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CHALLENGES AND STRATEGIES FOR PROMOTING NET-ZERO EMISSIONS IN TAIWANESE HEALTHCARE INSTITUTIONS: A QUALITATIVE STUDY FROM INDUSTRY–GOVERNMENT–ACADEMIC PERSPECTIVES

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Abstract

Climate change poses a critical and growing threat to public health, while the healthcare sector itself remains a notable contributor to global carbon emissions. Achieving net-zero operations in healthcare has thus become an urgent objective for sustainable development. This qualitative study explores the institutional challenges and strategic responses involved in the decarbonization of healthcare systems in Taiwan. Through 21 semi-structured interviews with experts from government, academia, and healthcare administration, we identified key barriers and opportunities in the path toward carbon neutrality. Thematic analysis revealed eight major challenges: (1) uncertainty and fragmentation in policy and regulatory frameworks; (2) infrastructural limitations and slow adoption of renewable energy technologies; (3) financial pressures and competing operational priorities; (4) lagging carbon

data disclosure and fragmented information systems; (5) weak leadership culture and underdeveloped governance mechanisms; (6) low engagement and awareness among clinical personnel; (7) lack of financial incentives and systemic integration of sustainability goals, including barriers to green procurement and circular economy practices; and (8) insufficient external support and underdeveloped public–private collaboration. Despite these obstacles, the experts proposed several strategic responses, such as mentorship models between large and small hospitals, application of smart hospital technologies, cross-departmental collaboration, and the establishment of robust policy incentives. Additional recommendations included the creation of integrated carbon accounting systems, development of multi-level governance platforms, and the promotion of leadership-driven sustainability initiatives. These findings provide actionable insights for policymakers and healthcare leaders seeking to advance net-zero transitions in Taiwan and other East Asian health systems facing similar structural and institutional challenges.

Keywords: healthcare decarbonization; health policy; net-zero transitions; sustainability governance; sustainable healthcare strategies

Introduction

Climate change is a rapidly escalating threat to human health worldwide (Crimmins et al., 2016; Romanello et al., 2021; Singh et al., 2023). The World Health Organization has called climate change "the defining public health issue of our time" and the UN Secretary-General labeled it a "code red for humanity" (Guterres, 2021). Ironically, the healthcare sector – tasked with protecting human health – contributes substantially to the very problem. Recent analyses estimate that global health care activities are responsible for about 4.4% of net global greenhouse gas emissions. This figure rises to around 8–10% in high-income countries (Karliner et al., 2020). Major emission sources in healthcare include hospital energy use, operating-room anesthesia gases, pharmaceuticals production, and medical transport. Without intervention, healthcare emissions could triple by 2050 compared to 2014 levels (Alshqaqeeq et al., 2020).

Accordingly, at COP26 in 2021, WHO launched the "Climate Resilient and Low-Carbon Health Systems" initiative with commitments from multiple countries (WHO, 2021c). The United Kingdom's National Health Service has set a roadmap to achieve net-zero emissions by 2040 (Tennison et al., 2021). These efforts highlight that decarbonizing healthcare is essential for sustainable public health. However, much of the existing research focuses on technical solutions or Western contexts, leaving a gap in understanding how hospitals in East Asia navigate this transition.

Climate change and population health are closely interlinked. WHO (2021) notes that climate change will intensify heatwaves, air pollution, infectious disease spread, and food insecurity, posing multi-layered impacts on global health. As warned by the Lancet Countdown report, "the resulting climatic extremes are increasingly claiming lives and livelihoods worldwide" (Romanello

et al., 2024). Healthcare systems themselves are significant contributors to emissions, prompting increasing calls to include "decarbonizing health systems" in climate agendas. Major initiatives such as the COP26 Health Program emphasize that ensuring climate resilience and low-carbon health systems is critical, and institutions like Health Care Without Harm have published roadmaps for healthcare decarbonization (Karliner et al., 2020; Lakatos et al., 2023).

