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The Development of a Life-Cycle-Based Sustainability Index That Incorporates Patient-Centredness for Assessing and Reporting the Sustainability of Healthcare Buildings in Saudi Arabia

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Abstract: This study aims to develop and test a life-cycle-based sustainability index that incorporates patient-centredness for assessing and reporting the sustainability of healthcare buildings in Saudi Arabia. The research strategy follows a triangulation method approach to meet the objective of this research. Semi-structured interviews were initially employed in developing sustainable healthcare building indicators based on a previously conducted literature review that explored sustainable building in Saudi Arabia. Then, a scoping review protocol including the Delphi technique was used to develop patient-centredness care, PCC, indicators. Questionnaire surveys were also employed in data collection for industry investigation and patient involvement. Lastly, case study practice tests were conducted involving a specialised hospital and a pre-occupant hospital for indicator verification. A set of sustainability indicators were developed to assess and report the sustainability performance of healthcare buildings. Patient-centredness indicators were also developed and incorporated into the resulting index. A case study practice test was conducted to confirm the feasibility of all final resulting indicators. The research study contributes towards a holistic approach to assess and report sustainability in healthcare buildings incorporating patient-centredness. The objectives of the research include (1) the development of sustainable healthcare indicators (primary indicators); (2) the development of patient-centredness indicators (secondary indicators); and (3) indicator practice tests for validation. The resulting index could be implemented to assess and report sustainability in healthcare buildings, and it could be a pivotal step to shift to sustainable patient-centred healthcare buildings in Saudi Arabia.

Keywords: healthcare building; sustainable building; patient-centredness; quality indicators; quality improvement; Delphi

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1. Introduction

Healthcare is seen as crucial for sustainable development [1] as the industry accounts for negative environmental consequences [2]. Thus, embracing sustainability in the sector would help as a solution to mitigate this impact [3].

At the 2021 United Nations Climate Change Conference, COP26, 14 countries set targets to achieve carbon net zero, and a group of 50 countries, including the world's largest carbon emitters, committed to taking concrete steps towards more sustainable, low-carbon and climate-resilient healthcare systems [4]. In addition, the official outcomes of the recent COP27 also have enormous implications for public health and the healthcare sector as health ministries around the world try to catch up to other sectors in developing and implementing adaptation plans [5].

According to the World Health Organization (WHO), 10–25% of the generated waste in healthcare may be considered hazardous waste including chemical, biological and radiological waste [6].

There is a growing need to deal with this negative environmental impact and associated health consequences as global investment increases in the healthcare industry [7]. The research has highlighted that the industry is responsible for up to 5% of the total global greenhouse gas (GHG) emissions including particulates, nitric oxides and sulphur dioxide, as well as nitrogen-rich runoff waters, a greater malaria risk and water scarcity [7].

Research studies in different countries have also estimated the national healthcare climate footprint. In the United States (U.S.), for instance, the country's healthcare emissions have reached 9.8% of the national total; in the United Kingdom (UK), it has been estimated to be approximately 6.3%; in Australia and Canada, the findings were about 7% and 5%, respectively [8].

Furthermore, hospitals and their supply chains in Europe account for at least 5% of the annual CO_2 emissions [9]. Due to this environmental burden caused by healthcare buildings, different countries around the globe have put effort into fulfilling their ecological commitments with regard to the healthcare sector [10]. For example, in the UK, the National Health Service has announced its plan for carbon "net zero" by 2040 [10].

COVID-19 has caused both new challenges and opportunities for the healthcare sustainability agenda. Healthcare construction, therefore, is expected to surge after the pandemic rebound as hospitals' investment increases in dedicated wards for future pandemic patients [11].

In 2022, the Saudi government officially launched the Healthcare National Transformation Programme to comprehensively restructure the sector to improve public health, disease prevention and service accessibility [12,13]. Continuous monitoring of this complex multiphase long-term programme is vital [12].

In healthcare buildings, the consumed energy/water and the potential for generated hazardous waste are relatively higher than in other facilities [9]. Therefore, the paradigm shift to sustainable healthcare calls for systematic assessment and measurements.

The WHO has defined sustainable healthcare as the balance of environmental, social and economic design that meets the needs of people's healthcare without compromising future generations' healthcare needs [14].

Moreover, there is an increasing interest in sustainability reporting systems of clinical service quality, accessibility, costs and efficiency [15]. The National Health Service (N.H.S.) in the UK has one of the most comprehensive sustainability reporting systems, referred to as the sustainable health dashboard, and uses a range of performance indicators in different domains including resources, governance, carbon, waste and pollution [15].

Furthermore, sustainable healthcare assessment methods may promote sustainability goals using different algorithms, machine learning and other emerging technologies [16,17]. The increasing concern about the sustainability of healthcare buildings and facilities has accelerated the proliferation of guidance and certification schemes and tools, e.g., the Green Guide for Healthcare by Leadership in Energy and Environmental Design (LEED) [18].

In sustainability certification systems, each building type has a different function. Therefore, the assessment criteria, credits and weights differ accordingly, e.g., residential, commercial, education, healthcare and retail [9,19].

This paper aims to develop a life-cycle-based sustainability index that incorporates patient-centredness to assess and report on healthcare buildings in Saudi Arabia. This index is a multidisciplinary evaluation tool designed to comprehensively evaluate a given healthcare building according to an appropriate concept of sustainability and patient-centredness (PCC).

The developed tool, which seeks to be simple and easy to use, includes the primary and secondary indicators representing the most critical factors and parameters in a dashboard to be used by relevant stakeholders in decision making towards improvements.

The indicators were experimentally tested through their application in an operative hospital building and a new hospital building located in the western region of Saudi Arabia. The practice test was carried out using onsite inspections, which demonstrated that they are easy to use, simple and effective. The resulting tool could, therefore, also be

improved considering its application to a higher number of healthcare buildings to deepen the understanding of the surrounding scenario further and concur in the realisation of a national database of healthcare buildings, which could be a pivotal step to driving sustainable healthcare improvements valued by patients. This study contributes to continuing research on sustainability and PCC in healthcare, giving researchers, practitioners and designers a practical means to measure and implement indicators through data collection, measurements and refinement.

2. Measuring Sustainability in Healthcare Buildings

Sustainable building is about maximising the efficient use of natural resources and materials as well as minimising the building's environmental, social and economic impacts throughout the whole building life cycle [20].

