ACHIEVING THERMAL COMFORT IN THE INTERIOR SPACES THROUGH ARTIFICIAL INTELLIGENCE TECHNIQUES

تحقيق الراحة الحرارية بالحيزات الداخلية من خلال تقنيات الذكاء الاصطناعي

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ABSTRACT

Construction operations account for a large proportion of the total primary energy consumption due to the proliferation of HVAC installations to improve the thermal comfort of indoor spaces where people spend significant time in them , One of the research objectives is to look at the challenges of using artificial intelligence to improve energy productivity and thermal comfort and to review artificial intelligence techniques used in building predictive control systems for healthy institutional spaces, The research problem lies in not paying enough attention to the design and energy management of healthy institutional buildings and not integrating energy management in the design, construction and use stages, and health institutions are best to advocate initiatives to achieve thermal comfort and energy efficiency simultaneously based on artificial intelligence technology in predictive control that enables energy in The average is between 21.81 and 44.36%, and the comfort improvement is on average between 21.67 and 85.77%.

KEYWORDS

predictive control (MPC); artificial intelligence (AI); Institutional spaces

الملخص

تمثل عمليات البناء نسبة كبيرة من إجمالي الطاقة الأولية المستهلكة بسبب انتشار منشآت التدفئة والتهوية وتكييف الهواء (*HVAC*) لتحسين الراحة الحرارية بالحيزات الداخلية نظراً لأن الناس يقضون بها جزءًا كبيرًا من وقتهم ويعد هذا تضاربا مع تقليل استهلاك الطاقة، يبين ذلك تعقيدات توفير الراحة الحرارية وتحسين جودة الهواء الداخلي للمستخدمين خاصة بالحيزات المؤسسية الصحية ، من أهم أهداف البحث هي النظر في التحديات التي تواجه استخدام الذكاء الاصطناعي لتحسين إنتاجية الطاقة والراحة ومراجعة للتقنيات القائمة على الذكاء الاصطناعي المستخدمة في بناء أنظمة التحكم التنبؤي بالحيزات المؤسسية الصحية. تكمن مشكلة البحث عدم إيلاء اهتمام كاف لتصميم وإدارة الطاقة للمباني المؤسسية الصحية وعدم دمج قضية إدارة الطاقة في مراحل التصميم والبناء والاستخدام،وتعتبر المؤسسات الصحية هي الأفضل لمناصرة مبادرات تحقيق الراحة الحرارية وكفاءة الطاقة في وقت واحد بناءً على تقنية الذكاء الاصطناعي في التحكم التنبؤي التي تتيح الطاقة في المتوسط بين ٢١,٨١ و ٤٤,٣٦٪ ، وتحسين الراحة في المتوسط بين ٢١,٦٧ و ٨٥,٧٧٪.

الكلمات المفتاحية

التحكم التنبؤي (MPC)؛ الذكاء الاصطناعي (AI)؛ الحيزات المؤسسية.

INTRODUCTION

Construction operations represent a large proportion of the total primary energy consumed due to the proliferation of heating, ventilation and air conditioning (HVAC) installations to improve thermal comfort within indoor environments. For energy, institutional spaces and workplaces are mostly among the major consumers of energy in any country and are mostly used indoors, this paper presents a deductive analytical methodology to develop an artificial intelligence prediction and control model for healthy institutional buildings to achieve indoor thermal comfort and energy management.

Research problem: The research problem is the lack of interest in the design and energy management of health facilities. As a result, most institutional buildings in the region do not integrate the issue of energy in the design, construction and use stages, and it is better for health institutions to take initiatives to achieve thermal comfort and energy efficiency based on predictive control using artificial intelligence strategies. Through effective new devices and interior design techniques and improvement of building systems through comprehensive criticism of the building envelope.

Not paying attention to ventilation rates in the internal environment of health facilities. It is recognized that the ventilation design is a vital element in the interior design that affects the productivity and health of passengers, especially that patients undergoing some treatments may weaken their immunity, making them more susceptible to infection. (Fonseca et al., 2019).

Research paper goals: If the hospital environment is uncomfortable and polluted, it will cause the spread of diseases, prolonging the impact of this polluted environment on not only patients, but also healthcare professionals including doctors, nurses and other paramedical personnel (Capolongo et al., 2008).

The main objective of the study is to provide a better way to improve indoor environmental quality and thermal comfort with the help of AI methods where thermal comfort level and IEQ are measured for each hospital and identify the low performing hospitals along with suggestions for improving their IEQ and thermal comfort conditions. (Abbaszadeh et al., 2006; Angelova, 2016; Asadi et al., 2017) where many factors affect indoor environment quality such as comfortable indoor temperature, air quality, acoustic quality, smell quality and visual comfort). Indoor environmental quality is a relative measure of the comfort perception of people exposed to indoor conditions) (Piasecki et al., 2017).

Research Methodology: This study was conducted by following an organized and formal research methodology where the research consists of the following steps 1. This step deals with the basic definition of the problem statement and the research objectives. The literature is thoroughly reviewed to identify the research gap. How this research can be beneficial for the convenience of the average man visiting a public healthcare facility for treatment is explored. The need for this research according to national and international circumstances is also taken into account. A study of the foundations of the interior design of health facilities and health facilities design strategies to increase the efficiency and effectiveness of the internal environment and the basic standards of thermal comfort and ventilation, methods of developing health facilities with modern technologies and improving internal comfort.

2. Studying indoor environmental quality standards and the basis for achieving indoor air quality in health facilities 3. Studying applications of artificial intelligence in health facilities (Hospital 57357).