The term "net-zero emissions" refers to balancing anthropogenic greenhouse gas emissions with removal, i.e., minimizing emissions and offsetting remaining emissions through carbon removal (Tennison et al., 2021). This concept has become central to climate governance. In 2021, the WHO launched a health program at COP26 committing member states to climate action. International organizations like Health Care Without Harm (HCWH) (WHO, 2021b) and Arup have jointly released a Global Road Map for Health Care Decarbonization, recommending seven strategic areas for healthcare facilities worldwide: (1) energy transition, (2) building optimization, (3) sustainable transportation, (4) low-carbon pharmaceuticals and supplies, (5) decarbonized clinical practices, (6) circular economy, and (7) systems integration and data transparency (Harm, 2019, 2021). The Global Green and Healthy Hospitals (GGHH) network also provides carbon accounting tools and action guides, with over 1,300 healthcare institutions globally participating in carbon reduction initiatives (Harm, 2021).

Taiwan's response to climate change has accelerated in recent years. In 2021, the Executive Yuan announced a goal of achieving net-zero carbon emissions by 2050. This ambition was institutionalized with the passage of the Climate Change Response Act in 2023, which mandates emission reductions across industries, including healthcare.

Under this policy framework, the Ministry of Health and Welfare has begun exploring sustainable development pathways in healthcare. Some public hospitals have initiated basic carbon inventory assessments and pilot programs for energy savings and waste reduction. However, research indicates that these efforts remain fragmented and lack long-term strategic planning. Hospitals often rely on initiatives at the departmental level without an overarching governance structure. In practice, most hospitals still lack dedicated sustainability units or personnel, and there is no national benchmark for healthcare carbon performance.

On the clinical side, significant emission sources include anesthetic gases, surgical supplies, patient and staff transportation, and health information systems. Studies have shown that certain anesthetics like desflurane and nitrous oxide have very high global warming potentials (GWPs). Replacing these with lower-GWP options like sevoflurane or total intravenous anesthesia (TIVA) is a key decarbonization measure (MacNeill et al., 2020; Wyssusek et al., 2019). Optimizing operating room processes – for example, using single-pack aseptic kits, smart scheduling, and streamlined post-operative workflows – can also reduce energy

and material use (Sanchez et al., 2020; Thiel et al., 2017; Vinoth et al., 2022). Moreover, expanding telemedicine has been shown to reduce patient and family travel emissions: virtual outpatient clinics can lower average carbon footprints by over 50% (Pickard Strange et al., 2023; Purohit et al., 2021; Thiel et al., 2023; Zotova et al., 2020).

Despite the growing diversity of decarbonization strategies available, implementation remains challenging. Many hospitals lack standardized carbon accounting systems and data integration capabilities, making it difficult to quantify and track emission reductions (Tennison et al., 2021). Clinicians often perceive sustainability initiatives as administrative tasks unrelated to their clinical duties, limiting engagement. Institutional fragmentation between administrative, support, and clinical departments further complicates coherent action (Braithwaite et al., 2024; Watts et al., 2019).

In Taiwan, climate action targets (e.g., net-zero by 2050) have been announced, but specific guidance for the healthcare sector remains unclear. It is therefore important to explore the real-world challenges Taiwanese hospitals face and the locally appropriate strategies to overcome them. Existing literature on healthcare decarbonization often focuses on technical or operational aspects, for example, facility energy upgrades (Balaras et al., 2007; de Oliveira et al., 2021; Dion et al., 2023; Khahro et al., 2021; Vinoth et al., 2022), clinical process improvements (MacNeill et al., 2020; Spoyalo et al., 2023). telemedicine adoption (Watts et al., 2019), and reusable medical supplies and green procurement (Wyssusek et al., 2019). However, systemic challenges such as internal governance mechanisms, policy linkages, and institutional barriers in healthcare organizations have been insufficiently explored. This gap is especially significant in Asia, where healthcare culture and institutional structures differ from Western contexts, making practical experiences and insights in the region particularly valuable.

To address this gap, we conducted a qualitative study with experts from government, academia, and healthcare administration to understand the real-world situation of Taiwanese hospitals pursuing net-zero goal. Drawing on practical perspectives, we conducted semi-structured interviews with 21 experts from the healthcare industry, government, and academia to integrate insights across these three sectors. By analyzing the specific coping strategies and suggestions proposed by these experts, we hope to provide policy-makers and hospital managers with concrete references for policy design and operational practice.