The situation in healthcare buildings and facilities is sensitive, complicated and even contradictory in some cases, with many occupants, systems, equipment and supplies in one place [21]. Therefore, considering a wide range of parameters in different healthcare building types may help sustainability measurements and evaluations [21]. The life cycle assessment approach would allow for a broader perspective and improve sustainability measurements [22].

From an architectural point of view, evidence-based design (E.B.D.) and eco-effective design (E.E.D.) are the two significant trends in healthcare building design [23,24]. The E.B.D. trend focuses on positive health outcomes through research-based solutions with occupant-oriented design decisions [23]. On the other hand, the E.E.D. trend mainly considers the quality of the indoor environment [23]. However, research has highlighted that it is essential to consider the dialogue between the two trends and promote the benefits of each [23–25].

Sustainability is an essential and legitimate domain of quality in healthcare [26], which calls for the redefinition of value to integrate social and environmental costs. It extends thinking on value as it broadens the scope of 'cost' considering patient and population outcomes against the environmental, social and economic costs [26]. This is important, as it provides a consistent framework for measuring and driving sustainable improvements in healthcare.

Sustainability in healthcare is a multidisciplinary area, having its presence in medical science and operations management [27]. It encompasses the three macro areas of the environment and economic and social fields [22]. Therefore, different criteria, indicators and parameters must be considered in the transformational journey to sustainable healthcare.

The use of sustainability measures/indicators is essential for an integrated systems approach to address sustainability challenges in healthcare [27]. This can help decision-makers formulate strategies, establish improvement goals, track progress and benchmark against other systems [27]. Therefore, interest is growing in how healthcare systems might better measure their sustainability performance.

Measuring healthcare quality is also a crucial policy and academic concern. However, patients are often excluded from planning and delivering healthcare quality improvements, although there is a growing emphasis on considering patient voices when measuring healthcare quality [28].

The existing healthcare schemes in certification systems such as LEED and the building research establishment environmental assessment method (BREEAM) aim to evaluate the structure of the hospital building and the presence of certain technical design aspects [29]. They are criticised, however, (1) for their lack of depth in economic and social aspects [30]; (2) because they are design tools rather than performance measurement tools [18]; and (3) because they are non-climate-specific and need to vary more with local environmental conditions [29]. They were born as guidelines for designing a healthcare building but still require those features to evaluate currently operated buildings. Moreover, they consider the evaluators' point of view without analysing the users' perspective, which is fundamental to the healthcare building reality [18].

As far as the possibility of evaluating healthcare services management through a set of indicators is concerned, examples such as those proposed by the WHO, the European Health Consumer Index (EHCI), Organization for Economic Co-operation and Development (OECD) and Joint Commission International (JCI) should be considered [18]. Apart from the last one, these systems are related to health and healthcare systems and consider many quantitative indicators [18]. JCI standards instead deal with hospital accreditation and assess many different qualitative factors. In different ways, these systems evaluate the quality and positivity of the offered services by analysing both managerial strategies and their health outcomes [18]. However, the existing healthcare evaluation tools may be improved, and an innovative tool should thus enable the identification of critical areas considering a multiplicity of visions [18].

Sustainability has emerged as an essential organisational strategy [31], and organisations in different industries have developed their own ways to integrate sustainability measures into various functional areas [31]. The concept of sustainability has been successfully applied in the manufacturing industry; however, this is not the case in other industries such as healthcare [32,33]. The Saudi government officially launched the Healthcare National Transformation Programme to restructure the healthcare sector with the aims of improving public health, disease prevention and service accessibility [12,34]. Measuring sustainability in healthcare buildings is a complex process involving different parameters and stakeholders.

Furthermore, the European framework for sustainable buildings, Level(s), offers an extensively tested method of assessing and reporting the sustainability performance of residential or office buildings [35,36]. This research employed the macro-objectives of the European framework to drive indicators to assess and report sustainability in healthcare buildings.

3. Measuring Patient-Centred Care in Healthcare Buildings

Patient empowerment can be defined as the patient's active participation in managing healthcare [37], and the WHO sets this perception as a goal for achieving better results in healthcare. Research highlights that a solution to our current healthcare sustainability problems is patients' active involvement in health management [37]. Therefore, this paper incorporates patient-centredness in assessing and reporting sustainability healthcare buildings.

Healthcare systems transform patients' lives and improve populations' health. Research increasingly demonstrates that patient-centred care (PCC) achieves the best outcomes, and there is a global movement towards this healthcare model [38,39].

Concepts of engagement, communication, quality and safety are fundamental matters for healthcare that enforce decisions in healthcare systems worldwide, and they all converge in the PCC dialogue [40].

The Institute of Medicine (IOM) defines PCC as "providing care that is respectful of and responsive to individual patient preferences, needs, and values, and ensuring that patient values guide all clinical decisions" [41].

This type of care comprehensively concentrates on critical clinical outcomes, improvements and other issues that patients say matter to them and may have yet to be given prominence. Outcomes of interest to patients include improved health-related quality of life or functional outcomes; patient, caregiver and family experiences; healthcare resource utilisation; and care provider satisfaction [40].

To achieve desired treatment goals, all segments of healthcare and all stakeholder groups need to understand and learn from patient perspectives and experiences and use these insights to develop strategies and inform decision making. The research that leads to and results from these insights must be designed and implemented in partnership with patients. Patient engagement can optimise research by ensuring it reflects the needs and priorities of patients in a way that is least burdensome to them [42].

The definition of PCC emphasises the importance of the individual patient and their clinical needs, and this assessment is a window into understanding the opportunities for improving PCC. Utilising appropriate measures of PCC for specific patient populations is

crucial to improving care quality. As such, there has been a proliferation of tools to measure patient experience for different types of health conditions (e.g., cancer care and mental health care) and care settings (e.g., nursing homes, dialysis centres, and hospitals) [41]. Each specific patient population has unique experiences and interactions with care providers and the healthcare system, which differ from each other and the general population. These differences imply a need for measurement specificity to capture experiences accurately [41]. Specific populations raise several core challenges for measurement to which researchers and practitioners should attend, identifying what principles to measure, who is the most appropriate assessor and how best to measure PCC.

