient's room, along with a washbasin for disinfection. This is necessary to keep individual records that can be accessed remotely and to disinfect the hands for the protection of the staff.

The hallway is part of the pandemic hospital that should connect all the sections and wards of the building. This part is very important and regularly used; therefore, special care must be given to this building part by regularly cleaning and sanitizing it. Also, it must connect with all other parts of the building at the same floor level or elevation so as to provide easy access for patients' beds, wheelchairs, and other wheeled hospital gadgets to be easily moved around the building to decrease the chance of accidents occurring. Other parts of the hospital that the hallway connected were the patients' wards or rooms, the interior reception area, elevators, doctors' and nurses' rooms, cafeterias, stores, emergency staircases, and exits. All the parts of the hospital can be kept at an average temperature of at least 30 °C except the patients' room, which is required to be around 37 °C and not more than 40 °C. Cross ventilation is encouraged in the patients' room instead of the provision of HVAC because natural ventilation is a very important factor in the fight against

COVID-19 and it is sustainable as well, according to the Building Research Establishment Environmental Assessment Method [83].



Figure 17. The hallway.

The hospital's tools and equipment sterilization process will be explained in the picture below (refer to Figure 18).

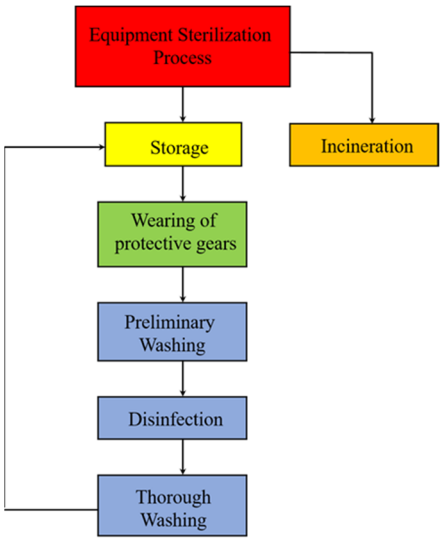

Figure 18. The Equipment Sterilization Process.

Figure 18 depicts the process of sterilization of equipment and tools during the event of COVID-19 and any other pandemics. The fact that thorough sterilization and burning or incinerating some tools and consumables eliminates the virus makes it an effective process of disinfecting the tools before reusing them on another patient. This process was developed in an effort to avoid the spread of the virus between different patients. The stages in the sterilization process, as shown in Figure 18, begin with the temporary storage of the equipment and the wearing of protective gear like hand gloves, protective suits, and boots to protect the staff conducting the process. A preliminary wash should be performed with a detergent because any detergent can kill the virus and remove dirt from the tools. Then, a disinfectant can be introduced, and the tools should be left inside the liquid for 5 s before finally being thoroughly washed to make sure they are safe to be reused. The disinfectant liquids are many, but some effective COVID-19 disinfectants are sodium hypochlorite (bleach or chlorine) (0.1% or 1000 ppm, or 1 part of 5% strength household bleach to 49 parts of water) and alcohol (at 70–90% concentration) [84]. The

sterilized equipment should be taken to a separate clean storage area, separated from the dirty ones, ready to be used.

4.3.2. The Application of Nanomaterial in the Design Process

The new nanometer materials challenge designers' thinking and promote the evolution of designers and interior design styles. As a result, nanomaterials in building materials have a very broad market application potential as well as significant economic and social benefits; new nanomaterials are increasingly "created", forming a virtuous cycle that has influenced and promoted the development of interior design [85–87].

This underlines the importance of carefully selecting finishing materials in the process of building or structural design. Nanotechnologies, therefore, serve as a useful tool for putting materials to better use in the field of architecture. The use of substances on a nano-length scale can enhance the features they possess and ensure that the ways in which they are properly utilized are well spread out [88,89].

The nanomaterial technology process in pandemic hospital design is shown in the figure above (Figure 19). The importance of this technology has been highlighted, which will help achieve an effective pandemic hospital management system. The pandemic hospital requires regular cleaning and sanitation, performed hourly. This technology will assist in so many parts of the hospital when it is applied. It needs to be applied to the walls, ceramics, ceiling, furniture, and floor of the whole hospital Figure 19. This will minimize sanitation efforts, prevent the transmission of infectious or communicable diseases, and purify indoor air quality. This is undertaken because the nanomaterial possesses several features that a clinical environment requires in order to have a disease-free environment. This feature is the self-cleaning environment, which prevents hospital infectious diseases, is antibacterial, kills insects like spiders and their webs, eliminates mold and fungi, and prevents chemical hazards.

