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RESEARCH ARTICLE

Towards an Amalgamated Framework for the Green Retrofitting Process of Healthcare Facilities

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ABSTRACT
Healthcare service providers have focused on the environmental effects of healthcare facilities (HFs) in recent years in order to mitigate the environmental impact of HFs, sustain the well-being of occupants and patients, and delineate the targets of the Sustainability Development Goals (SDGs), the Paris Agreement, and the 2021 United Nations Climate Change Conference (COP26) Special Report on Climate Change and Health. Because the fundamental aims of healthcare are to improve patient health and sustain the daily operations of an HF, green retrofitting practices in HFs form a crucial link between providing environmentally friendly HFs and patient health and well-being. Hence, the main objective of this paper is to propose an amalgamated green retrofitting framework for healthcare facilities by analyzing existing retrofitting methodologies and approaches. Normative refinement and frequency analyses were applied when reviewing the healthcare-specific green retrofitting methodologies and approaches for determining the dimensions and criteria to consider for the framework. Expert feedback also contributed to the framework's improvement and modification based on the methodology's validation step. The finalized conceptual framework is anticipated to facilitate an understanding of the fundamental considerations for green retrofitting HFs and to serve as a guide for healthcare building providers, academicians, and green building professionals.

Keywords: Green retrofit, healthcare facilities, retrofitting methodologies, SDG3, SDG7

1. Introduction

The challenges in providing and sustaining the delivery of required healthcare services have gained momentum due to climate change, its rising influence, and the adverse environmental effects of HFs. HF retrofitting is one of the most problematic types of projects in the construction industry (Mohammadpour et al., 2017). This study aims to investigate the current methodologies for retrofitting HFs with a particular focus on the retrofitting process itself, because retrofitting existing buildings is a sustainability goal that all sustainability-focused agreements aim to meet and the retrofit rate of existing HFs is below desired levels.

When taking climate change, health, and well-being into consideration, the 2030 Agenda, the Sustainability Development Goals (SDGs; United Nations [UN], 2015a), the Paris Agreement (UN, 2015b), and the 2021 United Nations Climate Change Conference (COP26) Special Report on Climate Change and Health (World Health Organization [WHO], 2021) have to be considered as motivators for the efficient and progressive steps all parties must take that are aimed at enhancing the built environment through retrofitting.

The 2030 Agenda for Sustainable Development was adopted by the UN General Assembly by considering the 17 SDGs as an action plan for people, the planet, prosperity, peace, and partnership (UN, 2015a). Implementing the 17 SDGs is an urgent need in order for all countries to end poverty, improve education and health, decrease inequality, and promote economic development (UN, 2021a). Notably, good health and well-being (SDG3); affordable and clean energy (SDG7); industry, innovation, and infrastructure (SDG9); responsible consumption and production (SDG12); and climate action (SDG13' UN, 2021a) are among the 17 SDGs that form a significant link between climate change and HFs. The Paris Agreement is a climate change agreement on how to combat climate change and its impacts and accelerate and intensify the movements and investments necessary to accomplish a sustainable, low-carbon future (UN, 2021b). The Paris Agreement can also likely be highlighted as the primary healthcare-related agreement

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for helping not only reduce and adapt to climate change-related health threats but also achieve the SDGs (WHO, 2018). Notably, HFs should urgently reduce their carbon footprint to deliver a low-carbon future.

Another critical aspect related to climate change, health, and well-being is the COP26 Special Report on Climate Change and Health, which prioritizes issues concerning climate change and critical health situations (WHO, 2021). The report developed 10 recommendations for coping with climate change, restoring biodiversity, and protecting health and well-being (WHO, 2021). Hence, the motivation for this paper is that SDGs, the Paris Agreement, and COP26 recommendations are the main drivers for reducing the environmental impacts of existing HFs for sustaining health.

Hughes (2020) also highlighted digital transformation to be critical for tackling the adverse impacts of climate change. Adopting digital technologies can help realize the desired goals regarding sustainability targets (World Economic Forum, 2023). According to the UN Environment Program (2022), digital transformation can potentially reduce carbon dioxide (CO2) emissions by at least 20%. Schweizer (2023 p.xx) stated, "To accelerate the journey to a net zero future and timely adoption of climate change, we must systematically integrate technology and data at every step of processes." Therefore, an urgent need exists not only to investigate the green retrofitting processes of HFs but also to integrate digital technology tools into these processes.

The detrimental impacts of the underperformance of existing HFs on society and the environment regarding sustainability have necessitated retrofitting actions for improving indoor environmental quality, providing occupant satisfaction, reducing infections, improving patient recovery rates and safety, and providing better service capacity, such as flexible rooms and spaces (Ergin & Tekçe, 2020). The retrofitting process is a general term that may consist of various treatments, including renovation, rehabilitation, restoration, and reconstruction. Therefore, selecting the appropriate strategy and methodology is a tremendous challenge in retrofitting and must be determined individually according to each project's unique conditions.

Green retrofitting existing HFs is a crucial response to mitigating climate change and its impacts and supplements the ability to accomplish all SDGs, the Paris Agreement, and COP26 recommendations by eliminating potential harmful loads regarding CO2 and energy consumption. Green retrofitting applications have a strong link between providing environmentally friendly HFs and patient health and well-being. The pressure to improve patient health and well-being and improve the environmental performance of HFs has led to an increased requirement for methodologies and approaches that enable the green retrofitting of HFs.

Despite the importance of the subject, the existing literature has a relatively limited number of healthcare-specific studies related to green retrofitting methodologies and approaches. Hence, this study works to develop an amalgamated green retrofitting framework for healthcare facilities by investigating the current methodologies and approaches.

2. Green Retrofitting Healthcare Facilities

The construction industry conducts retrofitting works based on advancements, the changing requirements of facilities' occupants, and the age of facilities (Salgın, 2019). Various studies in the existing literature have defined green retrofitting. Green retrofitting existing buildings is recognized as a critical opportunity for mitigating the impacts of global warming, such as greenhouse gas emissions and energy consumption (Ma et al., 2012). Doug Gatlin, who worked in significant positions at the US Green Building Council (USGBC) for many years, explained green retrofitting from USGBC's point of view as:

> *any kind of upgrade at an existing building that is wholly or partially occupied to improve energy and environmental performance, reduce water use, and improve the comfort and quality of the space in terms of natural light, air quality, and noise – all done in a way that it is financially beneficial to the owner. (as cited in Lockwood, 2009, p. 48)*

When considering global energy, building materials, and water usage, green retrofitting existing buildings substantially affects existing building performance, economic profits, and the health and well-being of the building occupants (Kavani & Pathak, 2014). Green retrofitting supports beneficial results that minimize the massive usage of energy, provide several green retrofitting implementations, enhance society's healthcare, protect the environment, and increase awareness related to retrofitting actions (Mickaityte et al., 2008). Notably, improving society's health and well-being arises as a significant situation in the health industry due to the primary objective of healthcare being to enhance patient health and well-being (Golbazi & Aktas, 2016). Ironically, HFs have been described as an energy-intensive structure that leads to considerable environmental impacts while coincidentally contributing to illnesses and harmful health consequences (WHO & Health Care Without Harm [HCWH], 2009). Generally, HFs run 24 hours a day, seven days a week, and provide proper essential patient care (Morgenstern et al., 2016). Consequently, HFs need to meet not only healthcare but also environmental requirements. According to the literature review, these needs can be identified as healthcare-specific requirements such as stringent control of indoor air quality (IAQ), proper medical equipment for treatments, strict control of diseases, and waste management systems (Kolokotsa et al., 2012), as well as the critical protection of occupants against hospital-acquired infections and occupational illnesses (Leung & Chan, 2006).