4. Methodology

Selecting an appropriate research methodology is vital for research success [43]. The main contribution of this research is to develop a life-cycle-based sustainability index that incorporates patient-centredness for assessing and reporting sustainability in healthcare buildings in Saudi Arabia. Therefore, two indicators (primary and secondary) have been developed using different methods. The primary indicators are intended to assess and report healthcare building sustainability from a life cycle perspective, while the secondary indicators are intended to assess and report on the patient-centredness of care.

The research was begun by defining the macro-objectives and their associated indicators of the European framework to assess and report building sustainability performance [44] as a starting point for this study based on the previously conducted literature review [45]. Then, a semi-structured interview was employed to evaluate and transfer the selected core criteria to measurable indicators. In addition, patient-centredness indicators were developed using a scoping review protocol. A questionnaire survey approach was also used twice in both types of indicator development. In the practice test at the end, a case study approach was employed to test and validate the generated list of primary and secondary indicators.

5. Research Methods

The objectives of this research are to (1) develop sustainable healthcare indicators (primary indicators); (2) develop patient-centredness indicators (secondary indicators); and (3) test and validate the proposed index. Therefore, a mixed method is used to develop two different types of indicators, with a case study approach for validation as follows.

5.1. Development of Sustainable Healthcare Indicators (Primary Indicators)

Semi-structured interviews were employed, aiming to derive the primary indicators from the European Union framework [46]. Level(s) is a voluntary reporting framework to improve the sustainability of buildings within the EU [47], and the proposed indicators of Level(s) are categorised as emissions, resources, water, well-being and comfort, resilience, and adaptation to climate change [47].

Fourteen experts accepted the invitation to participate in the interview, where each interview started with the interview goal identification as developing indicators that can be used to assess and report sustainable healthcare.

This research method was chosen to engage and interact with the industry through development processes. In addition, a questionnaire survey was used as a supplementary data collection tool, involving different experts' and end-users' perceptions. Figure 1 illustrates the method for developing the primary indicators.

5.2. Development of Patient-Centredness Indicators (Secondary Indicators)

A questionnaire survey was initially conducted. In addition, a scoping review protocol was also employed, which was previously used by Arksey and Levac et al. [41]. This protocol commenced by (1) identifying the research question; (2) identifying the relevant studies; (3) selecting eligible studies; (4) charting the data; (5) reporting; and, finally, (6) consulting stakeholders. Figure 2 illustrates the processes. A practice test was con-

ducted for both the primary and secondary indicators to verify the foreseen visibility of implementing these indicators in practice.

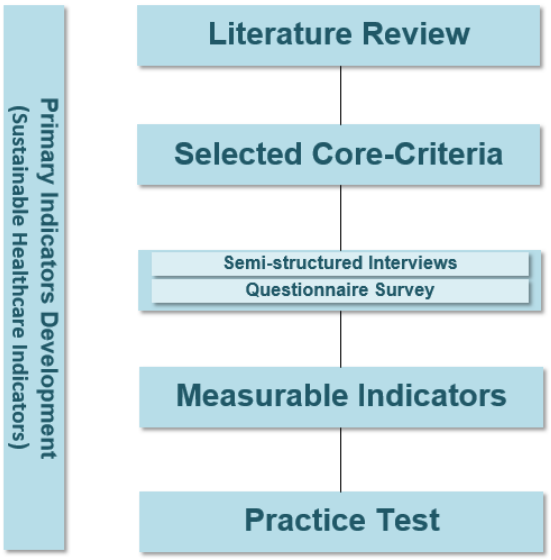

Figure 1. The Primary Indicators' Development.

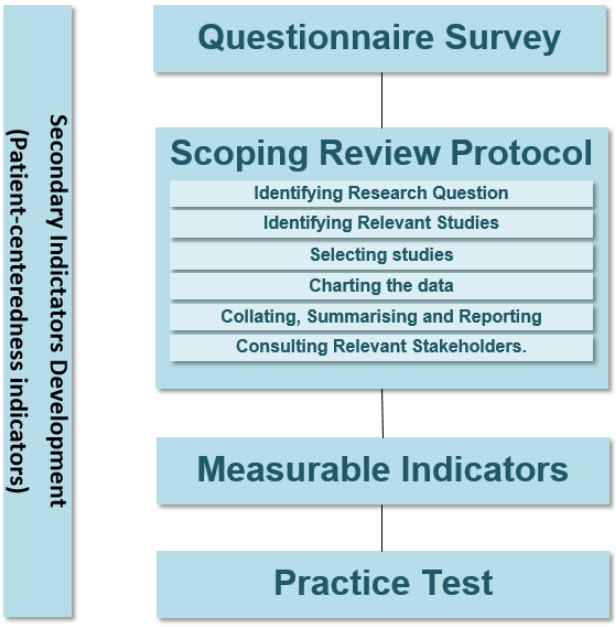

Figure 2. The Secondary Indicators' Development.

5.3. Practice Test

Two case studies of specialised hospital and pre-occupant hospital data were used to verify the feasibility of the resulting indicators.

6. The Development of the Indicators and Results Interpretation

The core criteria and their associated objectives, shown in Table 1, were defined as the foundation to start to develop the primary indicators. First, face-to-face interviews with experts were used to transfer the core criteria into measurable indicators. The 14 participants also answered a questionnaire survey with open-ended industry engagement questions. The experts' interviews were conducted in December 2022. Each interview session was started by briefly explaining the study objectives and the dedicated scope of work (Supplementary S1). Then, the core criteria and their associated objectives were

carefully reviewed, with the discussion orientated by the question of "how to transfer each indicator to a measurable, smart, efficient and effective indicator" that can be used to assess and report sustainability in the proposed healthcare building index.

Table 1. The core criteria and their associated objectives.

Core Criteria	Associated Objectives
Use Stage Energy Performance	Greenhouse Gas Emissions during Building's Life Cycle
Life Cycle Global Warming Potential	Greenhouse Gas Emissions during Building's Life Cycle
Bill of Quantities, Materials and Life Spans	Resource Efficient and Circular Material Life Cycles
Construction and Demolishing Waste and Materials	Resource Efficient and Circular Material Life Cycles
Design For Adaptability and Renovation	Resource Efficient and Circular Material Life Cycles
Design for Deconstruction	Resource Efficient and Circular Material Life Cycles
Use Stage Water Consumption	Efficient Use of Water Resources
Indoor Air Quality	Healthy and Comfortable Spaces
Time Outside of thermal Comfort Zone	Healthy and Comfortable Spaces
Lighting and Visual Comfort	Healthy and Comfortable Spaces
Acoustics and Protection Against Noise	Healthy and Comfortable Spaces
Protection of Occupier Health and Thermal Comfort	Adaptation and Resilience to Climate Change
Increased Risk Of Extreme Weather Events	Adaptation and Resilience to Climate Change
Sustainable Drainage	Adaptation and Resilience to Climate Change
Life Cycle Cost	Optimised Life Cycle Cost and Value
Value Creation and Risk Exposure	Optimised Life Cycle Cost and Value

Each expert interview was followed by the industry engagement questionnaire survey (Supplementary S2), which includes seven open-ended questions regarding industry engagement and investigation.