Research results: based on predictive control strategies using artificial intelligence, the developed system can provide real-time planning, help the interaction between the operator and the HVAC process, apply artificial intelligence techniques and personal comfort models, save energy on average between 21.81 and 44.36%, The comfort level improved with an average of between 21.67 and 85.77% in the health compartments for energy management in the sanitary compartments.

1. THE INTERIOR DESIGN OF HEALTH FACILITIES

Strategies for designing health facilities to increase the efficiency and effectiveness of the indoor environment:

Hospital room design has a significant impact on patient care and recovery outcomes. Patients rely on staff to respond to emergencies quickly, check in frequently, and ensure a full recovery. However, staff can treat patients effectively only when they can perform their tasks efficiently and have accessible equipment and supplies (korteco2021). By partnering with an architectural firm to design hospital rooms around the workflow of staff and make these spaces as comfortable as possible for patients and their visitors, hospital administrators can ensure the highest level of care.

1.1 Hospital room design challenges that designers must deal with:

One of the biggest challenges architects face when designing health facilities is the need to accommodate three very different functions in the space First, the room must be comfortable and quiet for patients second, the caregivers must be able to move around the space quickly and efficiently and finally, the family must have Other visitors are an area where they can sit or sleep comfortably without disturbing staff work or patient recovery in a small hospital room. This is a serious challenge, if the space is small.

To create the most efficient hospital room and health facility interior design strategy, designers conduct a thorough research of the facility's needs according to its function and patients' needs in advance. Environmental needs, research scientific studies, analyze data provided by the hospital, follow evidence-based design principles, and consider design strategies that can help staff perform their daily tasks more easily, while at the same time allowing better patient and family experiences in the hospital These strategies include:

- Improving line-of-sight into hospital rooms is a best practice that designers prioritize to streamline staff workflows and provide excellent patient care.
- Room layout and furniture placement in patient rooms is required for patient and visitor comfort, but may also disrupt staff workflow. To cause minimal disruption, room layout or appropriate size should be maximized. To create a more efficient hospital room design.
- Lighting, Ventilation and Acoustics: Patients and staff need a lot of light and healthy ventilation. Staff and staff are often loud, which can cause patients' distraction. To solve these challenges, the architects focus on the following features:

1. Diverse lighting: The highest levels of illumination are at the entrance to the patient's room, where caregivers perform their duties, as well as in nursing centers, dimming and night-lighting features on the orange and red spectrum can reduce the risk of a patient becoming disturbed while they are trying to sleep.
2. Quiet HVAC system: Super soundproof HVAC system or white noise sound masking system can reduce noise levels in rooms located near heavy traffic work areas.
3. Ventilation for comfort: Good ventilation improves patient and staff comfort, as well as patient health outcomes.

1.2 Methods of developing health facilities through modern technology and improving interior comfort

Digital Kiosks: When HMC Architects designed the Kaiser Permanente La Habra medical office building in La Habra, California, we included touch screens that allow patients to easily check in when they arrive at the facility. Patients are provided with waiting time information and digital forms that must be filled out in advance of the appointment. Not only do these booths eliminate the need for a receptionist, but they also benefit patients who may be anxious or have hearing difficulties.

Virtual Reality: You can also use technology throughout the design process itself. Virtual reality (VR) has dramatically improved how we collaborate with customers. Virtual reality enables the creation of a 3D digital model of any healthcare facility. This technology helps us and our customers make informed decisions about building design. For example, you can see if handrails are in appropriate locations as you "walk" through a 3D model of each floor in your facility.

Create Adaptable Spaces: Healthcare facility designers understand the benefits of flexible, multi-purpose spaces. From placing wheeled partitions in emergency departments to creating spaces in medical office buildings, architects are helping health care managers treat more patients and increase the size of square footage. To design adaptable spaces.

Use materials that protect against the spread of infection: Hospital designers focus not only on creating beautiful spaces, but also on using materials in those areas that protect against the spread of infection, according to the Centers for Disease Control and Prevention (CDC). To help prevent transmission, healthcare designers often use antimicrobial coatings on hard surfaces and lighting that fight the spread of disease such as:

1. Copper coating is naturally antimicrobial
2. Photochromic pigments: Glass, ceramic and steel surfaces coated with photoactive pigments kill microbes when exposed to artificial or natural ultraviolet light. These coatings are often found on commercial and residential bathroom tiles to help them stay clean for longer.

Executing Biophilic Interior Design: To implement a biophilic design in your hospital, start by inviting more natural light into the space. Floor-to-ceiling windows, glass curtain walls and skylights reduce the need for artificial lighting and help improve the mood of patients and staff. In addition, a recent study published in the Journal of Research Microbiome found that exposure to daylight can act as a natural disinfectant, particularly helping to kill bacteria normally present in dust.

AI: In an inpatient environment, technology can provide patients with an increased sense of control. Hospitals adopt in-room food service, AI devices are also used to control in-room entertainment, window shades, and thermostats. By offering these types of options, hospitals can provide a better patient experience without having to significantly impact the space.

Building smarter healthcare through better healthcare interior design: One of the important roles of technology is to enhance communication between patients and caregivers. This can be achieved through telemedicine - tele-consultations with caregivers - patient tracking systems, patient portals and, in the not-too-distant future, medical-grade wearables. Telehealth systems can also improve communications between caregivers themselves, another important goal is transparency and information sharing, to ease patients' anxiety by letting them know where they are in the process. As AI becomes more sophisticated in understanding our daily patterns, it can be used to remind people of their upcoming medical appointments, real-time location systems also allow waiting rooms to be reduced in size and transform that space into changing and flexible environments that take activity-based waiting to a whole new level, saving Freedom and choice for patients and staff. Thanks to technology, hospital waiting doesn't have to be at all - waiting

can happen anywhere, patients can get the same level of service they expect especially in the pandemic period, not all technological advancements may affect interior design directly, but they will on processes, and as processes change, they will provide new opportunities for design.