Green retrofitting HFs requires critical consideration to support the healthcare-specific necessities and occupant safety requirements (Robinson, 2012). Some essential difficulties occur in the process of green retrofitting HFs, mainly with regard to sustaining HFs' daily management and maintaining patient safety. The need exists for immediate efforts aimed at dealing with the spread of infections and sustaining patient safety during a retrofit in order to prevent dissatisfaction among the occupants and safety difficulties (Mohammadpour, 2014).

With the rising push to green retrofit HFs, significance is had in identifying the critical enablers and drivers of green retrofitting. As noted by Low et al. (2014, p.421), the main drivers that contribute to green retrofitting both new and existing buildings are "government legislation/incentives, corporate social responsibility, rising energy bills, overseas competition/influence, competent team members, marketing/branding motive, local competition, improve the well-being of employees, and return on investments (ROI)." From a regulatory point of view, policies and regulations related to greening have been seen among the predominant drivers for establishing energy efficiency and the technological requirements for promoting green retrofitting (Ma et al., 2012). Notably, Coskun and Selcuk (2022) stated that the processes for building retrofitting and performance assessment could be impacted by inadequate political regulations, economic issues, and user-centered social factors. Thus, consideration for healthcare and healthcare occupant-centered factors while setting regulations for retrofitting is particularly critical for improving retrofitting performance.

In terms of healthcare, Sheth et al. (2010b) underlined and classified the main driving factors for the refurbishment of HFs under their specific categories as users (covering profiles, demographic information, patterns, populations, and needs), construction (covering structural, seismic, energy, technical, and technological changes and improvements in construction), and future drivers (covering new regulations, changing demands, and improved technology).

When considering the green retrofitting of HFs, the methodologies and approaches should focus on healthcare-specific requirements. Several green retrofitting practices can be applied to HFs, and retrofit studies help to create awareness of the current retrofitting practices that are vital for taking fundamental actions. According to existing studies, the primary practices in green retrofitting are mainly based on energy efficiency, improving HVAC system performance, lighting systems, water usage, building envelope improvements, strengthening buildings' seismic performance, and improving the interior design (Ergin, 2020). Implementing these practices in HFs contributes to significant outcomes such as energy savings, providing sensitive control of the indoor environmental quality, preventing the spread of infections, reducing the higher expenses in day-to-day operations and maintenance, payback period adjustments, water savings, seismic improvement, improved occupant comfort and productivity, and reduced patient recovery and hospital stays.

Thus, green retrofitting should be considered an essential move for sustaining and improving the health and well-being of an HFs' users and for meeting sustainability goals regarding building performance. Green retrofitting can also be accomplished by implementing the different retrofitting methodologies and approaches various studies have proposed.

3. Green Retrofitting Methodologies and Approaches

In general, the retrofitting process faces numerous challenges. Hence, from a process management perspective, these difficulties are influenced by each other interactively, and some incur extra costs (Ho et al., 2021). Certain methodologies have been developed to support building retrofit decisions, facilitating the design of the building retrofit process.

To succeed in green retrofitting, the need exists for healthcare providers, project managers, and project stakeholders to have HF retrofitting roadmaps. In terms of guidelines and application strategies, Bertone et al. (2018) conducted a study based on proposing energy and water retrofitting guidelines and underlined five critical steps for a successful retrofitting project (Figure 1).

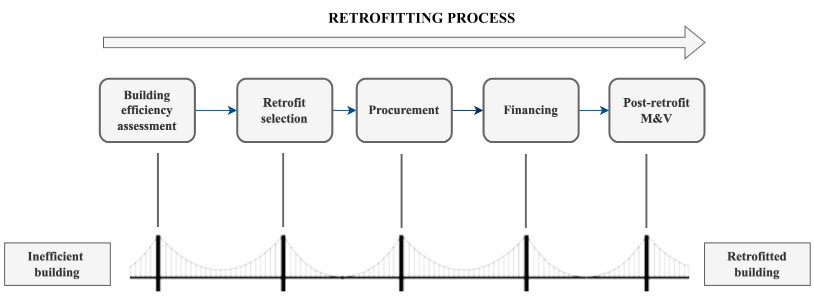


Figure 1. Key components of a building retrofitting project (Bertone et al., 2018).

Ma et al. (2012, p.891) designed a five-phase approach for green building retrofits that covers “project setup and pre-retrofit surveys, energy auditing, and performance assessment, identifying retrofit options, site implementation, commissioning, and validation and verification components” (Figure 2). This approach consists of five phases and is able to retrofit any building type.

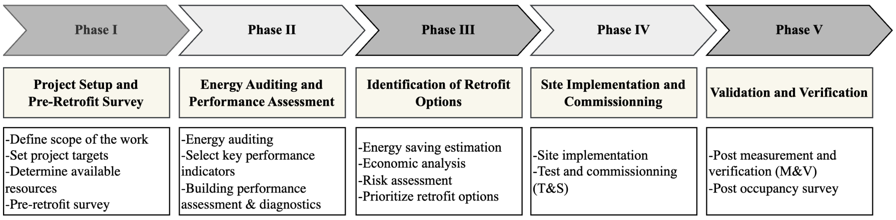


Figure 2. Key phases of building retrofits (Ma et al., 2012).

Moreover, Ma et al. (2012) created a systematic way to define, determine, and execute the possible retrofit measures for existing buildings (Figure 3). Their systematic framework for green retrofitting buildings is mainly based on identifying the key elements of building retrofits and critical elements of retrofit that will lead to the project’s success of the project and involve the factors of client resources and anticipations, retrofit technologies, human factors, building characteristics, policies, and regulations, as well as uncertainty factors.