Methods

Study Design and Participants

Qualitative research approaches are considered particularly helpful in revealing gaps between policy design and practical implementation (Creswell JW, 2018). Therefore, we used a series of in-depth interviews to collect and understand the real-world challenges, institutional barriers, and coping strategies faced by Taiwanese healthcare organiza-

tions in pursuing net-zero emissions. Participants comprised 21 experts purposively recruited based on their experience with healthcare sustainability. We targeted three sectors: government officials, senior hospital administrators, and academic/industry consultants in sustainable healthcare. Specifically, we interviewed

Table 1. Characteristics of Participants (N = 21)

Category	Subcategory	n	%
Gender	Male	17	71.4
	Female	4	28.6
Age (years)	41–50	3	14.3
	51–60	12	57.1
	≥61	6	28.6
Education	Master's degree	7	28.6
	Doctorate	14	71.4
Experience (Years)	≤10 years	1	4.8
	11–15 years	2	9.5
	16–20 years	0	0.0
	21–25 years	4	19.0
	26–30 years	6	28.6
	≥31 years	8	38.1
Work Background	Hospital administration	7	33.3
	Local health authority	3	14.3
	Central health authority	2	9.5
	Industry/consulting (opinion leader)	2	9.5
	Public health/health management academic	7	33.3
Position	City health authority head	1	4.8
	Hospital director	4	19.0
	Hospital senior executive	3	14.3
	Central health authority leader	3	14.3
	Local health authority leader	1	4.8
	Hospital chairman	3	14.3
	University associate professor or above	6	28.6

five government representatives, 10 hospital administrators, and six academics/consultants. Table 1 summarizes these participants' demographics and professional backgrounds. Briefly, 85.7% were over 50 years old; and 66.7% had more than 26 years of experience, reflecting a highly experienced expert panel. This diversity of roles and expertise ensured a comprehensive understanding of institutional perspectives toward bridging the gap.

Interview Procedure

We developed a semi-structured interview guide with questions on: (1) awareness of Taiwan's 2050 net-zero policy in healthcare; (2) difficulties encountered in implementing carbon-reduction actions; (3) perceived adequacy of institutional support and regulations; (4) internal governance and cultural challenges; and (5) ideas for future strategies or policy improvements. Interviews were conducted online or in person (February–September 2024), each lasting 60–90 minutes, and audio-recorded with participants' consent.

Data Analysis

Recordings were transcribed verbatim and analyzed using Braun and Clarke's thematic analysis approach (Braun & Clarke, 2006). Two researchers independently reviewed transcripts and performed open coding with the aid of NVivo 12 software. Similar codes were grouped into candidate themes, which were iteratively discussed and refined by the research team to ensure coherence and relevance. We applied triangulation (cross-checking codes among three analysts), respondent validation (members' checks), and constant comparison with literature to enhance credibility (Lincoln & Guba, 1985). Given the depth of expert interviews, we achieved thematic saturation with the 21 interviews, suggesting the sample was sufficient (Guest et al., 2006). The final themes were agreed upon by consensus.

Ethical Issues/Statement

The study protocol was approved by the National Cheng Kung University Institutional Review Board (IRB No. A-ER-112-411). All participants provided informed consent prior to the interviews. To maintain confidentiality, transcripts were de-identified and stored securely; no personal identifiers are reported and interview excerpts are referenced by anonymous codes.

Results

From analysis of the 21 interviews, we identified eight key challenge themes and corresponding strategic directions (see Table 2). Brief descriptions of each theme (with illustrative quotes) are provided below.

Theme 1： Uncertainty and Gaps in Policy and Regulatory Environment.