1.3 How will artificial intelligence affect the design of health facilities

AI appears to hold great promise for improvements in every aspect of healthcare: clinical quality, productivity, efficiency, cost control, management, research, community health, and interior design, as AI research and development accelerates, and its use becomes widespread. In health management as well as disease prevention, diagnosis and treatment, it is important to recognize that its success cannot be found in an isolated process or application. Thus, connections and networks now characterize every aspect of health facilities, providing opportunities to collect and analyze data in ways and at a scale previously unimagined.

AI will enable the design and modeling of system performance in many new ways. Architects who master this understanding will have the opportunity to positively influence the costs of developing or redeploying health facilities. AI (utilities, service providers, practitioners, and networks) may herald better air quality. thermal comfort, etc.) because it's all about the platform - and the power of AI - lies in connectivity.

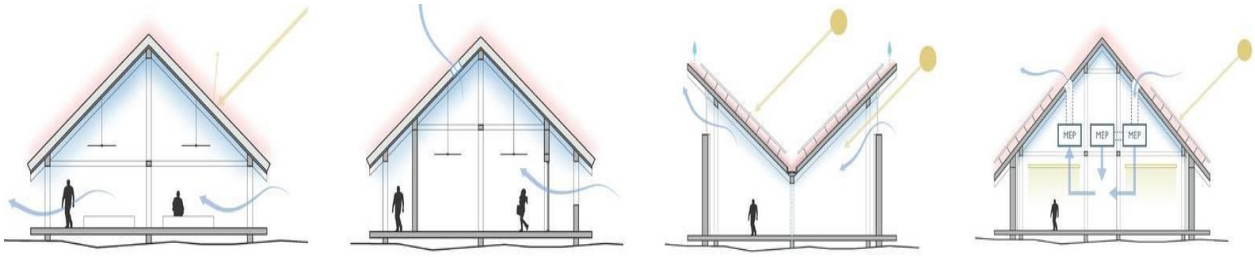

Figure 1 Gable or butterfly roof structures, depending on whether the job requires maximum natural light and cross ventilation or a more controlled environment

1.4 Models of smart health facilities:

Adjaye Associates

The design of the district hospitals was commissioned by Adjaye Associates, which is part of the Agenda 111 initiative by the Government of Ghana. The main vision for Ghana's healthcare sector will consist of 111 hospitals including 101 district hospitals, 2 psychiatric hospitals, 7 regional hospitals and the redevelopment of the Accra Psychiatric Hospital.

Approaching the hospital as more than just a place to provide medical services, the design scheme aims to unlock the potential of this ambitious initiative by repositioning the hospital as a piece of community infrastructure that embodies sustainability and efficiency and generously provides green spaces to facilitate wellness and healing. - David Adjaye

Defining a next-generation healthcare experience and recognizing that the design would need to adapt to more than 101 locations in different urban and rural environments, each hospital facility was planned as a one-story campus, supported by other buildings. The program primarily includes patient reception and treatment, administration, pharmacy, laboratory/diagnostics, outpatient clinics, physical therapy, public health, A&E, surgery ward, pediatric ward, maternity ward, isolation ward, and surgery. The buildings are

distinguished by their roof structures: gable or butterfly, depending on whether the function requires maximum natural light and cross ventilation or a more controlled environment (as figure 1) such as surgery spaces. However, despite the differences in roof structures, both types collect rainwater and provide an insulating envelope to reduce heat gain.

Unleashing the ancient wisdom of the Adinkra symbols, our design sought inspiration from the Denkyem, which symbolizes the crocodile - a creature capable of thriving with both air and water that is celebrated for its adaptability and intelligence. - Adjaye Associates.

Through smart strategies, environmentally responsive systems and the use of off-the-shelf systems that maintain the lowest possible carbon footprint, the project can be easily, quickly and efficiently reproduced.

Figure 2 Health facility interior: design Adjaye Associates

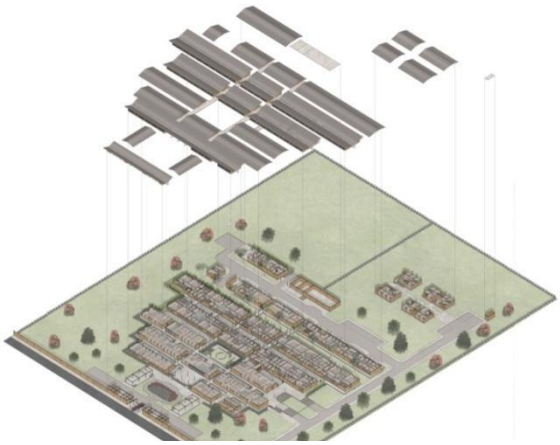

Figure 3 Horizontal projection of the health facility: Adjaye Associates

On the other hand, in terms of form, “the building
becomes an instrument for defining the way with a definite shaded entrance.” In fact, the building branches off from a central spine activated by a central garden and a series of public spaces filled with nature, which “permeate the plan and provide an inclusive atmosphere of healing essential to the sick.”(figure 2.3).