The collected data were synthesised, aligned and organised, resulting in measurable indicators. Table 2 shows the final set of sustainable healthcare indicators.

Some experts suggested new patient-focused indicators, such as healthcare access, patients' physical comfort, patient safety and follow-up services. All suggested patient-related indicators were considered in the development of the secondary PCC indicators.

In the case of any new expansions or modifications to the original planned design, all indicators are to be calculated twice for the original design and all newly added units.

The fourteen experts who attended the interview and answered the questions in December 2022 were academics, consultants, designers, contractors and governmental officers. Please refer to the following Table 3 for participant details.

The secondary indicators' development commenced by employing a patient involvement questionnaire for data collection (Supplementary S3). The collected data were then used to establish the necessary information such as the PCC status in Saudi Arabia compared to other countries, methods of improvement and PCC domains with the level of importance, which allowed us to proceed further to the next step.

An example of patient public involvement is a questionnaire answered by a patient/end-user providing feedback to be used in new research materials, and this method is often used by healthcare researchers to collect data [48].

PCC in healthcare is an emerging approach that emphasises partnerships between patients and healthcare providers, recognising patients' preferences and promoting service flexibility [39,49]. The PCC questionnaire was structured into three parts—personal details, general questions and PCC—and included questions that led to discussions on PCC domains, priorities and status, and participant feedback was collected.

The results showed that attention with regard to PCC has just started to gain prominence in Saudi Arabia. Therefore, such a measuring system could help in promoting this approach.

The results also have emphasised Picker's PCC domains [49], and all of these covered domains need attention with different levels of priority and importance. Please refer to Figure 3 for the summarised results of the survey.

Table 2. The final set of Sustainable Healthcare Indicators/Primary Indicators.

Origin	Indicators	Sustainable Healthcare Indicators (Primary Indicators)
Use Stage Energy Performance	Energy Performance	(Updated) Measured Total Energy Consumption/(Planned) Total Energy Consumption (Updated) Measured Total Renewable Energy Consumption/(Designed) Total Renewable Energy Consumption
Life Cycle (LC) Global Warming Potential	Life Cycle Global Warming Potential	(Updated) Life Cycle (LC) Global Warming Potential/(Planned) Life Cycle Global Warming Potential
Bill of Quantities, Materials and Life Spans	Bill of Quantities, Materials and Equipment	(Updated) Calculated Life Cycle Assessment (LCA) of Materials and Equipment/(Planned) Life Cycle Assessment (LCA) of Materials and Equipment
Construction and Demolishing Waste and Materials	Construction and Demolishing Waste and materials	Measured Generated Waste in Construction Stage/(Planned) Generated Waste in Construction Stage Generated Waste in Demolishing Stage/(Planned) Generated Waste in Demolishing Stage
Design For Adaptability and Renovation	Adaptability and Renovation	(Updated) Scoring Assessment of the adaptability and renovation for the whole building/(Planned) Scoring Assessment of the adaptability and renovation for the whole building (1 to 5 scale)
Design for Deconstruction	Deconstruction	(Updated) Scoring Assessment of Deconstructing the Building/(Planned) Scoring Assessment of Deconstructing the Building (1 to 5 scale)
Use Stage Water Consumption	Water Consumption	(Updated) Measured Total Water Consumption/(Planned) Total Water Consumption
Indoor Air Quality	Indoor Air Quality	(Updated) Measured Indoor Air Quality by Zones/(Planned) Indoor Air Quality by Zones
Time Outside of Thermal Comfort Zone	Time Outside of thermal Comfort Zone	(Updated) Measured Time Outside of thermal Comfort Zone/(Designed) Time Outside of Thermal Comfort Zone
Lighting and Visual Comfort	Lighting and Visual Comfort	(Updated) Measured Lighting and Visual Comfort by Zones/(Planned) Lighting and Visual Comfort Assessment by Zones
Acoustics and Protection Against Noise	Acoustics and Noise	(Updated) Measured Acoustics and Noise by Zones/(Planned) Acoustics and Noise Assessment by Zones
Protection of Occupier Health and Thermal Comfort	Futureproof of Building Performance Against Climate Change	(Updated) Scoring Assessment of Adaptation to Future Climate Change that will Impact Thermal Comfort/(Planned Scoring Assessment of Adaptation to Future Climate Change that will Impact Thermal Comfort (1 to 5 scale)
Increased Risk Of Extreme Weather Events	Increased Risk Of Extreme Weather Events	(Updated) Scoring Assessment of resilience and Resistance to Extreme Weather Event, e.g., flooding, pluvial, and coastal/(Planned) Scoring Assessment of resilience and Resistance to Extreme Weather Event, e.g., flooding, pluvial, and coastal (1 to 5 scale)
Sustainable Drainage	Sustainable Drainage	(Updated) Actual Sustainable Drainage as Percentage of total Drainage System/(Planned) Sustainable Drainage as Percentage of total Drainage System
Life Cycle Cost	Life Cycle Cost	(Updated) Life Cycle Cost/(Planned) Life Cycle Cost at Design Stage
Value Creation and Risk Exposure	Value Creation and Risk Exposure	(Updated) Value Creation and Risk Exposure Assessment/(Planned) Value Creation and Risk Exposure Assessment at Design Stage (1 to 5 scale)

Table 3. The Participants' Details.