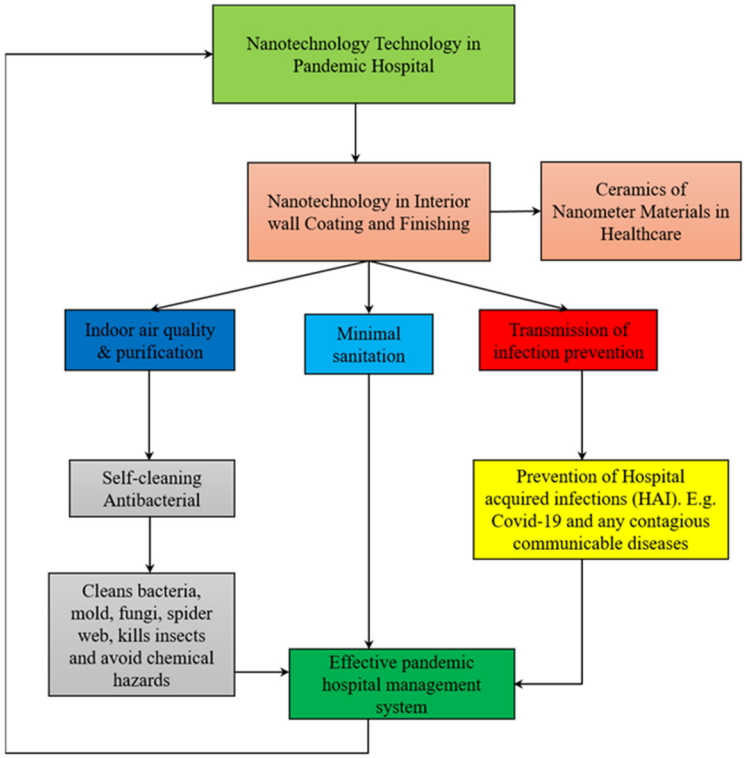

Figure 19. The Nanotechnology Process.

The table above (Table 14) explains the effects of nanotechnology when applied to the hospital building. The assessment was performed using various literature reviews

conducted for this research. The table begins with the pillars of sustainability measures such as economic, social, and environmental sustainability measures, for which the overall assessment was very good. The negative effects of nanotechnology are minimal, thereby resulting in a poor score; the score for unknown effects was also very poor, which indicates that most of the effects of the nanomaterials are known and are mainly positive. Preventing the loss of the energy effect of nanotechnology was good, as the material helped in retaining the interior temperature and used less energy in maintenance, which resulted in energy loss prevention from nanomaterial effects. The overall assessment of this table was "very good" with 13 scores and 6 measures indicated as "good", "fair", "poor", and "very poor". This shows the importance of nanotechnology's involvement in this study. These results are summarized in the chart below; refer to Figure 20.

Table 14. The assessment of the effects of nanotechnology on building structures.

S/N	Effects of Nanotechnology	Very Poor	Poor	Fair	Good	Very Good
1.	Economic, social, and environmental sustainability measures					*
2.	Negative effects		*			
3.	None or unknown effect	*				
4.	Energy loss prevention				*	
5.	Energy conservation					*
6.	Consumption of minimal natural resources					*
7.	Consumes minimal space				*	
8.	Minimal transportation costs				*	
9.	Minimal environmental toxic gas emission					*
10.	Maintain average indoor temperature					*
11.	Reduce cleaning time					*
12.	Minimize chemical substance usage in disinfecting					*
13.	Long lifespan				*	
14.	Ease of application					*
15.	Less need for repair and maintenance				*	
16.	Increase the indoor air quality					*
17.	Avoids bacteria spread					*
18.	Lighting energy-saving by Nano-reflective particles					*
19.	Maximum brightness and efficiency					*
20.	Reduced costs of cooling a room				*	
21.	Required during color filtration when changing the color	*				
22.	Energy saving					*
23.	The effects on human health			*		
24.	Recycle and reuse				*	

* Refers to the active assessment score.

The chart above (Figure 20) shows the overall assessment of nanomaterials when applied to hospital buildings. The result was presented in percentages, which summarizes the overall outcome of Figure 20. Good and very good amount to 82.61%, while poor and very poor amount to 13.04%, and fair is 4.35%, which means that it is neither good nor poor. The overall effects of 82.61% supersede the negative or poor effects; this shows that nanotechnology is highly effective in hospital design and management.

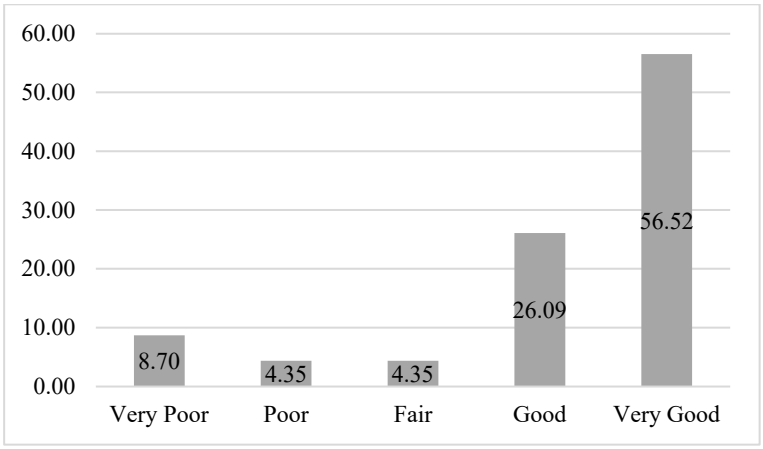

Figure 20. Overall Assessments of the Effects of Nanotechnology on Hospital Design.