1.5 Nemours Children's Hospital | Stanley Beeman & Sears

Nemours Children's Hospital, located in the mixed-use Lake Nona Medical City in Orlando, Florida, has set a new design standard. Led by architect Stanley Beeman & Sears, the hospital and new grounds are testament to the term “healing environment” – evoking a life-affirming quality that ensures parental reassurance and children’s happiness. The project's architectural solution arose out of collaboration with several Nemours stakeholders, including practitioners, administrators, and a family advisory committee of parents and children , the hospital's family-centric philosophy of care has led to strategies intended to support families from all walks of life: patient rooms with overnight accommodations for parents, laundry facilities, and a concierge desk in the elevator lobby on each floor to help parents navigate sometimes intimidation. health care system. The spacious lounges and playrooms overlook and provide access to spacious outdoor spaces designed for comfort and recreation. These include landscaped rooftop terraces, interactive water features, a "discovery garden" and an outdoor community event stage for live performances.

In Orlando's subtropical environment, intense sun and humidity were a major design concern. Extensive solar studies resulted in shaded outdoor spaces and also helped define the design of sunscreens - blocking direct sunlight while allowing abundant natural light into the interior spaces. In response to the rising water levels in the area, the architects designed a curving ramp to raise the entry drive to one level, allowing a

daylight vault to accommodate the facility's delivery and service functions. This gesture also acts as a major natural feature that continues through and out of the building, moving along with the exterior garden rooms, ending at another landscaped destination. Both function and feature, the honey-colored stone wall is also a defining device, giving a hierarchy of the site and leading to and from the main entrances. Most notable, from a functional point of view, is the alignment of outpatient and inpatient care. Outpatient clinics and inpatient rooms for a specific medical specialty are located in adjacent wards of the same floor, allowing a consistent care team to get to know children and their families during clinic visits and inpatient stays. Nemours Children's Hospital is a "smart" building in many ways: the "command center" monitors a range of clinical and facility-related metrics, technology integration is functional and fun, and the sustainability goal is to reap much more rewards than just energy savings. Nemours Children's Hospital is one of the Only three children's hospitals in the country have achieved LEED Gold certification with Stanley Beeman & Sears, who designed two of the three , the design team was fortunate to have a client, at Nemours, who took a keen interest in sustainability and understanding the tangible return from this investment in future energy savings as well as environmental quality. Because the green 60-acre site initially had very little vegetation, Nemours prioritized landscaping, and encouraged planting early in the construction process, so that it would mature.

2. INDOOR AIR QUALITY

Indoor air quality is a very important issue in interior design as continuous advances in interior design, medicine and technology require a continuous reassessment of the air conditioning needs of indoor spaces, especially hospitals and medical facilities. The application of air conditioning in health facilities poses many problems not encountered in the design of usual comfortable air conditioning Where hospital air conditioning plays a more important role than simply enhancing the thermal comfort of individuals, studies show that patients in a controlled environment generally experience faster physical improvement of those in an unsupervised environment.

Increasing attention is being paid to indoor air quality as one of the key factors for health and well-being. Indoor research is mostly concerned with indoor air chemicals within indoor architecture related to building design. Good indoor air quality can be effectively achieved by avoiding or minimizing sources of indoor air pollution and by choosing low-pollution building materials, both of which are low-cost and energy-saving solutions. And arrange them, as well as predict the tendencies of occurrence and set priorities for the future. There has been very limited interest in rigorous analysis of the buildings' actual environmental impacts to date. Healthy/green/sustainable building practices are typically implemented in non-systematic and often inconsistent ways without resolving the inherent conflicts between these practices. Designers, product manufacturers, constructors, and owners declare that their buildings and the technologies applied are beneficial to the environment without validating these claims, in general, people spend more than 80~90% of indoor living time every day, and human health and indoor environmental quality are closely related. The hospital has complex and unique environmental characteristics, where medical personnel and patients for prolonged periods are exposed to risk factors in a variety of environments. Therefore, the advantages of hospital indoor air quality not only threaten the health of medical personnel and patients, but also directly affect the quality and efficiency of health care work. Regular monitoring can improve and maintain indoor air quality, thus ensuring the safety of medical personnel and patients in the hospital. It has become an important issue for the hospital. Indoor air quality creates serious problems if not properly understood. As we breathe, we consume available oxygen and replace it with carbon dioxide which is a simple asphyxiation. When a poorly ventilated room or building lacks air quality improvement strategies, especially a crowded building and sometimes not having enough Adequate fresh air to keep carbon dioxide concentrations at low levels. This sometimes leads to drowsiness or discomfort , the US Environmental

Protection Agency (EPA) recognizes that about 30% of new or renovated buildings have serious indoor air quality problems, and ranks the IAQ as the most significant environmental problem (Roodman, 1995). The report 'Causes of Indoor Air Quality Problems in Schools' (ASHRAE Journal, P16, 1999) states that up to 20% of US schools have indoor air quality problems. The ASHRAE standard 62.2 P, Ventilation and Acceptable Indoor Air Quality in Low Rise Residential Buildings, specifies the roles and minimum requirements for mechanical and physical.