Participants	Experience (Years)	Title	Academic Qualification
Participant 1	25	General Manager/Contractor	Master's Degree
Participant 2	20	Executive Manager/Contractor	Master's Degree
Participant 3	28	Managing Director/Consultant	Bachelor's Degree
Participant 4	6	HSE Executive/Governmental Authority	Bachelor's Degree
Participant 5	10	Senior Facilities Engineer	Bachelor's Degree
Participant 6	27	HSE Consultant/Consultant	Bachelor's Degree
Participant 7	5	Graduate Research Assistant/Researcher	PhD Candidate
Participant 8	12	Director/Contractor	Bachelor's Degree
Participant 9	11	Senior Engineer/Designer	Bachelor's Degree
Participant 10	20	Business Manager/Consultant	Bachelor's Degree
Participant 11	18	Executive Officer/Consultant	Bachelor's Degree
Participant 12	34	Directors/Contractor	Bachelor's Degree
Participant 13	16	Executive Officer/Consultant	Bachelor's Degree
Participant 14	15	Dept. Head of Tech Services/Designer	Bachelor's Degree

Total	**73**

1. Gender	48	Male	25	Female

2. Age group	0	< 22 years old	18	23-33	34	34-44	14	45-55	7	>55 years old

3. Region	28	Mecca	18	Riyadh	13	Eastern	11	Asir	3	Medina

4. Educational level	33	High School	26	Bachelor's Degree	14	Master's Degree	0	PhD

5. According to your knowledge, please identify the current situation of patient-centredness in healthcare in Saudi Arabia compared to the top developed countries:							
3	Haven't started yet	61	Just started to be considered	7	Almost mature	2	Very mature and takes the lead

6. How can we improve the patient-centredness in healthcare building in Saudi Arabia, please select from the following options:							
8	Establish a governance system	6	Develop reporting and assessment system	7	Improve professionals' conscious	52	All

7. Do you think that developing patient-centredness indicators to be used by relevant stakeholders in healthcare building, would improve the situation?			
62	Yes	11	No

8. Considering the Saudi context. Do you agree that the following Picker's Patient-Centredness Care domains will cover all patient-centeredness aspects? If No please add new domain?			
64	Yes	9	No

9. Considering the Saudi context please specify the domains that need to be improved							
18	All Picker's PCC Domains	49	Most of them	6	Some of them	0	Non of them

Figure 3. The Summarised Results of the Patient Involvement Survey.

The patient involvement questionnaire represents the first step of developing PCC indicators before applying the selected framework, which commenced by identifying the guided research questions as (A) 'How should PCC quality indicators in healthcare settings be defined?'; (B) 'What PCC quality indicators have been developed to measure PCC?'; and (C) 'What PCC quality indicators can be used to report and assess PCC?'

A search was then conducted to identify relevant studies/articles using the King Abdulaziz journals database on the university website using terms such as 'patient-centredness indicators,' 'healthcare buildings,' 'healthcare quality indicators,' 'quality improvement' and 'Delphi.' The terms were selected according to the identified research questions.

In the article/study identification process, 489 peer-reviewed research papers were identified. Then, in the article eligibility exclusion process, all ineligible research papers were excluded. To be eligible for inclusion, the research paper had to identify PCC indicators and/or identify PCC performance measurements. Therefore, at this stage, the abstract of each identified research paper was screened for eligibility, resulting in six research papers that qualified for inclusion in developing candidate PCC indicators [39,50–54]. Please refer to Figure 4.

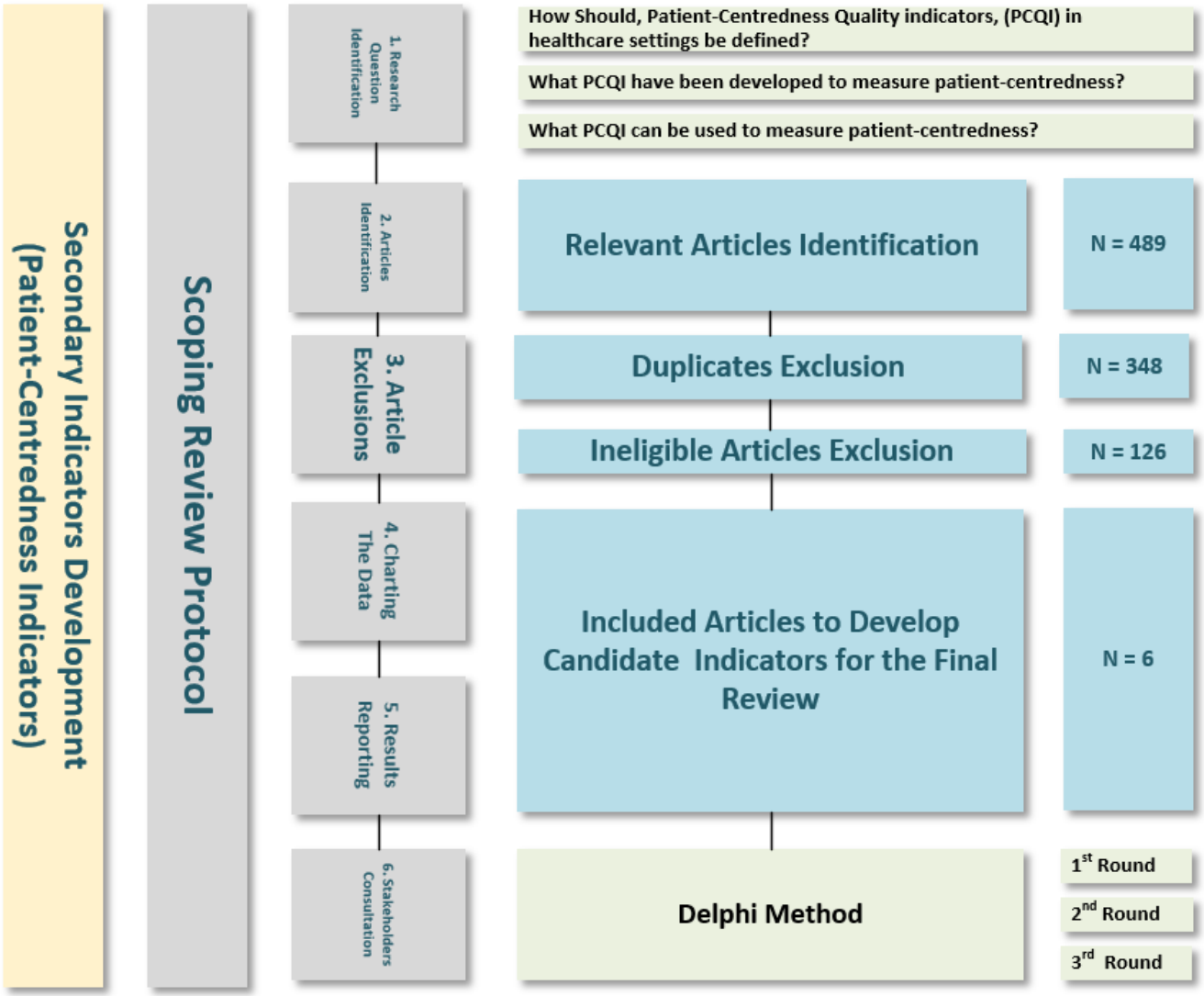

Figure 4. The development of the scoping review flowchart's secondary indicators.

