

ICTHM 2023**International Conference in Technology, Humanities and Management****STRATEGY DEVELOPMENT FOR REDUCING CARBON
EMISSIONS IN HOSPITALS**

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Abstract

Hospitals are institutions that must provide continuous service. In addition, their energy consumption is quite high. Therefore, carbon emissions produced by hospitals are also high. Carbon emissions harm both the environment and people. Therefore, it is necessary to reduce carbon emissions. Accordingly, the factors causing carbon emissions in hospitals were determined by literature review. The factors that cause carbon emissions in hospitals are the use of clean energy, effective control, the level of awareness of the personnel and the technological infrastructure. In order to minimize carbon emissions, it is not possible for managers to intervene in all of these criteria at the same time. For this reason, these criteria were weighted with the DEMATEL method. DEMATEL is one of the multi-criteria decision-making techniques that reveals the causal relationships in the criteria set with the help of matrices. According to the DEMATEL method, it defines the relationships between criteria with matrices and reveals the strength between the relationships. Accordingly, it was determined that the most important criterion that causes carbon emissions in hospitals is the use of clean energy. Accordingly, it would be appropriate for decision makers to work on the use of clean energy in hospitals. Another important criterion is the effective control mechanism. It is possible to reduce carbon emissions by establishing an effective control mechanism.

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1. Introduction

Carbon emissions cause an increase in greenhouse gases in the atmosphere. Because these gases are trapped in the atmosphere, they reflect some of the rays from the sun while reflecting the rest of the heat back to the earth's surface and retaining it in the atmosphere. This situation is called the greenhouse effect and causes an increase in temperature worldwide. The increase in temperature causes many problems called climate change. For example, increasing temperature causes glaciers to melt and sea levels to rise. As a result, the waters in the coastal areas rise and floods and floods occur. It can also cause environmental disasters such as increased temperature, drought, desertification, and forest fires (Yang et al., 2022). Carbon emissions can also cause health problems. For example, air pollution can lead to health problems such as respiratory problems, heart disease, and cancer. As a result, carbon emissions are harmful because they cause climate change, environmental problems, and health problems. Therefore, it is extremely important to reduce carbon emissions and fight against climate change. Renewable energies are of great importance to reduce carbon emissions. Renewable energy sources produce less carbon emissions compared to energy derived from fossil fuels. Therefore, the use of renewable energy sources such as solar and wind energy is an effective method of reducing carbon emissions (Lu et al., 2019).

Hospitals are institutions that serve 24 hours a day, 7 days a week. Hospitals have many environmental factors such as devices and systems with intense energy consumption, as well as various medical wastes such as various gases, liquids, and solid wastes emitted into the environment. Hospitals generate high levels of carbon emissions due to high energy consumption and waste generation. Therefore, hospitals apply various methods to increase sustainability and minimize carbon emissions. These methods are clean energy use, effective control, personnel awareness level, and technological infrastructures. Renewable energy sources such as solar and wind energy can help reduce carbon emissions by changing the source of energy used in hospitals. Hospitals need energy intensively for the delivery of health services. Heating, cooling, lighting, and operating appliances play an important role in energy consumption. Therefore, the transition to clean energy sources for hospitals will both reduce carbon emissions and lower energy costs (Lu & Wang, 2019).

Many hospitals are trying to reduce their carbon footprint by switching to renewable energy sources such as solar, wind, and hydraulic energy. For example, many hospitals utilize the space on the roof of the hospital building by using solar panels. These panels can produce some of the energy needed by the hospital and can also be an environmentally friendly energy source. Effective control is a strategy that can be used to reduce carbon emissions in healthcare facilities. These controls assess energy consumption, waste management, and other environmental impacts and help adopt more sustainable practices. The effectiveness of sustainability initiatives depends in large part on the degree of awareness of the personnel, which in turn depends on the level of awareness of the environment. By doing so, future generations with a more sustainable planet and lessen the negative effects hospitals have on the environment. Hospitals utilize a variety of technology systems to reduce their carbon footprints. Renewable energy sources, energy-efficient buildings, energy-efficient lighting and lighting controls, waste management and water conservation systems, and telemedicine technologies are all examples of such infrastructures (Sullivan et al., 2023).