Figure 4 Health facility interior design :Nemours Children's Hospital | Stanley Beeman & Sears

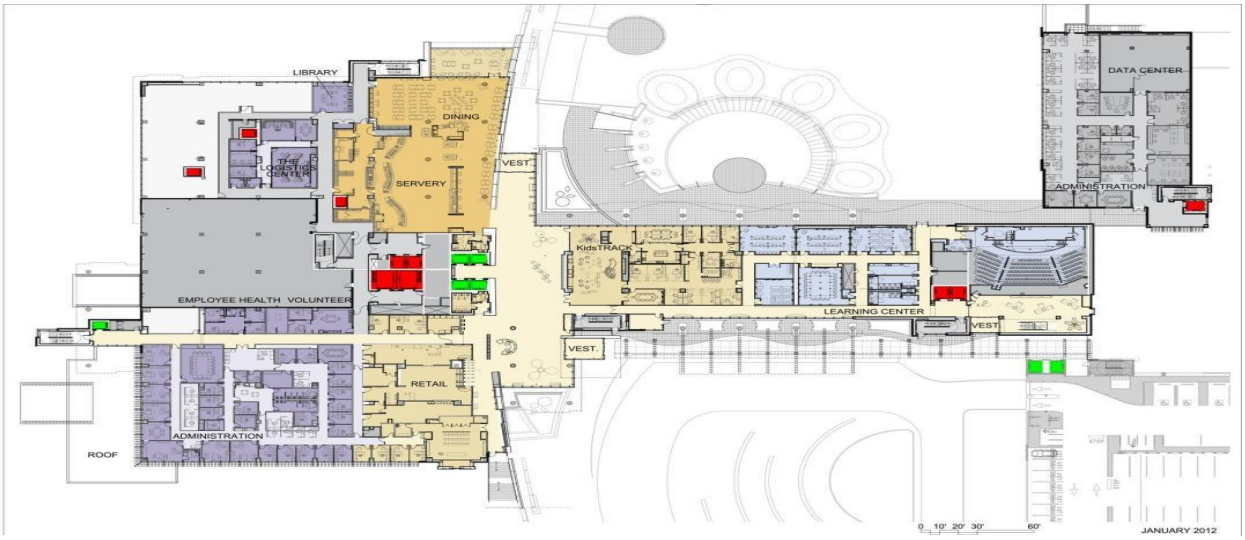

Figure 5 Horizontal projection of the health facility: Nemours Children's Hospital | Stanley Beeman & Sears

IAQ is defined as the process of providing air that is comfortable in every way and does not cause negative health effects or human disease and is as free from dust, odors, drafts and noise as possible, the air is not cleaned by itself only We need special equipment to monitor and control air quality Capital costs are in addition to Operating cost of HVAC plants is critical to maintaining air quality required for different applications. The more stringent the air quality requirements, the higher the capital and operating cost. Indoor air quality is a major factor during design, so healthcare and health facilities have to pay special attention to air concerns. Indoors There is a basic difference between air conditioning for hospitals (and related health facilities) and other types of buildings and that stems from:

- The necessity of restricting air traffic within and between the different departments.
- Specific requirements for ventilation and filtration to mitigate and remove contamination in the form of odor, airborne microorganisms and viruses, and hazardous chemicals and radioactive materials.
- Different temperature and humidity requirements for different regions.
- Evolution of the design required to allow precise control of environmental conditions.

Nordstrom and his team from Sweden investigated IAQ in hospitals regarding indoor space humidity, building type and construction type. by researchers from Greece on indoor air conditions in more than 20 hospital operating rooms in major hospitals in Greece and listed common problems such as insufficient change of indoor air, poor ergonomics in space, poor maintenance etc. (Balaras, 2007). Studies indicate a direct relationship between certain concentrations of air pollutants with indoor health problems, such as: allergies, asthma, bronchitis, pneumonia, lung cancer, etc. [(Deloach, 2004), (Craig, 2003), (Health Canada Modern approaches to managing indoor air problems have been outlined in numerous publications, with some examples including the World Health Organization's air quality guidelines, Health Canada's exposure guidelines for residential air quality in residential buildings, the US National Standards Institute, and the American Society of Health , The indoor environment consists of five main factors: thermal comfort, indoor air quality, acoustic control, odor control, and visual comfort (Abbaszadeh et al., 2006; Angelova, 2016; Asadi et al., 2017). These factors are cumulative in nature and interrelated in their function, temperature, relative humidity, carbon dioxide and number of occupants significantly affecting the indoor air quality of a healthcare facility (Beggs et al., 2015; Wan et al., 2011). Moreover, fungal particles are also a strong pollutant in the

healthcare environment, and their concentration often increases during construction or renovation work (Sarıca et al., 2002; Sautour et al., 2007). Finally, the correlative factor of indoor air quality is evaluated by various other factors such as carbon monoxide (CO), total volatile compounds (TVOCs), aldehydes (-CHO), ozone (O3), particulate matter (PM 1, PM 2.5, PM 10).), radon (Rn), nitrous oxide (N2O) and airborne microbial pollutants (Leung and Chan, 2006, Morawska et al., 1998; Nordström et al., 1999), Here are some of the symptoms of poor IAQ in the building:

- Fresh air is limited.
- Temperature and humidity outside the comfort zone.
- Eye, Nose and Throat Irritation - Dry facial skin.
- Respiratory infections and asthma.
- Fatigue and headache,Increased sensitivity.
- Sick Building Syndrome - SBS.

Possible causes of poor air quality:

- Low ventilation.
- Building materials and furnishings.
- Deferred maintenance to save money.
- Pesticides, office supplies and chemicals in personal care products.
- Indoor air pollutants: National Institute for Occupational Safety and Health, investigation and analysis of indoor air quality, sources of indoor air pollutants include outdoor and indoor human activities, indoor air conditioning systems, building materials, equipment and supplies, indoor sources of organic matter, such as the six, pollutants and sources are shown in Table 1(Hoskins, J. A.2003)