Please refer to Figure 4 for the scoping review flowchart illustration.

Although the candidate PCC indicators were mainly chosen from the selected papers, other suggested indicators from the earlier survey were also included for the final consultation review, and Figure 5 shows the candidate PCC secondary indicators.

First domain: Access to care

1.1 Access to the Healthcare location
1.2 Transportation to Healthcare location
1.3 Appointments availability when needed
1.4 The ease of getting an appointment
1.5 Timeliness
1.6 The time to receive a diagnosis
1.7 Timeliness of first treatment
1.8 The access to the services according to their needs
1.9 Patent-centeredness policies are in place

Second domain: Continuity and transition

2.1 Ongoing treatment after discharge
2.2 Timeliness
2.3 Follow-up care
2.4 Survivorship
2.5 Follow-up timing

Third domain: Involvement of family and friends

3.1 Providing accommodations services to family and close friends
3.2 Involving them in important decision-making
3.3 Recognizing family and friends needs
3.4 Timeliness
3.5 Shared decision-making
3.6 Home care knows about the patient's status
3.7 The opportunity for them to ask questions
3.8 Family and friends Involvement

Fourth domain: Emotional support and alleviation of fear and anxiety

4.1 Anxiety
4.2 Timeliness
4.3 Psychosocial care
4.4 Adequately addressing patient's psychosocial needs
4.5 An appropriate referral to relevant psychosocial support services as needed
4.6 Patient was asked whether he had problems with living conditions
4.7 Patient received support in mental health if needed
4.8 Emotional support – relieving fear and anxiety
4.9 Provide psychological counselling service to postoperative patients
4.10 Patients involvement in fully supported and informed decisions

Fifth domain: Physical comfort

5.1 Pain management
5.2 Assistance with activities and daily living needs
5.3 Patient surroundings and facilities.
5.4 Safety aspects
5.5 Patient got support for daily activities.
5.6 Patient's support to control physical complaints
5.7 Physical comfort
5.8 Reduce patient falls
5.9 Offer radiation-free zones
5.10 Provide barrier-free facilities
5.11 Provide safety alarm facilities

Sixth domain: Information and education

6.1 Information on patient status and treatment progress.
6.2 Timeliness
6.3 Provided information to patient
6.4 Comprehensiveness of information provided to patients
6.5 The style of provided information to patient e.g ~~sub~~ written; understandable; consistent ...etc.
6.6 Information on treatment options including benefits and risks
6.7 Information on pain management
6.8 Information on medication(s) use
6.9 Patient involvement in shared decision-making
6.10 Patient's awareness of side effects
6.11 Guidelines are present on how to identify needs for groups of patients such as asthma patients, diabetes patients, surgery, and rehabilitations.
6.12 Patient feedback (regular surveys of patient experiences are conducted).
6.13 Confidentiality (Patient health and contact details are kept confidential at all times
6.14 Direction signs to guide patients
6.15 Provide information regarding access to clinical, social, physical and financial support on a continuing basis.
6.16 Patient knows at discharge their medication details

Seventh domain: Coordination and integration of care

7.1 Effective Communication with patients.
7.2 Technical expertise and knowledge of healthcare professionals.
7.3 Patients' confidence and trust in the doctors' knowledge and expertise
7.4 Doctors encourage the patient to ask questions
7.5 Patient had opportunities to ask questions
7.6 Patient's health history consideration.
7.7 Coordinated and integrated care.
7.8 An induction program is in place, which promotes the philosophy of care.
7.9 Clear policies are in place on how services are offered to patients.
7.10 Tailoring healthcare services for each patient (taking into account their circumstances, their ability to access services and their coexisting conditions).
7.11 Competent and courteous staff (reception staff are fully trained and are welcoming, courteous and efficient in all their dealings with patients).
7.12 Patients are made aware of how to raise a concern.
7.13 Patient's safety while, they are hospitalized.
7.14 Build hygiene maintenance system.
7.15 Keep toilets hygiene
7.16 Enforce smoking ban
7.17 Use IT to manage medical records
7.18 Equip pharmacy with automation
7.19 Manage hand hygiene of medical staff
7.20 Set up agency to tackle patient complaints
7.21 Set up privacy protection facilities

Eighth domain: Respect for patients' values, preferences and expressed needs

8.1 Timeliness
8.2 Consideration of special needs groups by services
8.3 Patient's preferences consideration
8.4 Interstation services are available when needed
8.5 Additional assistance is provided to people with other disabling and/or chronic conditions
8.6 Sensitivity to cultural differences and perceptions
8.7 Sensitivity to differences in the needs of other special groups (e.g. elderly, people with disabilities, those with low health literacy etc.)
8.8 Patients are treated with respect
8.9 Consideration to patients' values, preferences, and expressed needs
8.10 Compassionate care
8.11 Knowing the patient as an individual (patients have opportunities to discuss their health beliefs, concerns and preferences to inform their individualized care)
8.12 Essential requirements of care (patients are treated with dignity, kindness, compassion, courtesy, respect, understanding and honesty)
8.13 Equality (patients with special needs are given care and support 24/7 services according to their needs)

Figure 5. The candidate PCC secondary indicators.

In three rounds of Delphi reviews, eight panellists were asked to nominate appropriate PCC indicators for each domain. Panellists were asked to select indicators that cover and satisfy each domain in the first round. Then, the results were revealed to participants, asking them to revise their answers. The final version of the PCC indicators was sent to the panellists for final revision and approval in the last round.

The experts' panel includes healthcare quality experts, healthcare facilities engineers and consultant doctors. The flowing list in Figure 6 shows PCC indicators that have resulted from the three rounds of Delphi multidisciplinary consultation.