Most participants noted that although Taiwan has set a 2050 net-zero vision, concrete policies and regulations for

Table 2. Summary of Main Challenges in the Net-Zero Implementation Process

Theme #	Title	Description
1	Uncertainty and Gaps in Policy and Regulatory Environment	The government has announced a 2050 net-zero goal but lacks clear regulations or guidance specific to the healthcare sector, making it difficult for hospitals to develop long-term plans or assess outcomes.
2	Limitations in Infrastructure and Renewable Energy Deployment	Many hospital buildings are old and space-limited (e.g., insufficient roof area for solar panels). Even where installed, renewable systems often only power a portion of needs (lighting or heating), yielding limited carbon reduction.
3	Financial Pressures and Conflicts in Operational Priorities	Carbon reduction investments have high upfront costs and long payback periods. Under NHI budget constraints, hospitals prioritize clinical outcomes. Sustainability initiatives are often pursued only "if there's spare capacity."
4	Lagging Carbon Data Disclosure and Integration Systems	There is no standardized carbon accounting tool or cross-department data integration system. Data are siloed across departments, making it hard to quantify and manage carbon performance and monitor reduction progress.
5	Fragmented Leadership Culture and Governance Mechanisms	Sustainability is not yet embedded in hospitals' core governance. There is a lack of senior leadership commitment and cross-department coordination. Many carbon reduction efforts are short-term projects without long-term integration or momentum.
6	Low Clinical Staff Engagement and Sustainability Awareness	Frontline medical staff have limited awareness of sustainability goals and often view carbon reduction as an administrative issue. They lack motivation and guidance to incorporate sustainability into daily clinical practice.
7	Missing Incentives and Tied Sustainability Performance	Current NHI payment and hospital accreditation systems lack carbon reduction indicators or incentives. Hospitals have little economic motivation to invest in sustainability; green procurement and reusing medical supplies face cost and regulatory barriers.
8	Weak External Support and Public–Private Partnership Models	There is a lack of inter-hospital collaboration, technical support, and governmental platforms. Each hospital operates in isolation, and small-to-medium hospitals especially struggle to implement carbon reduction at scale. Urgent support through public–private partnerships is needed.

the healthcare sector are unclear, leaving institutions without clear direction.

"The central government has set a target, but there are no detailed measures or even a platform or standard to tell everyone how to proceed." – Respondent I *"Hospitals fear the lack of regulatory standards. Right now, everyone is groping along on their own; it's hard to promote anything based solely on voluntary action."* – Respondent O

"Currently, hospitals are acting on their own initiative because there are no explicit legal requirements." – Respondent D

"Even though there is a hospital accreditation system, carbon performance isn't part of the core evaluation. There's no incentive to push for it." – Respondent H

"Our energy-saving projects often die out because hospitals have clinical pressures. You need policy incentives to balance things out." – Respondent H

These comments reflect how policy ambiguity and absence of support measures lead to institutional anxiety and lack of organizational momentum on the ground. One issue is the fragmented governance structure for healthcare, which spans multiple ministries (health, environment, economy) and often results in inconsistent policies and blurred responsibilities. Respondent C suggested:

"We should set up an inter-ministerial platform for healthcare sustainability to coordinate resources." – Respondent C

In other words, hospitals have no clear roadmap, regulations, or KPIs tailored to healthcare carbon reduction.

Consistent with respondents' concerns, Tennison et al. (2021) emphasize that clear policies and cross-level coordination are foundational for successful net-zero strategies (as seen in the NHS case), whereas unclear guidance makes it difficult for the health sector to integrate into national net-zero. In Taiwan, the lack of a coordinated climate governance framework and the exclusion of sustainability goals from NHI payment and hospital evaluation systems make it hard to embed net-zero into everyday healthcare operations. Stakeholders highlighted the need for "mission-oriented" policies that are action-driven (WHO, 2021a; Pichler et al., 2019). Many respondents said that without detailed implementation rules and phased targets, frontline institutions are "eager but powerless." They called for a clear carbon transition roadmap for the health sector, with stage-wise targets and action guidelines for different levels of hospitals. Proposed measures include setting explicit interim goals, enacting progressive regulations, and providing incentives (subsidies, accreditation credits, tax breaks) to boost hospitals' participation.

Theme 2： Limitations in Infrastructure and Renewable Energy Deployment.