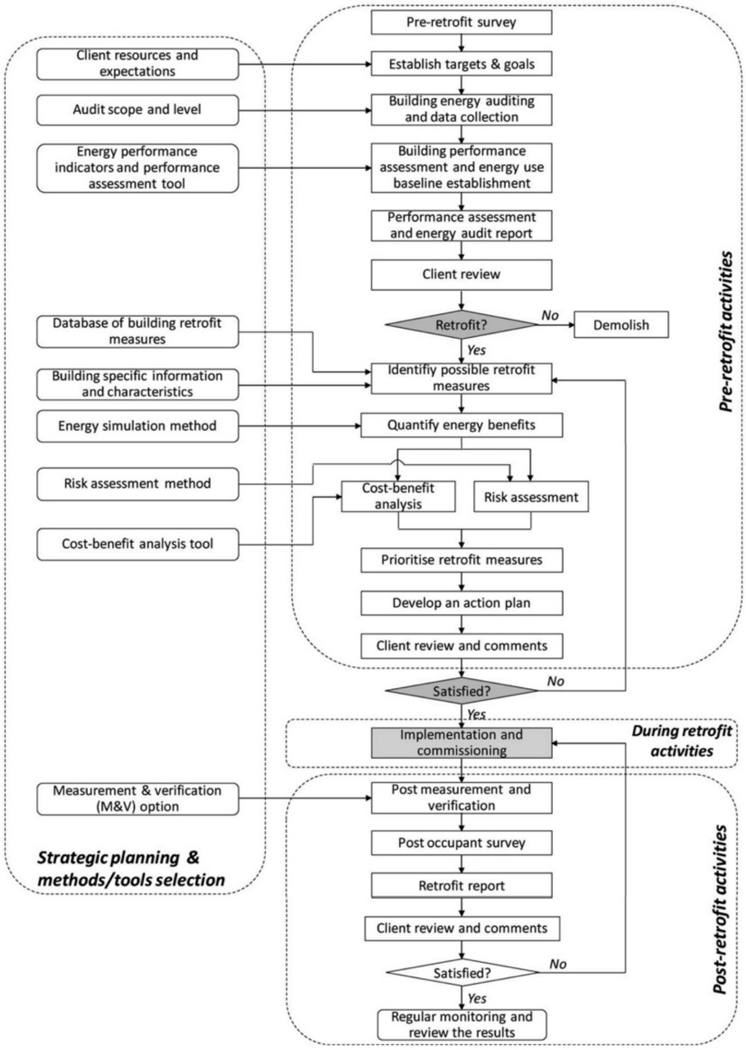


Figure 3. A systematic approach to sustainable building retrofits (Ma et al., 2012).

In addition to the reviewed studies, Luther & Rajagopalan (2014) have identified an energy retrofitting methodology categorized into four stages (Figure 4). The primary consideration of this energy retrofit methodology is to define the energy waste, minimize the need for electricity, and then retrofit to achieve energy efficiency (Luther & Rajagopalan, 2014).

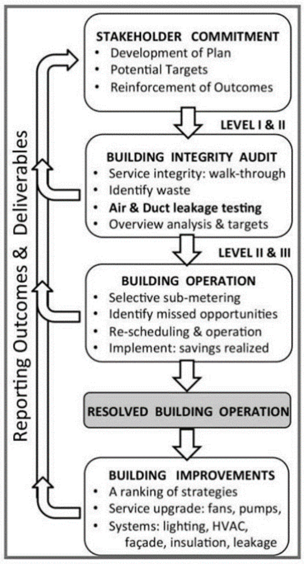


Figure 4. A proposed methodology for energy retrofitting (Luther & Rajagopalan, 2014).

Mickaityte et al. (2008) proposed a refurbishment model from a sustainable viewpoint involving different dimensions such as the technical, cultural, ecological, social, architectural, and economic considerations that substantially impact the general efficiency of a refurbishment implementation (Figure 5). This conceptual model focuses on public health, occupant comfort, aesthetics, decoration, cultural and behavioral norms, public awareness and education, collaboration, and social safety by considering human-based aspects. In addition to the aforementioned dimension, the process of a sustainable building refurbishment should follow the identified steps of "information collection, decision modeling, solution selection, and implementation" (Mickaityte et al., 2008).

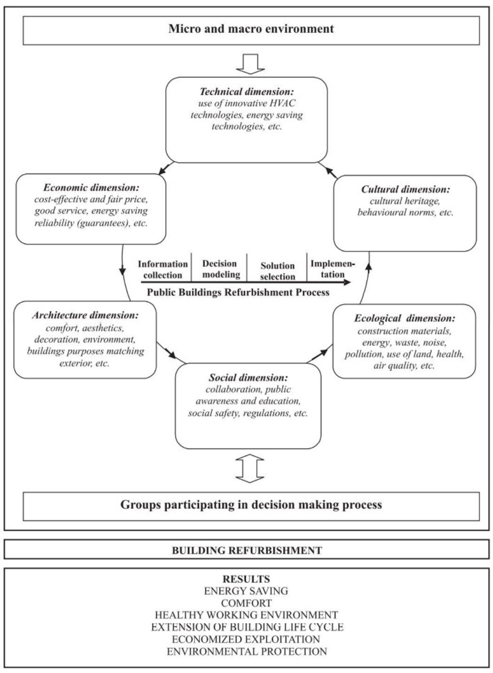


Figure 5. The concept model for sustainable building refurbishment (Mickaityte et al., 2008).

Abidin et al. (2019) conducted a critical study on developing a decision-making tool for energy reduction called the multi-criteria retrofitting energy efficient building (MCREEB). MCREEB consists of retrofitting initiatives, criteria selection, and assessment stages. Decision making with regard to retrofitting is a complex process that can be affected by design issues, building efficiency, and green technologies, as evaluating these critical components contributes to achieving rational and realistic results. Therefore, the development of MCREEB provides a significant path for assessing several factors (Figure 6).

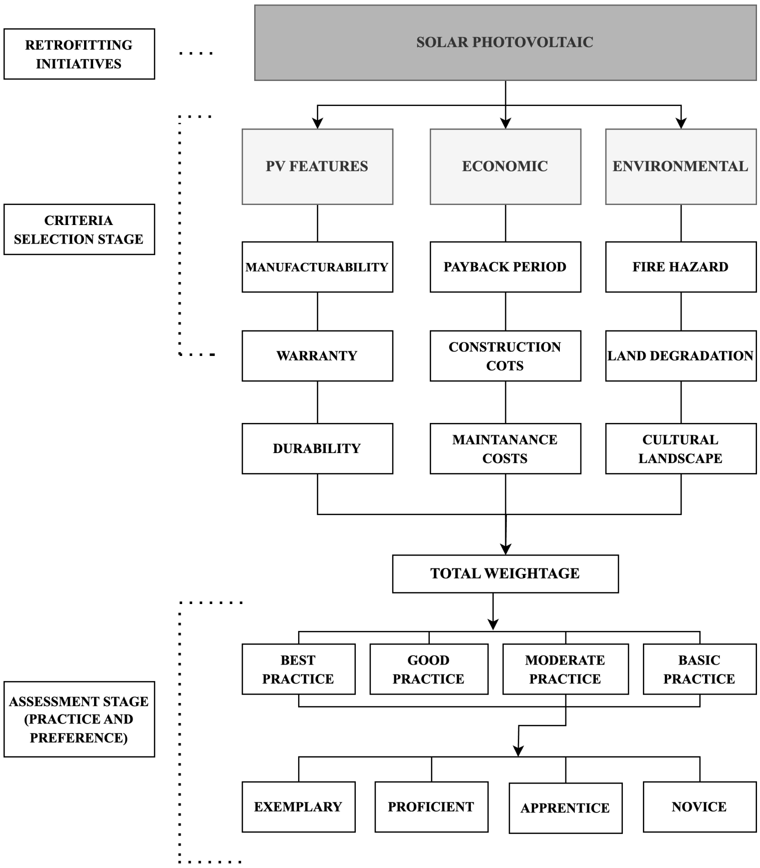


Figure 6. Flow of the decision-making process in retrofitting (Abidin et al., 2019).

Geldenhuys (2017) developed a holistic framework related to implementing green retrofits for existing buildings in South Africa. The study was designed based on the retrofit measures framework Ma et al. (2012) proposed. The proposed framework for the South African context includes five steps: retrofit feasibility, pre-project planning, construction, post-retrofit activities, and operation and maintenance. The significance of the current study is that the first two phases of the developed framework have been implemented in a real-life case study involving a retrofitting project. Figure 7 represents the generic green retrofitting framework for the South African context.