Table 1. Indoor environmental pollution source and pollutant

Pollution Source		Pollutant
Outdoor air	Stationary sources	SO_2, O_3,Dust,CO,Hydrocarbon,Other toxic substances
	Mobile sources	CO,Dust,Nitrogen oxides, Oxysulfide, Lead
	Soil	Radon, Microorganism Bacteria Germ, Fungifungus.
Indoor human activities	Human activities	CO_2, Vapor, Bad smell,Microorganism
	Smoke	Dust,CO,CO_2, Ammonia,Nitrogen oxides, Hydrocarbon, Volatile organic contaminants,Carcinogenic compounds
	Spray	Fluorocarbon, Bad smell,Volatile organic contaminants
Air conditioning system	Air handling unit	Fungi Fungus,Allergen ,Bacteria Germ , Bad smell
	Air conditioner line	Dust,Fiber,Fungi Fungus,Allergen, Bacteria Germ
Building materials	Concrete, stone	Radon
	Inorganic mineral board, Plywood, Carpetrug, Furniture	HCHO,Volatile organic contaminants
	Insulating materials, Insulation or fireproofing materials	HCHO, Glass fiber,Asbestos,Volatile organic contaminants
Equipment and supplies	Burning appliances	CO_2,CO, Nitrogen oxide, Hydrocarbons,Dust
	Service machines (Copier,Clean machine)	O_3, Dust,Bacteria Germ, Fungi Fungus
	Other	Stationery solvent, Fungicide,Pesticides,Volatile organic contaminant
Indoor organic material	Perishable foods	Fungi Fungus, Bad smell
	Plants and flowers	Pollen, Fungi Fungus
	Waste	Ammonia,Allergen, Bacteria Germ

2.1 The foundations of achieving indoor air quality in health facilities

1. Avoid indoor air quality problems by design
2. Allow moisture in the building envelope to escape.
3. Provide balanced mechanical ventilation.
4. Avoid contamination from attached garages.
5. Designing air- and weather-tight building envelopes.
6. Ventilation to avoid leakage and water vapor problems.
7. Condensation inside the building, which is one of the main reasons for the growth of mold.
8. Passive filtration and air cleaning: Filtration and air purification are effective means of controlling many indoor air pollutants, especially those associated with poor outdoor air quality. Air filtration

or air cleaning can provide an important adjunct, and in some cases a partial alternative to outdoor ventilation. The guide provides a detailed treatment of filtration and air purification alternatives which, when properly managed and maintained, can improve IAQ performance and energy.

9. Windows and doors: Proper design and detailing of doors and windows will eliminate water and mold ingress because door and window assemblies with end gaskets are rarely placed under waterproofing and should slope down and wrap on the outside of the wall The insulation level of the glass and door should also align with the wall insulation to avoid bridging Thermal and condensation.
10. Heating and cooling: According to the American Society of Heating, Refrigerating, and Air Conditioning Engineers (ASHRAE), increasing ventilation and air circulation is the best and most cost-effective way to freshen air inside most buildings. Blowers and fans that transport air, ducts that deliver it to the rooms of the building, and vents that distribute it achieve ventilation in the modern office building. A good ventilation design will distribute the supply air uniformly, except for areas with heat and steam producing office machines that require additional airflow. Placing the intake and exhaust vents far enough apart allows fresh air to circulate more freely. ASHRAE has developed general guidelines of 20 cubic feet of outdoor air per minute per person for an office environment to adequately dilute building pollutants and maintain a healthy environment. Scatter it in the air. Vacuums with true HEPA filters reduce the number of airborne particles so patients, visitors and staff can breathe easier.
11. biological filtration technology: It is one of the easiest ways to remove pathogens. Mitigation through ventilation strategies can improve IAQ, reduce energy, and control particulate matter by removal through ventilation, a method widely used in HVAC systems to improve air quality by using high-efficiency particulate air (HEPA) filters in specific areas or Through filters treated with antimicrobial agents, Future experiments need to focus on passive indoor air purification to create a more vibrant indoor environment. This includes the possibility of integrating both traditional and emerging trends into sustainable, zero-emission green spaces and the development of several systems with green walls and microalgae. It has long been known that existing technologies On plants filter the air and convert carbon dioxide into biomass and oxygen. These systems can use algae, which is currently being extensively investigated. This offers new possibilities for incorporating carbon capture technology into a highly polluted environment resulting in a significant improvement in air quality.
12. IAQ sensors: Installs IAQ sensors to highlight contaminants that may be present, and bring that data to your centralized analytics platform to provide actionable insights or facilitate demand-based controls.
13. Building insulation (envelope) : Envelope insulation, non-toxic materials from sustainable sources are among the practices to consider while working on any project. An ergonomic mindset should ideally be adopted from pre-design through to post-handover maintenance. There are many smart design solutions to provide healthy indoor air quality (Mawara Khan and others,2021).
14. natural ventilation: Adequate natural ventilation is one of the first considerations when designing a home. The orientation of the building and the well-thought-out layout of the openings promote efficient air flow through the space (cross ventilation, cooling towers). Implementation of a functional hybrid ventilation system indoors will contribute to the mitigation of some pollutants .

15. Materials and finishes : One of the most effective ways to mitigate the spread of indoor air pollutants is to choose the best materials. It is possible to reduce and eliminate sources of pollution. This can be done using modern, non-toxic materials that were purposely created for safe indoor constructions and their use. Looking for green-labeled or health-approved items is a good solution to reduce indoor air pollution. Designing buildings and homes using elements manufactured with new technology can contribute to obtaining coveted certifications such as BREEAM, LEED and WELL (grading systems). Materials such as Activ'Air® ceiling and gypsum board even capture pollutants and dilute up to 70% of the VOCs inside. It provides a passive and therefore long lasting technology that will not release captured gases regardless of temperature. They do not require maintenance and regulation, and therefore will be more effective in reducing formaldehyde than additional ventilation.
16. Suggestions of biophilia (natural human connection and desire to belong to nature) with indoor air quality: Active green walls (those grown in activated carbon) provide the highest cost of value. These walls are largely self-sustaining, actively pushing air through their root system, can metabolize 200 times more pollution (such as formaldehyde, benzene and other VOCs) than passive plants, and can be maintained at a reasonable price, Advanced living plant walls can also reduce particulates, adjusting carbon dioxide levels in areas where fresh air is not possible. This is common even in buildings with excellent circulation.