5. Conclusions and Recommendations

The aim of this research is focused on refining the present COVID-19 Hospital Design process in the Management of Pandemic Cases and recommending a procedure for the hospital management of pandemic cases that would lessen the effects of the current and future pandemics. A mixed method was used in this research, in which both qualitative and quantitative data were taken and analyzed using the descriptive method. Case studies were four hospital buildings, which were selected and analyzed based on their capacity to accommodate the COVID-19 disaster and contain the virus, thereby avoiding the rapid spread of the virus. These hospitals, all in Jordan, were found lacking these capabilities. Questionnaires were also used to fetch raw data in this research, which focused on the perception of the hospital workers, and were analyzed and the results were reported in this research. Findings from this research work revealed that there has been a considerable upward rise in the number and level of adoption of technological advancements in hospital spaces. The sizes of the resulting machines concerning the space they are to occupy may pose some sort of initial challenge at the introduction of any particular piece of technology, but with the work of interior architecture and a series of advancements in the technology, reasonable solutions are arrived at. The role of nanomaterial technologies is remarkable and necessary for implementation in any pandemic hospital.

A key point to note in this study is the fact that the introduction of any machine or product of technological advancement into a hospital's interior module process cannot be random or ubiquitous. This has to involve careful work to be undertaken by designers in arriving at effective solutions that will be suited to casual day-to-day illnesses in hospitals and also be well-equipped and easily adapted to any unforeseen epidemic of disease, just like in the case of the coronavirus.

The set objectives of this research study were met by considering the present and substitutes that exist for any future healthcare facility in Jordan, which has to do with emerging technologies in interior architectural and management processes.

Findings reveal that basic alterations are predicted to take place relating to space and medicine in a typical healthcare facility that will affect and are well suited to tackling pandemic cases of diseases while also prioritizing flexibility and dynamism as essential tools for fine-tuning decisions in the healthcare environment. This research strongly endorses the need for flexibility in healthcare facility design and process solutions.

The recommendations in this paper are drawn from the problems found in the entire research work. These recommendations were expected to address the current and anticipated pandemic disasters that may occur. Therefore, the following recommendations are listed below:

- The government, private sector, and organizational bodies related to health provision in Jordan should provide adequate hospital beds in one or more individual hospitals to

handle the remarkable number of patients in the country as a whole. When analyzing the proposed module, "Pandemic Hospital", it was stated to have not less than 1550 hospital beds. The country has seen how many people have died during this COVID-19 pandemic and how much economic damage was recorded, and it would not be wise to allow it to happen again. Therefore, the Government has to be prepared for any kind of biological disaster to reign due to the lack of building facilities in the country.

- Adequate healthcare staff should be employed and trained on how to handle the virus strain and ways to protect themselves, their patients, and their families at home. Provisions for adequate functional equipment in hospitals are necessary to fight any kind of pandemic. This equipment can be oxygen and respiratory machines, charged paddles, and the entire clinical tool required for the fight against COVID-19 and a future pandemic.
- Public enlightenment about the COVID-19 virus and ways to protect them is necessary. This is because when the public is aware of the virus and of ways to avoid it, the hospital will not become congested with infected patients. Public enlightenment can be undertaken through media of any kind.
- The proposed pandemic hospital module process designed in this paper was an excellent way to reduce the crowding in hospitals and was sufficient to handle any anticipated biological disasters, pandemics, and endemics, both current and future ones. This hospital was airtight and located in an isolated area, well equipped with the emergency measures and tools required to help patients heal faster. Therefore, this research strongly recommends the implementation of this pandemic hospital process to help the entire nation.

Lastly, it is highly recommended that this paper be used as a guideline required to fight against any pandemics or endemics in both the present and the future. This is because this paper provides a comprehensive process guideline to combat any deadly viruses, which are shown in detailed photos and process diagrams. In addition, the use of nanotechnology in new hospital designs is trending in the world nowadays, and when incorporated into any hospital design, it will drastically reduce the virus spread among human beings. The research also suggests that future research be conducted on patients' perceptions and opinions about the capacity of existing hospitals in Jordan to handle current and future pandemics, because this paper's research has mainly focused on the hospital staff's perceptions about the hospitals' ability to contain and fight COVID-19 cases in Jordan.

Author Contributions: Conceptualization, S.H.A. and Ç.Ç.; Methodology and Literature Retrieval S.H.A. and Ç.Ç.; Writing—Original Draft Preparation, S.H.A. and Ç.Ç.; Writing—Review and Editing, S.H.A. and Ç.Ç.; Supervision, Ç.Ç. All authors have read and agreed to the published version of the manuscript.

Funding: This research received no external funding.

Data Availability Statement: The data presented in this study are available on request from the corresponding author.

Acknowledgments: This article is generated from the Ph.D. thesis prepared by Saeed Hussein Alhmoud at the Near East University, under the supervision of Çiğdem Çağnan.

Conflicts of Interest: The authors declare no conflict of interest.

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