Experts commonly pointed out that aging hospital facilities and physical space limitations hinder renewable energy deployment. Many hospitals lack sufficient roof area for large-scale solar

panel installations. Even when solar arrays are installed, the hospitals' large energy demand often means solar can only power partial loads (e.g., lighting or hot water), yielding minimal carbon reduction. As Respondent P noted:

"Solar output is limited. Hospitals cannot tolerate unstable power supply." – Respondent P

"Rather than aiming for 100% green energy, it's better to improve building efficiency and power management first." – Respondent J

"Although these investments are high upfront, they definitely make sense in the long run. However, smaller hospitals say they lack funds and technical resources, which is the main reason they can't follow suit." – Respondent I

To overcome these obstacles, several respondents recommended partnering with external entities, such as green energy providers or solar farms, or introducing energy storage systems and smart energy management platforms to increase flexibility in power usage. Many hospitals have also been gradually upgrading building systems – for example, replacing high-energy appliances and installing smart HVAC and lighting – to systematically reduce energy consumption.

Theme 3：Financial Pressures and Conflicts in Operational Priorities

The majority of respondents indicated that hospitals face substantial financial challenges in the net-zero transition, especially given the high initial costs of energy-efficient retrofits and renewable energy installations. As one regional hospital administrator (Respondent I) frankly admitted:

"A magnetic levitation chiller can save about 30% in electricity, but the initial investment is tens of millions [NTD], which we simply cannot afford." – Respondent I

Others noted that under Taiwan's NHI global budget system, hospital finances are already tight, leaving little room for additional sustainability expenditures.

"Carbon emissions aren't related to our medical performance, and clinical care is the priority, so carbon reduction can only be done 'if there's any spare capacity." – Respondent E

This reflects the reality that carbon neutrality has not been included in core management considerations.

Respondents emphasized that investments in green infrastructure (e.g. energy retrofits, renewable installations) require high capital with long payback times. Given the fixed hospital budget and the need to deliver patient care under the national insurance scheme, clinical outcomes take precedence. As Respondent E noted,

"Sustainability projects proceed only if there's spare capacity." – Respondent E

In sum, hospitals feel financial pressure to prioritize immediate health services over environmental upgrades. Therefore, experts suggested that policy support is needed to alleviate hospitals' financial burden. Examples include offering energy-efficiency grants, equipment upgrade loans, and performance-based carbon-neutrality rewards to avoid conflicts between carbon reduction actions and operational efficiency. They also advocated for innovative business models such as "leasing rather than buying" (e.g., leasing reusable surgical kits, or implementing dialysis supply recycling) to spread out capital expenditure and increase participation incentives.

Theme 4：Lagging Carbon Data Disclosure and Integration Systems

Respondents agreed that carbon accounting is fundamental to hospitals' emission reduction efforts, yet most Taiwanese hospitals lack a complete system for it. Respondent H (a Deputy Director of a public hospital) explained,

"Right now, we can only estimate roughly. Electricity usage is relatively easy to track, but Scope 3 emissions (supply chain) are almost impossible to capture." – Respondent H

The current accounting lacks unified standards; methods are complex and tools inconvenient, which is a major barrier to on-the-ground implementation. A scholar (Respondent S) suggested:

"The government should provide carbon accounting tools and an integrated platform, even standardized inventory templates." – Respondent S

Most respondents also noted that hospital carbon accounting is still in a nascent stage and that different departments use separate information systems, making data integration and analysis difficult.

"Currently, carbon accounting relies on manual data compilation. Even energy usage data are scattered across different platforms, so real-time tracking is impossible," – Respondent I

"The hospital systems we use now were not designed for carbon reduction. To analyze data, you have to export them all manually, which is extremely inefficient." – Respondent Q

A major gap is the lack of standardized carbon accounting systems. Hospitals do not have an integrated platform to aggregate energy, waste, supply chain, and clinical data for emissions tracking. Data remain siloed in different departments, making it difficult to measure baseline carbon footprints or monitor reductions. Several participants called for a unified data integration system to enable real-time carbon management. This data fragmentation prevents institutionalized management of carbon performance and undermines decision support. Singh et al. (2022) proposed that integrating clinical information systems (CIS) with environmental management systems (EMS) into a "smart carbon governance platform" could enable data-driven sustainability strategies (Singh et al., 2022). Currently,

few Taiwanese hospitals have such integrated tools or government-supported unified platforms. Some experts emphasized the need for data transparency: establishing public carbon disclosure platforms and benchmarking (similar to international practices) could foster positive competition among hospitals and promote carbon performance reporting.