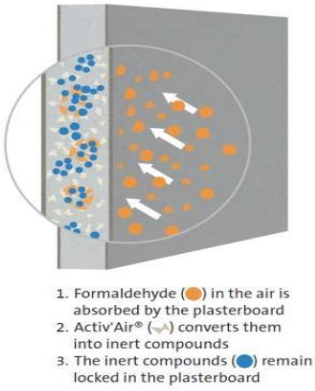

Figure 6 Activ'Air diagram

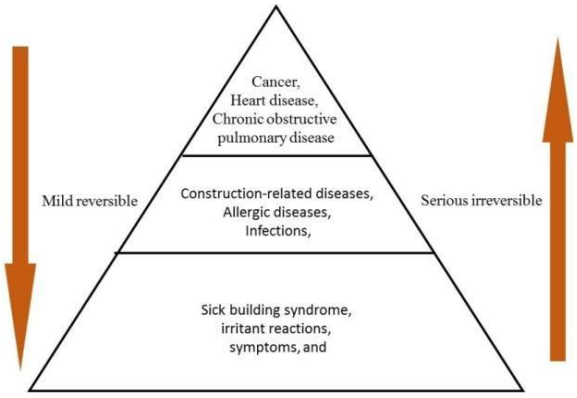

Figure 7 Indoor air quality and health hazards.

3. ARTIFICIAL INTELLIGENCE (AI)

3.1 WHAT IS artificial intelligence (AI)

Artificial intelligence is the simulation of human intelligence processes using machines, especially computer systems. Including learning, inference, and self-correction as well.

It is as opposed to the natural intelligence displayed by animals including humans. Some of the AI applications include the following: expert systems, speech recognition and machine vision, in addition to advanced web search engines (Google), recommendation systems (used by YouTube, Amazon and Netflix),human speech assist (like Siri or Alexa), self-driving cars like tesla, in addition to automated decision-making and competing in strategic games. As machines become increasingly capable, tasks considered to require "intelligence" are often removed from the definition of AI, a phenomenon known as the AI effect. For instance, optical character recognition has become a routine technology, and it is frequently excluded from things considered to be AI (Ghahramani Ali,others 2021).

It is important to know that AI is bridging the gap between the client and the designer. The Design process involves collecting data from the client whatever their choice is and after that connecting them to interior designers like-minded applications for better guidance.And there are many examples for AI applications , the upcoming situation is forcing industries to be pushed to find the best AI-powered applications and solutions in business. Although architecture and in particular interior design is widely considered to include more creative design process than technical solution, it has more potential for growth in parallel with technological integration.

AI Elements can be seen in the visualization of virtual and augmented reality (VR & AR) programs for both designers and professionals. If it is a complex VR simulation that helps in serving a virtual scene of a required space or a collaborative design program completed with virtual design assistants and build elements. We can't deny the role of the undercurrent of artificial intelligence acting as design aid is.

As soon as clients and designers begin to experience how the AI-powered solutions usage accelerates their projects without avoiding quality or affecting the wealth of human knowledge or experience, we should start to touch an affecting progress towards integrating these types of software applications and platforms into our daily life use. Similarly, AI technologists will continue to push the envelope in 2019, developing new design platforms and tools that help to bridge the understanding between man and machine (British Board,2021).

3.2 AI-Powered Home and Interior Designing Tools

In the past few years, the interior designing task has witnessed a significant popularity. With the upcoming technologies like artificial intelligence (AI), virtual reality (VR), and augmented reality (AR), the field is just getting wider and better. The developments are so clear that we have a great number of mobile applications, web applications and many other tools doing the same job of an interior designer. Some of AI powered interior design tools:

- LexSet.ai: An AI based solution for selling furniture in a new way. The application identifies different furniture options depending on a previous. The requirements in the scanned space and comes up with recommendations for items (for example, furniture) that the user would like to have in that space.
- Planner 5D: it is an application that is available for Web, iOS, Android, Mac IOS and Windows. It is regarding home design solution that is AI-powered, VR and AR. It makes it easier for anyone to simply create floor drawings design and interior plans as a whole. The Majority of this tool has reached such a level that it has 40 million users and these users have designed more than 80 million projects without any special design or software skills.

Another function of the application is that it converts a 2D Drawing into a 3D virtual model. The floor plans of a smart neural network are created instantly.AI will do its job as an interior designer, all that is needed is to upload a floor plan of the required space.