4. Healthcare-Specific Green Retrofitting Methodologies and Approaches

Due to the requirements and considerations specific to healthcare, the need exists to develop retrofitting roadmaps, especially for HFs. Providing and sustaining patient safety is one of healthcare's greatest concerns, which is why Mohammadpour (2014) conducted a retrofitting study based mainly on patient safety and energy efficiency. Mohammadpour (2014) proposed the patient safety and energy efficiency (PATSiE) framework, which includes five efficient phases (Figure 8). This framework has critical considerations regarding HF regulations in the context of a retrofit project, as improving patient health and building efficiency is crucial. Notably, identifying the healthcare retrofitting stakeholders, as well as their roles and responsibilities, strongly influences the ability to achieve the goals of a healthcare retrofitting.

Likewise, Sheth et al. (2010a) developed a framework for refurbishing HFs with an energy focus on other possible construction concerns. The framework covers the three primary refurbishment progressions of pre-refurbishment, refurbishment, and post-refurbishment (Figure 9). To gain better understanding, the framework was designed with three main columns representing the phases, purpose, and tools and processes.

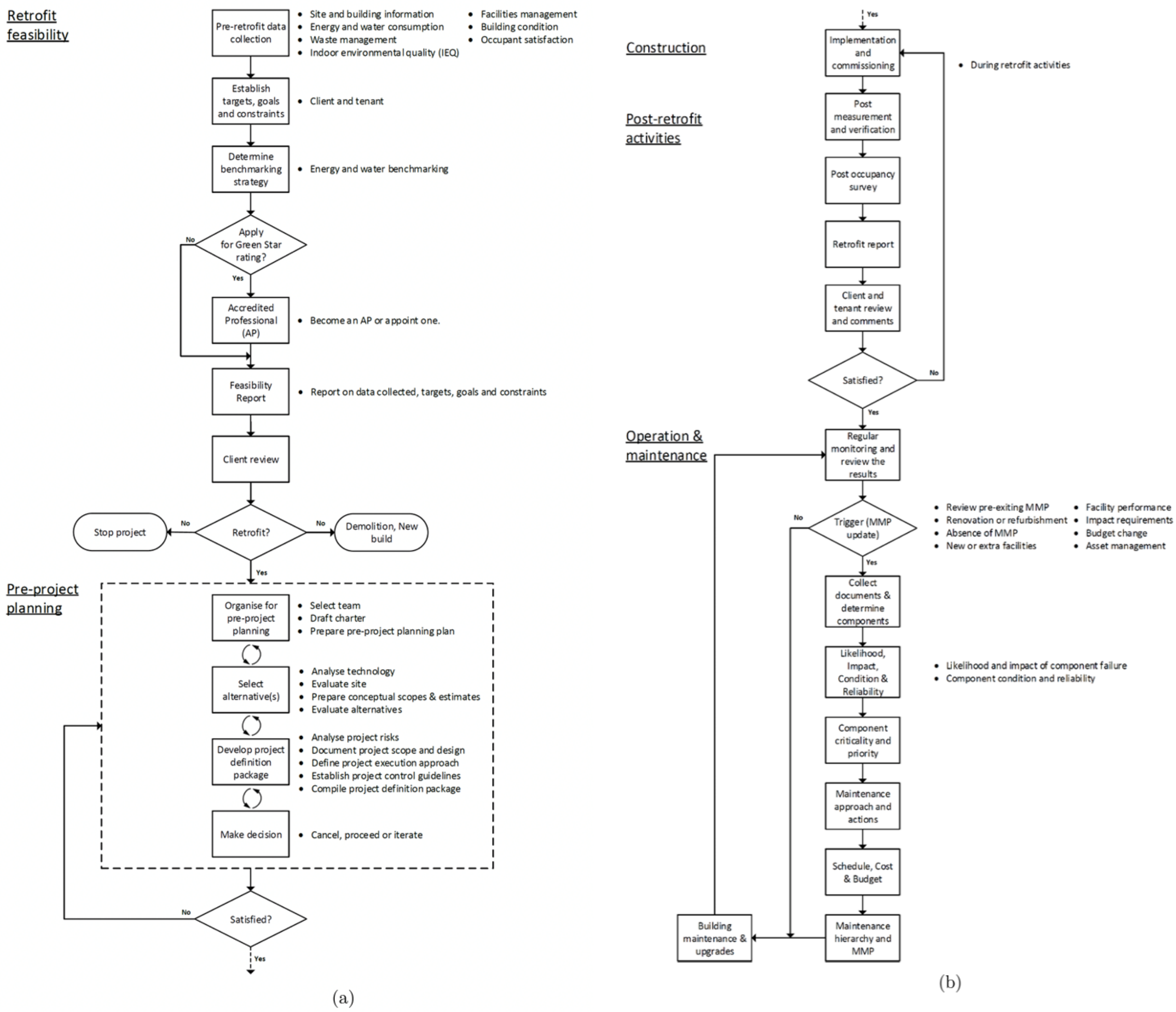


Figure 7. A generic green retrofitting implementation framework for the South African context (Geldenhuys, 2017).

Furthermore, Sheth et al.'s (2010a) framework underlies the significance of taking into account occupant feedback after implementing the refurbishment for improving project performance. It also provides a critical viewpoint of aspects such as the lessons learned during the refurbishment process, as learning from past projects helps prevent making the same mistakes twice.

In addition to developing healthcare-based retrofit frameworks, Sheth (2011) developed a more structured healthcare energy and refurbishment (HEaR) framework. HEaR consists of four phases (i.e., pre-proposal, proposal, proposal execution, and post-proposal execution) that are supported by the project actors, systems, and tools that have a significant role in the refurbishment phases (Figure 10). Notably, identifying the main stakeholders, systems, and tools for the actions to take in an HF refurbishment is crucial for achieving the refurbishment goals. Another critical point for this framework is validation, because receiving feedback leads to the improvement of a retrofit's actions and processes.

The processes in a green retrofitting require decision-making, building energy performance assessment, monitoring, and controlling. Technology offers various digital tools and systems for minimizing changes and potential operational expenses while executing a retrofit and also support effective decision-making. Digital transformations significantly promote having the construction industry become more intelligent and greener (Shen & Wang, 2023). The usage of digital technologies (i.e., digital twins, building information modelling (BIM), Internet of Things [IoT], big data, artificial intelligence [AI], virtual reality [VR], augmented reality [AR], and Blockchain applications) in retrofitting projects and their processes can improve occupant comfort, energy efficiency, and building performance. Sensors, automation, and data analytics are critical for monitoring and controlling different building functions during a green retrofit (Uche Akabogu, 2023). In order to enhance the success of a green retrofit with regard to identifying retrofit objectives, design and planning, data collection from the environment and building, building energy performance assessment, and decisions regarding retrofitting options, these technologies have a significant role by using a proactive approach. Identifying potential problems and benefits and detecting faults before the start of a green retrofit are significant, as