Theme 5： Fragmented Leadership Culture and Governance Mechanisms

Sustainability had not yet been institutionalized in hospital governance structures. There was a lack of high-level commitment (e.g. a Chief Sustainability Officer) and no cross-department task force. Many carbon reduction initiatives were reported to be isolated, short-term projects. Participants observed that without senior leadership championing green policies, efforts tended to be fragmented and lacked continuity.

Even medical centers that initiated energy-saving projects face challenges of institutionalization and cross-departmental resource allocation. Braithwaite et al. (2024) noted that without dedicated governance structures and integrated frameworks, sustainability efforts can become marginalized. Indeed, effective carbon reduction relies on cross-departmental operations and sustained execution; relying solely on individual enthusiasm or one-off projects is unlikely to endure. Organizational culture significantly influences sustainability actions. Hospitals need to establish a new management model (van Schie, 2024). MacNeill et al. (2023) found that the success of healthcare sustainability initiatives often depends on whether senior leadership embeds them into core values and decision-making, executing through cross-departmental governance (Sherman et al., 2023). If sustainability remains only a symbolic slogan, it is hard to galvanize collaboration across departments.

Theme 6： Low Clinical Staff Engagement and Sustainability Awareness

Most respondents agreed that clinical staff, while playing a role as key executors of net-zero actions, are often marginalized in policy design and implementation, and have limited understanding of what "sustainable healthcare" means in practice.

"Clinical personnel think this is an administrative issue and don't connect it to their daily work." – Respondent J

"Our nurses and doctors are already so busy; sustainability is not even on their radar." – Respondent K

"Healthcare staff are so busy. Many know about energy saving, but beyond turning off lights, they don't know what else to do." – Respondent L

There was consensus that there is much room to improve staff participation and awareness. Frontline medical staff generally showed limited awareness or interest in hospital carbon goals. Clinical personnel often viewed green initiatives as beyond their remit, or administrative burdens. Several interviewees pointed out that under usual circumstances, doctors

and nurses are dedicated to patient care and lack incentives or knowledge to integrate sustainability in clinical practice (e.g. waste reduction, green prescribing). Raising awareness and motivation among medical staff was identified as a key challenge (Huang et al., 2024).

Experts suggested embedding carbon reduction concepts into staff training, designing internal energy-saving competitions and bonuses, and even extending awareness-raising to patients and communities (e.g., holding community lectures, integrating sustainability education into outpatient visits) to build public support for sustainable healthcare. The literature refers to this phenomenon as the "engagement gap." Van (2024) pointed out that knowledge, management involvement, commitment and execution of medical professionals are crucial factors for medical sustainability (van Schie, 2024). Braithwaite et al. (2024) argue that to successfully implement decarbonization in hospitals, efforts must address grassroots education, institutional participation, and professional empowerment simultaneously, strengthening staff ownership of sustainability actions (Braithwaite et al., 2024). Relying solely on top-down mandates cannot achieve deep cultural change.

Theme 7：Absence of Financial Incentives and Linkage of Sustainability Performance

Interviews showed that under the current NHI reimbursement and hospital financial management mechanisms, environmental sustainability goals are not integrated, making it difficult for healthcare institutions to prioritize carbon reduction. Practices like green procurement and resource recycling face cost and regulatory constraints.

"Our hospital budget is for patient care; we have to find funding for sustainability projects ourselves," – Respondent P

A hospital manager (Respondent H) noted,

"If doing these [sustainability] things earned points in evaluations or brought funding, then hospitals would take it seriously." – Respondent H

"Eco-friendly supplies are more expensive; department heads ask, 'Why not just buy the cheaper ones?'" – Respondent N

"Medical waste sorting and reuse often hit infection control regulations, so most single-use supplies still have to be used." – Respondent L

"The government should establish green procurement standards and incentives, set safety standards and recycling rules for reusable supplies, and encourage leasing and sharing platforms to reduce redundant equipment." – Respondent A

The UK NHS requires sustainability reporting and links it to annual budget allocations. In contrast, Taiwan has not established such incentive structures, meaning hospitals, even if willing, lack financial and institutional support to act.