The aim of this study is to determine the priority factors for minimizing CO₂ emissions in hospitals. In this context, firstly, a literature analysis was carried out. As a result of this analysis, 4 different criteria were determined to minimize CO₂ emissions in hospitals. As a result, a priority analysis was carried out to determine the importance weights of these factors. In the relevant process, the DEMATEL method was used. Thanks to the results of the analysis to be obtained, it is aimed to present the solutions that can be implemented in minimizing CO₂ emissions in hospitals, to policymakers and hospital managers, and to present priority strategies.

2. Literature Review

Environmental sustainability has become a critical issue recently and this issue is gaining more importance in hospitals as well. Hospitals consume substantial amounts of energy, water, and other natural resources as they are institutions that provide services 24 hours a day, 7 days a week (Dogan et al., 2022). Therefore, they cause important levels of carbon emissions (Sun & Dong, 2022). While these emissions increase environmental impact, they also increase healthcare costs. Minimizing carbon emissions and increasing the use of clean energy in hospitals are significant and many solutions are offered for this. The most prominent among these are use of clean energy, effective supervision, personnel awareness, and technological infrastructure.

The use of clean energy in hospitals means increasing the use of renewable energy sources while reducing the use of fossil fuels. This directly reduces carbon emissions. Examples of clean energy sources that can be used in hospitals are solar energy and wind energy (Borges de Oliveira et al., 2021). Solar energy is one of the most widely used clean energy sources in hospitals. The use of solar energy in hospitals reduces electricity bills while also reducing carbon emissions. In hospitals, solar energy is provided by using solar panel systems and these systems meet the energy needs of the hospital by converting solar energy into electricity (Alotaibi et al., 2019). Wind energy is another clean energy source that can be used in hospitals. Wind turbines can be used to meet the energy needs of hospitals. However, it is necessary to create suitable conditions for the use of wind energy in hospitals. Rodriguez-Hernandez et al. (2019) explore the technical and economic possibilities of using renewable energy sources in a hospital complex in Mexico. As a result of the study, they found that the use of clean energy sources such as solar energy and wind energy can reduce the energy consumption of hospitals and increase their environmental sustainability by reducing their carbon footprints.

The health sector is responsible for approximately 5% of global carbon emissions and this rate is expected to increase (Rodríguez-Jiménez et al., 2023). Effective control is a strategy that can be used to reduce carbon emissions in hospitals. These audits help adopt more sustainable practices while assessing energy consumption, waste management, and other environmental impacts (Song & Xia, 2022). In addition, effective audits help hospitals identify and effectively manage the resources needed to achieve their environmental sustainability goals. Vourdoubas (2022) found in his study that effective controls implemented to reduce the environmental impact of a hospital in England helped adopt various strategies such as energy conservation, waste management, and renewable energy use. As a result of the study, it was determined that effective controls are effective in reducing carbon emissions in health facilities. Fennelly et al. (2023) evaluated the environmental sustainability performance of a hospital in Scotland.

They have demonstrated that effective controls are successful in reducing carbon emissions, in areas such as energy saving and sustainable facility management.

Staff awareness is a critical factor in minimizing carbon emissions in hospitals. The level of awareness of hospital employees about the environment has a significant impact on achieving sustainability goals. There are many ways to increase staff awareness. For example, methods such as encouraging environmentally friendly practices, training personnel to use energy-efficient devices, conducting recycling programs, and saving water can increase the level of environmental awareness of personnel (Abu Qdais et al., 2019). Many studies have been conducted on the effect of personnel awareness on minimizing carbon emissions. These studies have shown that increasing the environmental awareness of staff can help implement sustainability strategies and reduce carbon emissions in hospitals (Umo et al., 2023). For example, raising awareness of employees about energy use not only saves energy but also increases the sustainability of hospitals by increasing the awareness of employees about the environment. Khan et al. (2022) discussed the issue of increasing the environmental awareness of the staff working in hospitals and adopting environmentally friendly practices. As a result of the study, employees' attitudes towards environmental awareness and environmentally friendly practices have changed positively. This shows that the level of awareness of the staff is effective in reducing hospital carbon emissions.

Different technological infrastructures are used in hospitals to minimize carbon emissions. These infrastructures include renewable energy sources, energy-efficient buildings, smart heating, ventilation, and air conditioning systems, energy-efficient lighting systems, waste management systems, water-saving systems, and telemedicine technologies (Zhang et al., 2021). Many studies show that technological infrastructure is effective in minimizing carbon emissions in hospitals (McAlister et al., 2022). The effect of technological infrastructure in minimizing carbon emissions in hospitals provides both environmental sustainability and economic benefits. Therefore, hospitals should constantly update and renew their technological infrastructure. Rena et al. (2022) focus on technological innovations to reduce carbon emissions in hospitals. As a result of the study, they offer suggestions for reducing carbon emissions with the use of technologies such as renewable energy sources, energy-efficient lighting systems, self-adjusting systems, smart devices, and data analysis.