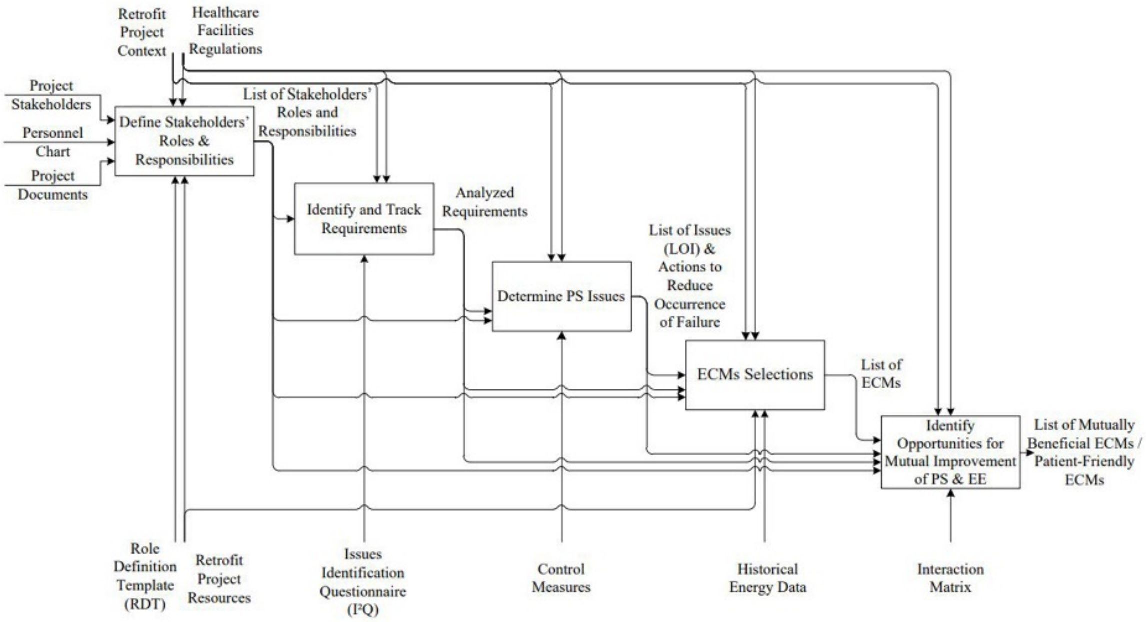


Figure 8. PATSiE framework retrieved from Mohammadpour (2014).

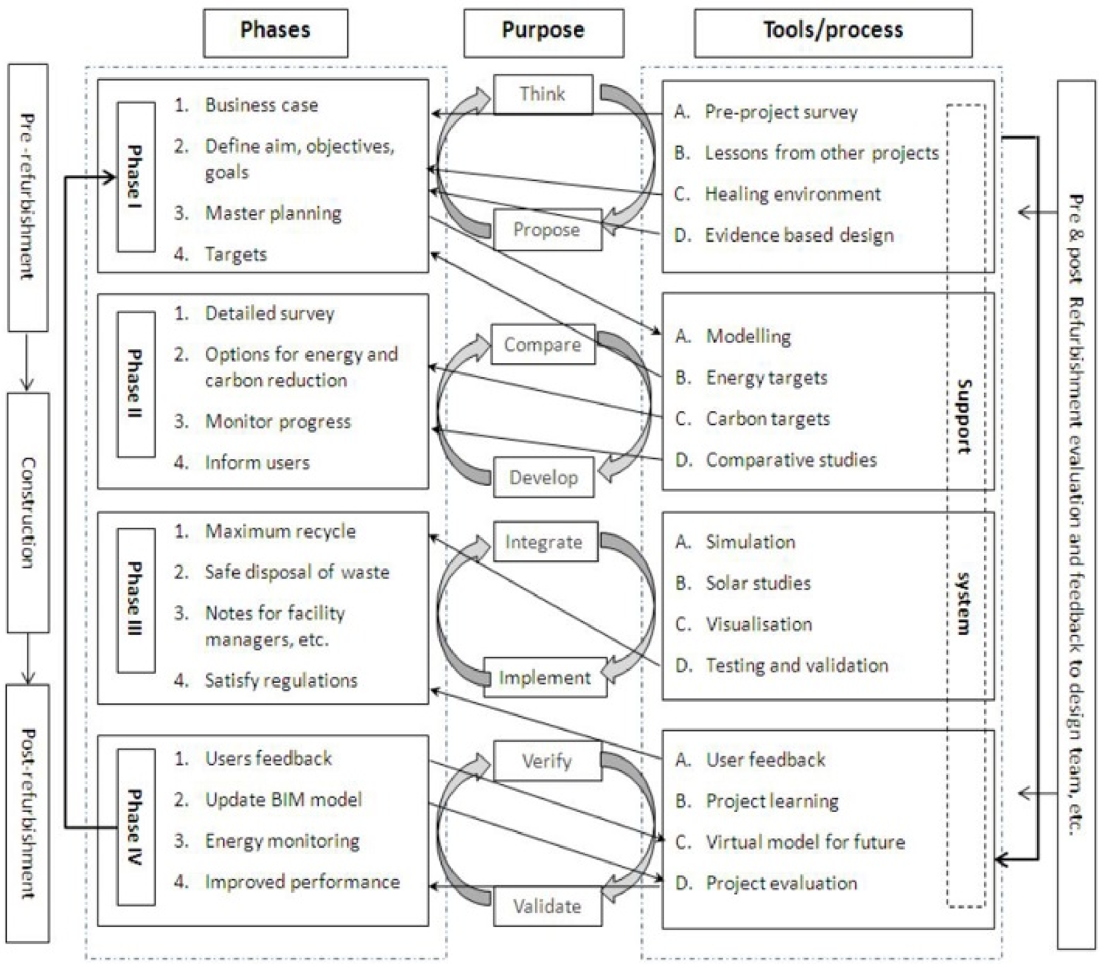


Figure 9. Framework for the refurbishment of HFs (Sheth et al., 2010a).