Taiwan's hospital accreditation and payment systems do not currently include any rewards for carbon reduction. Interviewees noted that hospitals have almost no economic motivation to go green under existing policies. Even efforts like green procurement or reusing medical supplies face regulatory hurdles and higher short-term costs. The absence of financial incentives or accreditation credits linked to sustainability was seen as a major disincentive. As a hospital manager (Respondent H) claimed,

"There's no tangible benefit to cutting carbon under the current system." – Respondent H

Theme 8：Weak External Support and Public-Private Partnership Models

Experts widely noted the absence of cross-hospital exchange, technical support, and government collaboration platforms, leading most hospitals to explore solutions independently.

"Right now, everyone is researching on their own and buying equipment on their own, with no overall planning or resource integration," – Respondent M

"We really need a platform to engage with people who can teach us, evaluate us, and also share experience and resources." – Respondent H

Laktos et al. (2023) emphasize that advancing healthcare sustainability requires establishing regional support systems and policy–practice intermediary platforms that provide toolkits, expert consultation, and performance tracking (Laktos P, 2023). For resource-limited regional or district hospitals, public–private collaboration mechanisms can be a key driving force.

Participants highlighted a lack of external support infrastructure. To date, Taiwan has no comprehensive public–private platform to share technical resources or best practices. Hospitals largely operate in silos; especially, small and medium-size hospitals have been struggling to implement clean-tech measures without help. Therefore, many suggested that a more active inter-hospital collaboration network or government-led partnership scheme is urgently needed to accelerate decarbonization at scale.

Despite these barriers, all respondents proposed actionable strategies and policy ideas. Key suggested measures included developing an explicit net-zero roadmap for healthcare; building a centralized carbon accounting and information platform; establishing mentorship networks between large and small hospitals; incorporating sustainability into professional training; and designing financial incentives such as accreditation points or subsidies for green investments. These proposals are discussed and elaborated below.

Discussion

Unlike prior research focusing on technical fixes (e.g. energy-efficient equipment), our findings emphasize governance, culture, and policy gaps as critical hurdles. We found that Taiwan's hospitals recognize the climate imperative

but currently lack clear guidance and integrated support. Policy planning is still in its infancy: national targets exist, but specific regulations for the health sector are absent. At the organizational level, hospitals face resource constraints, fragmented leadership, and incomplete data systems. Crucially, medical staff engagement remains low, and external partnerships are minimal.

In light of these insights, we propose the following five policy and practice recommendations to effectively advance healthcare net-zero agenda.

Clarify Policy Governance and Establish a Healthcare Net-Zero Roadmap

Health authorities (MOHW, EPA, MOEA) should collaboratively develop a sector-specific decarbonization blueprint. This plan would set phased targets (e.g. interim goals by 2030, 2040), regulatory measures, and resource allocation principles for hospitals. For example, embedding carbon-reduction metrics into National Health Insurance funding and hospital accreditation could create accountability and motivation. A cross-agency task force on healthcare sustainability should be formed to align policies, eliminate inter-departmental gaps, and oversee progress (similar to what one respondent called an "inter-ministerial platform for healthcare sustainability"). Regulations should be updated to facilitate eco-friendly practices (e.g., easing rules for medical supply reuse, mandating green procurement standards).

Invest in Carbon Data Integration and Smart Systems

A major enabler would be a nationwide healthcare carbon accounting platform. This digital system would link hospitals' existing information technologies (electrical meters, building management, electronic medical records, etc.) to automatically calculate carbon footprints in real time. Standardized tools and databases (tailored to different hospital sizes and energy profiles) should be developed to improve data quality and comparability. Regular public disclosure of hospital emission data (benchmarked between institutions) could foster transparency and a culture of continuous improvement. Real-time feedback from such smart systems would allow managers and clinicians to monitor outcomes of sustainability interventions.