As a result of the literature review, it is possible to reach the following conclusions.

Carbon emissions negatively affect both people and the world.

Minimizing carbon emissions in hospitals has become very popular in the literature in recent years.

In a significant part of the studies, factors that will minimize carbon emissions in hospitals such as the use of clean energy, effective control, personnel awareness level, and technological infrastructure have been emphasized.

However, it is very unlikely that hospitals can improve each of these factors at the same time.

Therefore, a new study is needed to determine the variables that are more important for minimizing carbon emissions in hospitals.

In this context, the aim of our study is to develop a strategy to reduce carbon emissions in hospitals. For this purpose, a weighting study will be carried out on the criteria determined.

3. Methods and Results

Hospitals are generally dependent on energy sources such as electricity, heating and cooling to meet their energy needs. These energy sources often rely on fossil fuels. Accordingly, fossil fuel use is one of the main sources of carbon emissions. Clean energy sources are energy sources that produce less or no carbon emissions compared to fossil fuels. Sources such as solar, wind, hydroelectric, biomass and nuclear energy are clean energy sources. The use of clean energy can help reduce the carbon footprint of hospitals and plays an important role in minimizing their environmental impact.

DEMATEL analysis was used in the study. DEMATEL is one of the multi-criteria decision-making techniques that reveal the causal relationships in the criteria set with the help of matrices. The DEMATEL method defines the relationships between criteria with matrices and reveals the strength between the relationships. The criteria used in the study were obtained as a result of the literature review. The criteria obtained are given in Table 1.

Table 1. Criteria Set

Criteria	Literature
Use of Clean Energy (K1)	Alotaibi et al. (2019), Borges de Oliveira et al. (2021)
Active Control (K2)	Song and Xia (2022), Yue et al. (2022)
Personnel Consciousness Level (K3)	Abu Qdais et al. (2019), Umo et al. (2023)
Technological Infrastructure (K4)	McAlister et al. (2022), Zhang et al. (2021)

The steps of DEMATEL analysis were applied to the determined criteria. Accordingly, the direct relationship matrix is given in Table 2.

Table 2. Direct Relationship Matrix

	K1	K2	K3	K4
K1	0	2,33	2	2
K2	3,33	0	2	1,667
K3	3,33	2	0	1,333
K4	3,67	2	1,667	0

With the implementation of the necessary steps, the criteria were weighted. Accordingly, the weighting of the criteria is given in Table 3.

Table 3. Weights

Criteria	Weights
K1	0,336
K2	0,284
K3	0,265
K4	0,113

Accordingly, the most important criterion for reducing carbon emissions in hospitals was found to be the use of clean energy. The most effective criterion after the use of clean energy was determined as the establishment of an effective control mechanism.

4. Discussion and Conclusion

Hospitals are one of the buildings that consume the most energy. In addition, it is important to ensure the sustainability of hospitals since they provide 24/7 service and health is a human right. Therefore, it is necessary to maintain health services without sacrificing service quality. However, carbon emissions are also produced in excess due to continuous service. Accordingly, both the sustainability of services should be ensured, and carbon emissions should be minimized. Sun and Dong (2022) argue that clean energy should be used to reduce carbon emissions. Ali et al. (2022), state that the use of clean energy has a significant impact on carbon emissions.

As a result of our work to minimize carbon emissions in hospitals, it has been found that the most important criterion is the use of clean energy. Providing the necessary infrastructure and support for hospitals to switch to clean energy will help reduce carbon emissions. In addition, the use of renewable energy will contribute to the reduction of carbon emissions. With the use of renewable energy, both carbon emissions will be reduced, and the energy costs of the hospital will decrease.

Apart from this, another important criterion affecting the reduction of carbon emissions in hospitals is effective inspection. Carbon emissions can be reduced by inspections of hospitals by higher institutions. In addition, activities such as filters and cleaning in the relevant devices should be inspected within the framework of the determined standards. This will contribute to the reduction of carbon emissions.

For future studies, studies can be carried out on which renewable energy type can be used in hospitals. In addition, studies can be conducted on how the control mechanism should be established and what its scope should include.

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