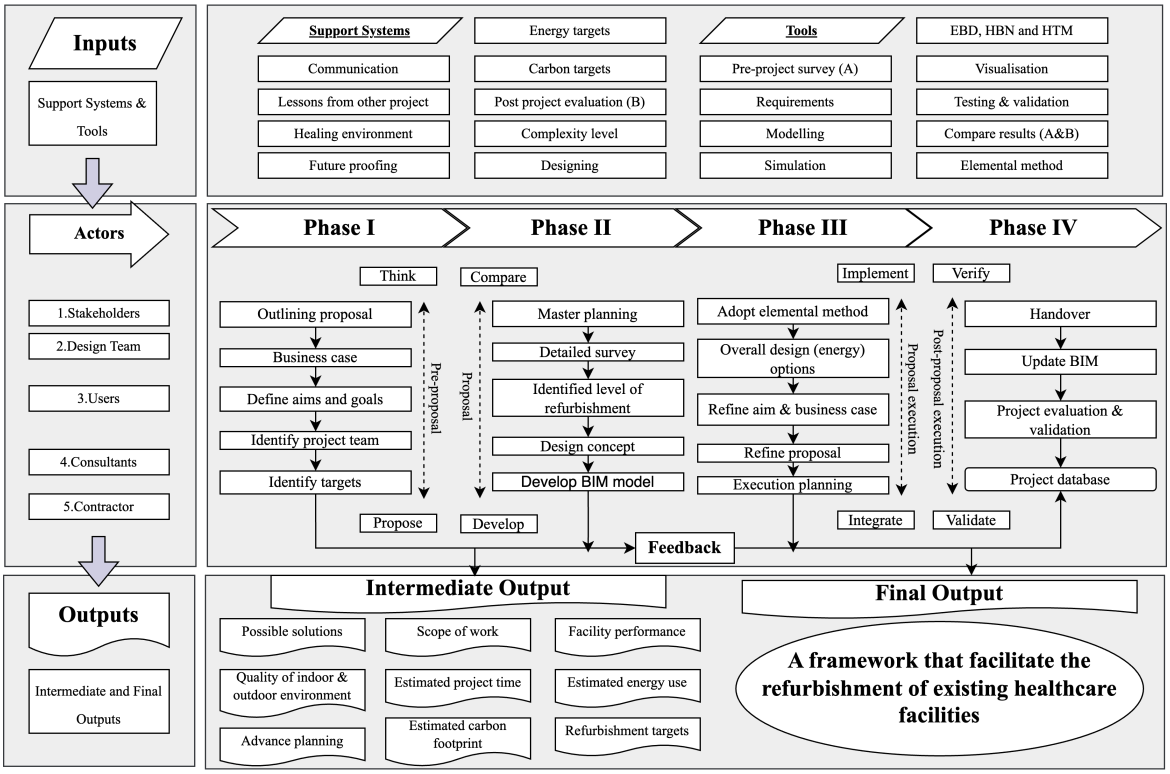


Figure 10. A healthcare energy and refurbishment (HEaR) framework (Sheth, 2011).

green retrofitting has challenges and various uncertainties. Therefore, using embedded digital technologies in any green retrofitting process can help avoid project delays, increase efficiency, reduce operational expenses, and improve decision making.

5. An Amalgamated Green Retrofitting Process Framework for Healthcare Facilities

After investigating the green retrofitting methodologies and approaches specific to healthcare in order to determine the required phases and primary considerations for the framework, normative refinement and frequency analyses were applied as the methodology. The main phases and activities most common in the existing literature have been added to the proposed conceptual framework (Table 1). In addition to common elements, healthcare-specific actions in green retrofitting processes have also been added to the new framework. Existing green retrofitting frameworks also cover the strategic planning and methods, tools, and simulations needed to accomplish the goals of green retrofitting existing HFs (Table 2). Notably, this study proposes adopting digital technologies to drive green retrofitting as being supportive in all framework phases.

Table 1. Frequency Analysis of Phases and Activities of Existing Green Retrofitting Frameworks

Main Phases	References	Total	Activities	References	Frequency
Pre-Retrofitting/ Refurbishment	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Geldenhuys (2017)	4	Set project targets and goals	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Luther & Rajagopalan (2014);Geldenhuys (2017)	5
			Develop a master plan	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Luther & Rajagopalan (2014)	4
			Client review, feedback, and overview analysis and targets	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Luther & Rajagopalan (2014); Geldenhuys (2017)	5
			Pre-Retrofit Survey	Sheth et al. (2010a); Sheth, (2011); Ma et al. (2012)	3
			Define aim and objectives	Sheth et al. (2010a); Ma et al. (2012); Luther & Rajagopalan (2014); Geldenhuys (2017)	4
			Identify project team and stakeholders' roles and responsibilities	Sheth (2011); Mohammadpour (2014); Geldenhuys (2017)	3
			Detailed survey	Sheth et al. (2010a); Sheth, (2011)	2
			Building performance assessment and diagnostics	Ma et al. (2012); Bertone et al. (2018); Geldenhuys (2017)	3
			Retrofit selection	Mickaityte et al. (2008); Bertone et al. (2018)	2
			Building energy auditing and data collection	Ma et al. (2012)	1
			Select key performance indicators	Ma et al. (2012)	1
			Assess building performance and establish the energy use baseline	Ma et al. (2012); Geldenhuys (2017)	2
			Performance assessment and energy audit report	Ma et al. (2012); Geldenhuys (2017)	2
			Identify the level of refurbishment	Sheth, (2011)	1
			Identify possible retrofit measures	Ma et al. (2012)	1
			Quantify energy benefits and estimate energy savings	Ma et al. (2012)	1
			Cost-benefit analysis/Economic analysis	Ma et al. (2012); Geldenhuys (2017)	2
			Risk assessment	Ma et al. (2012); Geldenhuys (2017)	2
			Prioritize retrofit measures and options	Ma et al. (2012)	1
			Develop an action plan/Make an execution plan /Decision modeling	Mickaityte et al. (2008); Sheth (2011); Ma et al. (2012); Geldenhuys (2017)	4
Retrofitting, Refurbishment, Execution, Construction, and Implementation	Mickaityte et al. (2008); Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Geldenhuys (2017)	5	Implementation	Mickaityte et al. (2008); Ma et al. (2012)	2
			Testing and commissioning	Ma et al. (2012)	1
			Building operation	Luther & Rajagopalan (2014)	1
			Monitor progress	Sheth et al. (2010a)	1
Post-Retrofitting, Refurbishment, adn Execution	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Geldenhuys (2017)	4	User feedback	Sheth et al. (2010a)	1
			Post measurement and verification (M&V), as well as validation	Sheth et al. (2010a); Sheth (2011); Ma et al. (2012); Geldenhuys (2017)	4
			Post occupancy survey	Ma et al., (2012); Geldenhuys (2017); Bertone et al. (2018)	3
			Retrofit report	Ma et al. (2012); Geldenhuys (2017)	2
			Client review and comments	Ma et al. (2012)	1
			Regularly monitor (Energy monitoring) and review the results	Ma et al. (2012); Sheth et al. (2010a)	2
			Project evaluation	Sheth et al. (2010a)	1
			Project learning	Sheth et al. (2010a)	1

Table 2. Strategic Planning, Methods, and Tools in Existing Green Retrofitting Frameworks

Strategic Planning and Methods/Tools	References	Total
Lessons from other projects	Sheth et al. (2010a); Sheth (2011)	2
Healing environment	Sheth et al. (2010a); Sheth (2011)	2
Client resources and expectations	Ma et al. (2012)	1
Energy performance indicators and assessment tool	Ma et al. (2012)	1
Database of building retrofit measures	Ma et al. (2012)	1
Building-specific information and characteristics	Ma et al. (2012)	1
Energy simulation method	Ma et al. (2012)	1
Risk assessment method	Ma et al. (2012)	1
Cost-benefit analysis tool	Ma et al. (2012)	1
Measurement and verification	Ma et al. (2012)	1
Criteria selection	Abidin et al. (2019)	1
Communication	Sheth (2011)	1
Energy targets	Sheth (2011)	1
Carbon targets	Sheth (2011)	1
Retrofit project context	Mohammadpour (2014)	1
HF regulations	Mohammadpour (2014)	1
Determine patient safety issues	Mohammadpour (2014)	1
Stakeholder commitment	Luther and Rajagopalan (2014)	1
Group participation in decision making	Mickaityte et al. (2008)	1
Economic, cultural, technical, architectural, social, and ecological dimensions of the micro- and macro-environment	Mickaityte et al. (2008)	1
Pre-project survey	Sheth (2011)	1
Testing and validation	Sheth (2011)	1
Energy conservation measures (ECMs)	Mohammadpour (2014)	1
Infection control	Mohammadpour (2014)	1
Adopt digital technologies	Schweizer (2023)	1

In accordance with the existing methodologies and approaches, this study has designed its proposed framework by referencing Ma et al.'s (2012) retrofit study under three phases: pre-green retrofitting (Sheth et al., 2010a; Ma et al., 2012; Geldenhuys, 2017), green retrofitting (Ma et al., 2012; Geldenhuys, 2017), and post-green retrofitting (Sheth et al., 2010a; Ma et al., 2012; Geldenhuys, 2017; Bertone et al., 2018).