Enhance Organizational Capacity and Leadership

Hospitals should institutionalize sustainability governance. This might involve creating a dedicated sustainability committee or appointing a Chief Sustainability Officer at senior level to integrate climate goals into executive decision-making. Strengthening cross-department coordination (administrative, clinical, facilities) is crucial so that sustainability initiatives are not siloed. Leadership training programs and environmental education should be implemented to shift organizational culture. For instance, integrating sustainability modules into continuing medical education or hospital orientation can raise awareness among clinical staff and managerial teams. Visible commitment from top hospital leaders (e.g. public net-zero pledges) can further drive internal engagement.

Create Financial Incentives and Support Mechanisms

To accelerate the progress of hospitals towards net zero, standardized metrics and national incentives are needed (Hough & Cohen Tanugi-Carresse, 2024). To address cost barriers, the government should consider incentive programs for hospitals that reduce emissions. Ideas include adding sustainability criteria in hospital accreditation (e.g. extra credits for meeting carbon targets) or adjusting payment schemes to reward green investments. Financial subsidies or tax incentives for renewable installations or energy-efficient upgrades could improve the business case. Public hospitals might receive earmarked funds or grants when they hit emission-reduction milestones. In the private sector, competitive grants for pilot projects (e.g. hospital waste recycling, solar microgrids) could stimulate innovation. Linking green procurement policies across healthcare facilities would also create economies of scale and lower costs.

Foster Public–Private and Inter-Hospital Collaboration

The government and industry associations should facilitate platforms for knowledge-sharing. For example, establishing a national consortium or regular forums where large medical centers mentor smaller hospitals on sustainability practices could accelerate diffusion of best practices. Partnerships with technology providers (e.g. clean energy firms, waste management companies) can provide needed expertise. Involving civil society and patient groups can also build public support for green healthcare. A coordinated network would ensure smaller or rural hospitals are not left behind, addressing the "weak links" in the system.

By systematically addressing the above areas, Taiwan's healthcare system can transform these challenges into opportunities. The expert suggestions gathered in this study offer concrete, locally grounded blueprints for action. Our findings are not only relevant to Taiwan but may also inform other East Asian and middle-income healthcare systems undertaking similar sustainability transitions.

Conclusions

This unique qualitative study collected insights from 21 experts spanning government, academia, and hospital administration to map the challenges and strategies for net-zero healthcare in Taiwan. Eight major challenge themes emerged, covering gaps in policy, technology, finance, data, leadership, and culture. Although there is widespread acknowledgment of the need for climate action, our experts identified that current policy support is vague and fragmented; hospitals often lack the resources and governance structures to implement carbon reduction; and frontline staff remain disengaged from these goals. These findings echo concerns raised in international literature about fragmented sustainability leadership in healthcare and the need for stronger policy coherence (Atwoli et al., 2021; Eckelman et al., 2020; Eckelman & Sherman, 2016; Romanello et al., 2021).

External support mechanisms are also underdeveloped, reflecting broader structural weaknesses in aligning national health and climate agendas (Watts et al., 2019).

In response to the challenges of climate change, the interviewed experts proposed a range of innovative solutions with high policy relevance. They advocated for a clear, phased decarbonization roadmap for healthcare (with targets and resources for all hospital tiers), development of an integrated carbon accounting and monitoring platform (Huang et al., 2024), stronger organizational leadership and training in sustainability (Mortimer et al., 2018) (consistent with the leadership frameworks proposed by Mortimer et al., 2018), and creation of financial rewards—such as accreditation incentives and grants—to motivate emission cuts (Karliner et al., 2020). These recommendations provide concrete, evidence-based guidance for hospital administrators and policymakers.

Our findings provide new policy insights for advancing a low-carbon transformation of healthcare systems and may serve as valuable reference for other countries encountering similar challenges. We believe that by implementing these strategies, health systems can align climate goals with patient care priorities and embed resilience into the future of healthcare delivery (Lenzen et al., 2020; MacNeill et al., 2020).

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Ethical Approval

Ethical approval was obtained from the National Cheng Kung University Institutional Review Board (IRB No. A-ER-112-411), and all participants provided informed consent.

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