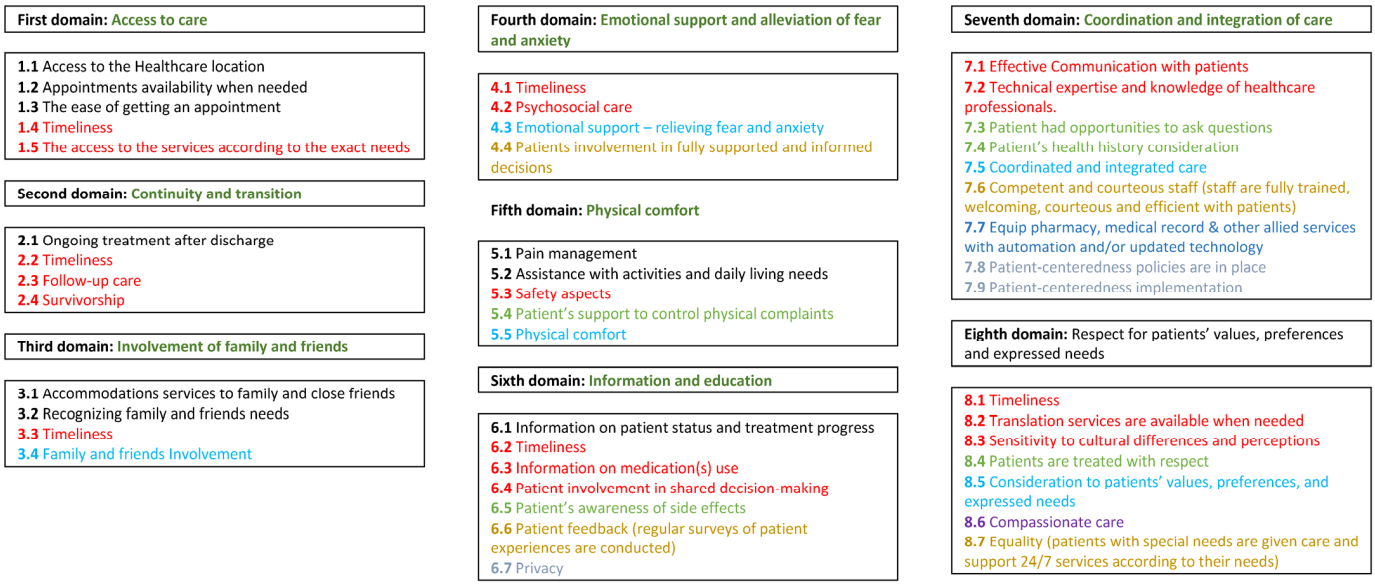

Figure 6. The List of PCC indicators.

7. Practice Test

The resulting indicators came into use by practice tests to validate the feasibility of the proposed indicators using a case study approach.

Data from two selected case studies, a specialised hospital and a pre-occupant hospital, were used to verify the feasibility of the developed indicators.

The pre-occupant hospital was included in the primary indicators practice test. This is because the expectation is relatively high at this stage for all design documents, drawings, specifications and other project-related documentation to be available at the site, which allows for comparing each indicator's availability during the construction and operational phases.

The verification of each indicator's availability was conducted through site inspections and meetings. For each unavailable indicator, a timeframe is assumed according to the availability of data, resources and materials at sites, which enables the establishment of the indicator. Please refer to the following Figure 7.

In Figure 7, the primary indicators in the third column have been tested through site inspections. Each indicator consists of a numerator and denominator. Therefore, the practice test results in a fourth column specifying the indicators' availability. For each unavailable indicator, a timeframe is assumed, and the numbers refer to the duration in days to extract the indicator according to data availability.

In the PCC indicators practice test, site inspections emphasised that most PCC indicators can be extracted from the hospital records in the dedicated departments. However, the indicators can also be established based on real opinions from the patients who received the service by asking them to rate each PCC indicator against a certain scale, and accordingly, a score would be generated for each indicator.