5.1. Pre-Green Retrofitting

In the pre-green retrofitting phase, the pre-retrofit survey is applied to identify the targets, goals (Ma et al., 2012; Sheth et al., 2010a; Sheth, 2011), stakeholders' roles and responsibilities with a focus on context of the retrofit project, the HF's policies and regulations, patient safety issues (Mohammadpour, 2014), and infection control criteria. In addition, the lessons on the targets and goals as learned from past studies (Sheth et al., 2010a) have a vital role while identifying during the pre-green retrofitting phase in achieving success for the HF's green retrofit.

This phase is the most critical, because it also covers building energy performance assessments such as energy performance indicators and performance assessment tools, developing a master plan, developing a green retrofit implementation plan, identifying the possible healthcare-based retrofit measures (Ma et al., 2012), implementing a detailed survey (Sheth et al., 2010a), quantifying energy benefits (Sheth, 2011), and selecting the green retrofitting options (Mickaityte et al., 2008; Bertone et al., 2018).

5.2. Green Retrofitting

The green retrofitting phase is the operational phase for an HF, in which the selected green retrofitting options are implemented (Mickaityte et al., 2008; Ma et al., 2012; Sheth, 2011; Luther & Rajagopalan, 2014; Bertone et al., 2018). One critical point during green retrofitting is that HFs sustain their operations 24/7, so determining a green retrofitting implementation plan is essential for endangering patient safety and satisfaction. Another significant consideration for HF occupants is their behaviors in the building and during the retrofit, as human factors directly impact buildings' energy usage (Coskun & Selcuk, 2022). Therefore, the development implementation plan for green retrofitting of HFs should be designed before implementing selected green retrofitting options.

5.3. Post-Green Retrofitting

In the post-green retrofitting phase, measurement and verification (M&V; Sheth et al., 2010a; Sheth, 2011; Ma et al., 2012; Bertone et al., 2018) are applied to the post-occupancy survey (Ma et al., 2012), and the results of the green retrofitting are monitored and reviewed. The results demonstrate HF performance regarding energy usage, environmental behavior, reduced water usage, and enhanced quality and comfort of the HF with regard to air quality, natural lighting, and noise (Lockwood, 2009).

6. Validating the Framework

Following the amalgamated framework design, a validation study was conducted to ensure the framework is appropriate for the objectives, processes, and context of green retrofitting HFs. Therefore, investigating the validity of the proposed framework has a substantial role in improving this framework. For the validation step, usefulness, practicality, and applicability criteria were determined based on existing studies (Bassioni et al., 2004). The validation step also consists of expert feedback, benefitting from qualitative and quantitative data from selected experts.

6.1. Expert Feedback

Expert feedback was gathered through a validation survey conducted on a varied sample of 15 professionals that included industry practitioners and academic researchers. The respondents to the validation survey were selected using purposive sampling based on being professionals with specialist skills and certificates in green buildings and sustainability in Türkiye. The databases of the Leadership in Energy and Environmental Design [LEED] People Directory (USGBC, 2022) and the Building Research Establishment Environmental Assessment Method [BREEAM] Assessors and APs (BREAM, 2022) were selected to identify the related sample. The validation survey was sent to the experts via e-mail. The validation survey covered open- and close-ended questionnaires to produce qualitative and quantitative input by collecting data from the respondents. A 15-day duration was given for completing the questionnaire, but the response rate was low at the end of the duration. The questionnaire was resent again to the respondents, and an additional 15-day time limit was given for completing it. Fifteen questionnaires were returned within one month of being sent out. The validation study data collected from the experts were analyzed using the statistical software program IBB SPSS Statistics. The program Microsoft Office Excel 2018 was also used to create smooth visual graphs and charts.

The results from the validation were tested at a 95% confidence level. The reliability of the questionnaire responses was measured using Cronbach's alpha (α), according to which the reliability scale was identified. Yaşar (2014) stated the scale to consist of four different levels, with $0.0 \leq \alpha < 0.40$ showing the scale to be unreliable, $0.40 \leq \alpha < 0.60$ to show low reliability, $0.60 \leq \alpha < 0.80$ to show the scale to be quite reliable, and $0.80 \leq \alpha < 1.00$ to show the scale to be highly reliable. The results from the reliability statistics performed by applying Cronbach's alpha test to the validity criteria of the amalgamated green retrofitting process framework for healthcare facilities show the overall reliability value for all validity criteria to be 0.756 (Table 3), which is accordingly considered quite reliable.

Table 3. Cronbach's Alpha Coefficient from the Validation Study

Reliability Statistics		
Cronbach's Alpha	Cronbach's Alpha Based on Standardized Items	Number of Items
0.756	0.790	3

6.2. Qualitative Feedback

Qualitative feedback was mainly based on whatever possible healthcare-specific criteria might be missing, as well as on the performance measurement criteria and tools, healthcare-specific performance measurement tools, and any other comments on the framework related to processes and tools in the development of the framework. According to the results from the qualitative feedback, if any missing considerations or relevant recommendations related to the study were found, the framework was accordingly improved. The framework was adjusted to incorporate the suggested points as visually indicated by different shapes and colors. The following points summarize these findings and the potential enhancements that were made to the framework.

(1) The number of occupants using an HF, as well as their habits and behaviors were determined and added to the proposed framework as a critical consideration in the green retrofitting of HFs, as HFs operate 24 hours a day, seven days a week. During a green retrofitting, non-stop operations should be taken into consideration, because an HF's patients and employees occupy these facilities; also, the number and usage habits and behaviors of these occupants can impact and be impacted by the green retrofitting process.

(2) Patient comfort was identified as a driving factor contributing to green retrofitting and improving HFs' conditions, as patients need conditions more sensitive to their comfort compared to healthy adults. For this reason, needs should be considered such as sensitivity in terms of patient comfort during the green retrofitting process and increasing IAQ at the end of the green retrofitting process.

Enhancing patients' thermal and visual comfort stands out as a crucial healthcare-specific factor that can significantly contribute to the overall success of a green retrofit. Efforts toward improvements that will increase thermal and visual comfort should be considered in green retrofitting, such as increasing indoor environmental quality (IEQ), lighting improvements, HVAC system changes, and development of usable outdoor areas.

(3) The usage of certified environmentally friendly materials, healthcare waste management considerations, water management, and food safety are other supportive actions that can enhance the sustainability of HFs and environmental health.

(4) Seismic resistance of HFs was identified as a significant concern for study, because during green retrofitting of the existing building, the seismic condition of the building should be evaluated, and related activities should be added as needed to the green retrofitting process.

(5) Evaluating the parameters of quality, cost, and time regarding the operations of hospitals and a green retrofit were defined as driving factors for the decision to green retrofit HFs.

(6) Successful implementation of the green retrofitting process can also be assisted by green building certification systems such as LEED and BREEAM. To measure the performance of green retrofitted HFs, categories and criteria for each green building certification system can be taken into consideration. A performance measurement tool can be created by considering the requirements of the certification systems for hospitals and existing buildings. Also, IAQ, accessibility, time, cost, quality, energy performance, and occupant evaluations play an essential role in performance measurement.

(7) Energy performance contracts were also seen as a significant contributor to developing the process of green retrofitting HFs.

(8) Whether a building should be demolished or not is too important to be left to the client alone at the final stage. Therefore, client review and feedback has been revised in the proposed framework to include project stakeholders with an environmental perspective in the decision-making mechanism.

6.3. Quantitative Feedback

A validation questionnaire was designed to rate various validity aspects of the proposed framework to gain quantifiable feedback. The questionnaire was designed to ask the significance of each performance factor in terms of the criteria of usability, practicality, and applicability that were determined for validation using a 5-point Likert scale (1 = Far below standards, 2 = Substandard, 3 = Meets standards, 4 = Exceeds standards, and 5 = Greatly exceeds standards). Feedback was collected from 15 respondents for the validation study. By using a significance level of $p < 0.05$, all answers for the validation were found to be normal. The results from the questionnaire demonstrate the mean values for the validation criteria to range between 3.8-4.2. The mean values for responses with a 5% confidence limit indicate that the proposed amalgamated framework has been assessed as "Exceeds standards" for each validation criterion (Figure 11).

The results from the validation demonstrate that the assessments obtained from the experts positively indicate the proposed framework to be usable, practical, and applicable. The significant missing steps, tools, and considerations were identified and added to the proposed framework in accordance with the qualitative feedback. The omitted considerations have been incorporated and adjusted as elements or processes denoted by asterisks (*) within the finalized framework (Figure 12).

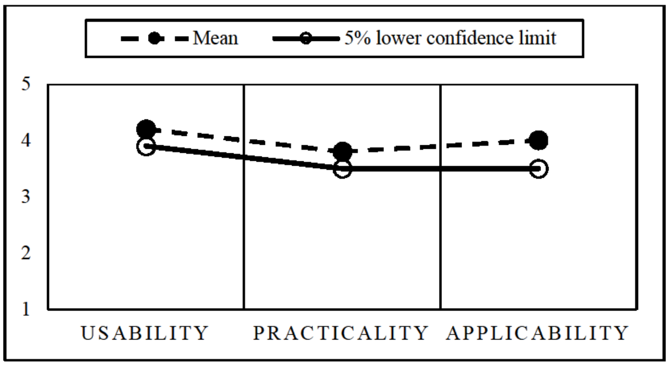
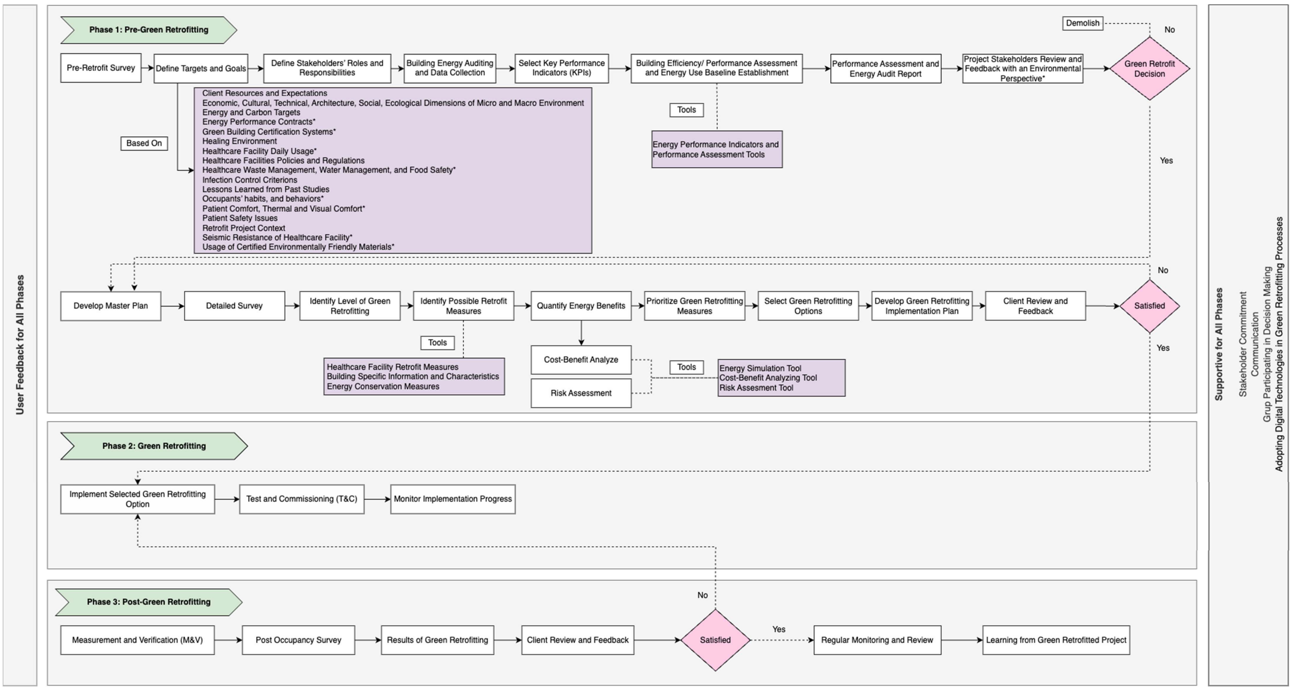


Figure 11. Quantitative feedback regarding the framework for the process of green retrofitting HFs.



*added in accordance with the qualitative feedback.

Figure 12. An amalgamated framework for green retrofitting HFs.

7. Conclusion

Green retrofitting HFs is an urgent and fundamental action for achieving long-term sustainability goals for the healthcare and construction industries. Within the existing literature, a noticeable scarcity exists regarding healthcare-specific studies that have delved into green retrofitting methodologies and approaches. This paper investigates the current green retrofitting methodologies and approaches for existing HFs by conducting a literature review.

The study initially delved into the decision-making processes' retrofitting roadmaps applied across diverse building types. Subsequently, the research focused predominantly on retrofitting methodologies and approaches specifically tailored for healthcare settings. Within the literature, several methodologies have been identified, each concentrating on distinct aspects such as energy efficiency, public health, and ensuring patient safety in retrofitting practices.

Proposing roadmaps to achieve retrofitting goals and implementing the proposed retrofitting roadmaps help at understanding retrofitting processes completely and improving awareness of green retrofitting processes for HFs. Green retrofitting phases from existing studies were described using normative refinement methodology as pre-green retrofitting, green retrofitting, and post-green retrofitting. As a result of the normative refinement process, this study proposes an amalgamated green retrofitting process framework for healthcare facilities in order to enhance the successful outcomes of green retrofitting projects. The proposed framework will improve the understanding of the primary considerations of green retrofitting HFs and will be a practical roadmap for healthcare building providers, academicians, and green building professionals.

Future stages of this research will investigate the implementation of the proposed green retrofitting framework in HFs and the performance measurement of this framework in order to improve the performance of current HF retrofits and make them more sustainable and energy efficient. Moreover, the need exists to investigate key performance indicators for the process of green retrofitting HFs as these indicators provide an objective standard for enhancing the procedural success of the identified HFs' green retrofitting framework. These indicators also have the potential to provide a concrete method for evaluating the identified processes regarding a project's performance.

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