Origin	Indicators	Sustainable Healthcare Indicators (Primary Indicators)	Practice Test						
				Test.1			Test.2		
Use Stage Energy Performance	I.1 Energy Performance	PI.1.1 (Updated) Measured Total Energy Consumption/(Planned) Total Energy Consumption	PI.1.1	Num	✔		Num	✔	
				Den	✖	60	Den	✖	60
		PI.1.2 (Updated) Measured Total Renewable Energy Consumption/(Planned) Total Renewable Energy Consumption	PI.1.2	Num	✔		Num	✔	
				Den	✖	15	Den	✖	15
				Test.1			Test.2		
Life Cycle Global Warming potential	I.2 Life Cycle Global Warming potential	PI.2 (Updated) Calculated Life Cycle Global Warming Potential/(Planned) Life Cycle Global Warming Potential	PI.2	Num	✖	60	Num	✖	60
				Den	✖	30	Den	✖	30
				Test.1			Test.2		
Bill of quantities, materials and life spans.	I.3 (Bill of quantities) Materials and Equipment	PI.3 (Updated) Calculated Life Cycle Assessment (LCA) of Materials and Equipment/(Designed) Life Cycle Assessment (LCA) of Materials and Equipment	PI.3	Num	✖	90	Num	✖	90
				Den	✖	60	Den	✖	60
				Test.1			Test.2		
Construction and demolishing waste and materials.	I.4 Construction and demolishing waste and materials.	PI.4.1 Measured Generated Waste in Construction Stage/(Planned) Generated Waste in Construction Stage	PI.4.1	Num	✖	90	Num	✖	90
				Den	✖	90	Den	✖	90
		PI.4.2 (Updated) Generated Waste in Demolishing Stage/(Planned) Generated Waste in Demolishing Stage	PI.4.2	Num	✖	90	Num	✖	90
				Den	✖	90	Den	✖	90
				Test.1			Test.2		
Design For Adaptability and Renovation	I.5 Adaptability and Renovation	PI.5 Scoring Assessment of the Adaptability and Renovation/(Planned) Scoring Assessment of the adaptability and renovation (1 to 5 scale)	PI.5	Num	✔		Num	✔	
				Den	✖	30	Den	✖	30
				Test.1			Test.2		
Design for Deconstruction	I.6 Deconstruction	PI.6 Scoring Assessment of Deconstructing the Building/(Planned) Scoring Assessment of Deconstructing the Building (1 to 5 scale)	PI.6	Num	✔		Num	✔	
				Den	✖	30	Den	✖	30
				Test.1			Test.2		
Use Stage Water Consumption	I.7 Water Consumption	PI.7 (Updated) Measured Total Water Consumption/(Planned) Total Water Consumption	PI.7	Num	✔		Num	✔	
				Den	✖	30	Den	✖	30
				Test.1			Test.2		
Indoor Air Quality	I.8 Indoor Air Quality	PI.8 (Updated) Measured Indoor Air Quality by Zones/(Planned) Indoor Air Quality by zones	PI.8	Num	✔		Num	✔	
				Den	✖	60	Den	✖	30
				Test.1			Test.2		
Time Outside of thermal Comfort Zone	I.9 Time Outside of thermal Comfort Zone	PI.9 (Updated) Time Outside of thermal Comfort Zone/(Planned) Time Outside of thermal Comfort Zone	PI.9	Num	✔		Num	✔	
				Den	✖	60	Den	✖	60
				Test.1			Test.2		
Lighting and Visual Comfort	I.10 Lighting and Visual Comfort	PI.10 (Updated) Measured Lighting and Visual Comfort by Zones/(Planned) Lighting and Visual Comfort by Zones	PI.10	Num	✔		Num	✔	
				Den	✖	30	Den	✖	30
				Test.1			Test.2		
Acoustics and protection Against Noise	I.11 Acoustics and Noise	PI.11 (Updated) Measured Acoustics and Noise by Zones/(Planned) Acoustics and Noise t by Zones	PI.11	Num	✔		Num	✔	
				Den	✖	90	Den	✖	60
				Test.1			Test.2		
Protection of Occupier Health and Thermal Comfort	I.12 Futureproof of Building Performance Against Climate Change	PI.12 (Updated) Assessment of Adaptation to Future Climate Changes that will Impact Thermal Comfort/(Planned) Assessment of Adaptation to Future Climate Changes that will Impact Thermal Comfort (1 to 5 scale)	PI.12	Num	✔		Num	✔	
				Den	✖	90	Den	✖	90
				Test.1			Test.2		
Increased Risk Of Extreme Weather Events	I.13 Increased Risk Of Extreme Weather Events	PI.13 (Updated) Scoring Assessment of Resilience and Resistance to Extreme Weather Event, e.g. flooding, pluvial, and coastal/(Designed) Scoring Assessment of Resilience and Resistance to Extreme Weather Event, e.g. flooding, pluvial, and coastal (1 to 5 scale)	PI.13	Num	✔		Num	✔	
				Den	✖	30	Den	✖	30
				Test.1			Test.2		
Sustainable Drainage	I.14 Sustainable Drainage	PI.14 (Updated) Actual Sustainable Drainage as Percentage of total Drainage/(Planned) Sustainable Drainage as Percentage of total Drainage	PI.14	Num	✔		Num	✔	
				Den	✖	30	Den	✖	30
				Test.1			Test.2		
Life Cycle Cost	I.15 Life Cycle Cost	PI.15 (Updated) Life Cycle Cost/(Planned) Life Cycle Cost at Design Stage	PI.15	Num	✔		Num	✔	
				Den	✖	90	Den	✖	90
				Test.1			Test.2		
Value Creation and Risk Exposure	I.16 Value Creation and Risk Exposure	PI.16 (Updated) Value Creation and Risk Exposure Assessment/ (Designed) Value Creation and Risk Exposure Assessment (1 to 5 scale)	PI.16	Num	✔		Num	✔	
				Den	✖	60	Den	✖	60

Figure 7. Practice Test Results of the Primary indicators.

8. Research Contribution

This study proposes an assessing and reporting method to determine the sustainability of a healthcare building. Integrating the resulting method in healthcare settings can lead to

significant benefits as the accurate measurements of sustainability and PCC quality indicators are essential for decision making and improvements. Using such indicators is critical to identify and prioritise efforts by taking advantage of the voice of patients. Patients are in a position to provide valuable and reliable information about their level of satisfaction.

Healthcare buildings use different quality indicators from different standards, and internal policies and instructions may vary by organisation. In contrast, the proposed index needs to unify the spoken language, which allows comparison, highlights weaknesses at the system level and therefore improves decision-making processes, which consequently may facilitate advancements in healthcare.

The resulting life-cycle-based sustainability index could be implemented to assess and report sustainability in healthcare buildings and could be a pivotal step to shift to sustainable patient-centred healthcare buildings in Saudi Arabia.

The proposed index assesses and reports the overall sustainable performance of the healthcare building from a life cycle perspective incorporating patient-centredness.

The research findings will further develop and validate healthcare performance assessment and reporting tools and therefore open the door to increase research in this area.

Developing a set of indicators for relevant stakeholders is a step towards sustainable patient-centred healthcare settings. Indicators can be based on standards as well as experts' recommendations. However, including the voice of patients will lead to a more comprehensive picture.

9. Research Limitations

A healthcare building is a place where healthcare is provided to patients. Centres for Disease Control and Prevention (CDC) defines a healthcare facility as a hospital, long-term care facility or clinic [55]. Other healthcare facilities include associated sites such as pharmacies and outpatient laboratories. This healthcare definition does not include assisted living facilities, senior living facilities, prisons or group homes [55]. This research study applies to limited types of healthcare buildings and facilities, in particular general hospitals, specialised hospitals, referral (tertiary) hospitals, primary care centres and clinics. Another limitation of this study is that research for the relevant studies in the scoping review protocol was limited to the King Abdulaziz University database.

10. Further Research

Recommendations for further research include implementing the resulting index with its primary and secondary indicators at the city/province level for various locations in Saudi Arabia as a framework to assess and report on healthcare buildings. Therefore, the primary/secondary indicators can regularly be revised according to feedback analysis, climate change, local economic conditions and other social factors. Moreover, this step also will offer a comprehensive database and great research resources for future research.

Furthermore, the accelerated global effort facing climate change and other environmental challenges may influence the priorities. Therefore, increasing the research in this area is needed to meet the local requirements in this context.

The local legal systems and policies may also influence the indicators. Accordingly, further research is needed to align these and consider new policies.

New technologies such as artificial intelligence, computer modelling and generative design may also improve the indicators' use to assess and report healthcare building performance.

Further research may also focus on classifying healthcare buildings into different categories according to the new model of care, for instance, primary care hospitals, general hospitals, specialised hospitals, etc. Therefore, each category's assessment indicators may differ considering the services they provide.

Finally, comparing public and private hospitals in the context of measuring sustainability and PCC could be a consideration in future research.

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