3.3 AI impact on health care facilities design

Because the impact of AI profoundly impacts healthcare and health care systems, architects in particular, as well as planners and designers are more likely to find opportunities for solutions in each of the following as well.

a) The field of health care. In a larger scale view that doesn't only care about the use of buildings, Greater impact on the advancement of the field of health care will be in consideration:

- AI may characterize the concept of efficient healthcare because it is all about the platform and connectivity is the main force of AI in this field of design.Seeking to increase efficiency, many healthcare integrations have been undertaken by operators and that's one of the main goals of AI. The most important partners of healthcare systems are architects who can think clearly in terms of system and platform.
- Access to the healthcare system is no longer determined by the design of the external interface and the entrance. Designing external doors of entry will be the new challenge - they will need to be digital, patient-friendly, and promote rapid, on-demand healthcare services. The first priority will be using artificial intelligence in coordinating telemedicine and other virtual and physical capabilities, and the healthcare field will appreciate the integration of the assets of physical and digital health systems through architecture from architects who are actively working to fulfill that aim.

b) The health of the population. The shift in health care systems away from traditional diagnostics and treatment-based medicine to focus on managing personal and population health:

- The field of planning and design must give great attention to the "Design for Health" as a challenge and begin to focus more on health, social, economic and genetic determinants, not just environments of clinical intervention and caregiving. Architects Familiar with Artificial Intelligence already skilled integrators of disparate building information data sets, by using societal and global data collection sources, and that will be able to create integration in all major determinants of health through designs, and in turn, positively impact community health.

c) Thoughtful integration. architects use effective, integrated, thoughtful team leaders to guide teams of different fields in order to solve problems where the ability to see the big picture and integrate a variety of disciplines is the most valuable skill set , such as clinical care, technology, operations, costing life-cycle and community planning, into a single offering or one solution:

- Architects who redefine processes using AI help in a health system will have an expanded opportunity to influence initial, operational, and lifecycle costs. increasingly important extensions of traditional design services as health systems will be a great extension of the useful life of assets, reallocation and/or disposal of assets, which will become seeking to integrate new technologies with existing capabilities.
- A creative incorporation of disparate inputs to get a composite solution can be achieved by architects by the help of Artificial intelligence integration. Architects also will be able to join innovation teams, not just as building designers in the future of AI. So apparently AI is enabling health system innovation on a very wide scale.

d) Traditional roles. As design professionals, architects use traditional, augmented roles but with the expectation that they will be strongly motivated by research and aware of the growing impact of AI in healthcare and how it is reshaping the design and design process:

- AI is introducing an exciting new phase in healthcare technologies, with innovative technologies, for example surgeons are allowed to superimpose AI-made diagnostic images on patients in real time. Members of the design community who have become familiar with these systems and are ready to provide innovative healthcare design solutions will have meaningful opportunities that embrace new technologies.

- AI will drive exciting design opportunities. AI has become an essential partner in providing care enhancing the accuracy of diagnosis, prescribing care for patients with rare diseases or conditions, preventing medical errors, and giving practitioners the ability to stay side by side of the mountains of new research and medical knowledge that are being produced daily. The central importance of information technology must be recognized by Designers in parallel to artificial intelligence in every aspect of health practice, designers also have to become experts in providing access to them.

3.4 Impacts on design

Other facilities are attached to the large, traditional hospital building in providing care. Smaller facilities initially can be seen as places likely to undergo many transformations as components of the health system field will emerge with settings of choices in a flexible way. AI will lead the definition and development of healthcare design.

Design professionals will have access to additional opportunities, this will be based on their skills in integration and innovation. Great demand will be inCreativity in strategic and logistical thinking. As architects and designers consider the nearly endless possibilities offered by AI, A combination of unconventional approaches along with unconventional resources is what the design will require to achieve success.

The best way for how to position health design professionals would be to ask the AI to assess the situation and tell the field professionals the best metrics to use, and that becomes in the first place to get the most benefit.

3.5 AI for Thermal Comfort efficacy: requirements, applications, and future directions.

Thermal comfort is affected by many factors, and it is determined mainly by heat gain and loss, some of these factors are climatic like air temperature, average radiation temperature, air velocity and humidity, materialistic factors like clothing insulation and biological factors like metabolic rate and also psychological factors like individual expectations (CEN, 2005) .

A large proportion of the total primary energy in most countries is consumed in building operations due to the massive increase of heating, ventilation and air conditioning (HVAC) installations to improve thermal comfort. Maintaining comfortable conditions in buildings in parallel with reducing the associated energy consumption are contradicting goals and represent a typical optimization problem that requires intelligent system design. Over the past decade.

It was important to find the ideal point between energy use in HVAC systems and appropriate interior comfort levels for occupants;various methodologies based on Artificial Intelligence (AI) technologies have been deployed to get this point (velux2020).

This paper tries to make a comprehensive and in-depth systematic review of AI-based technologies used in building control systems by evaluating the outputs of these technologies, their implementation in the reviewed works, as well as verifying their capabilities to improve energy efficiency, while maintaining thermal comfort conditions, This allows a comprehensive view of :

- The complications of providing thermal comfort to users in interior spaces in an energy-efficient way.
- For facing this challenge, we have to highlight the accompanying bibliographic materials to assist researchers and experts in the interior design field.

Functions such as identification patterns, optimization, and predictive control are from the 20 AI tools developed for both power consumption and comfort control. The application of AI technology in building control is a promising and still ongoing research area,based on the results of this work, the performance of AI-based control is not yet fully satisfactory(hse.gov 2021).

This is partly due to the fact that these algorithms typically need a large amount of high-quality real-world data, which is lacking in the building or, more in more precise way, in the energy sector.
In order to save energy through the period from 1993 to 2020, artificial intelligence techniques and personalized comfort models are used widely that affect savings on average between 21.81 and 44.36%, and comfort improvements on average between 21.67 and 85.77%.
This paper opens up key future directions regarding AI-based building control systems for human comfort and energy efficiency management, and mainly discusses the challenges of using AI to improve energy productivity and comfort.

4. PROPOSED RETROFITTING TECHNIQUES FOR IEQ OF HOSPITALS

In order to find the optimal solutions suitable for the design modification plan, which must be specifically designed for the chosen place, all the current design and functional requirements were studied. Some of the following proposals were reached that are commensurate with the design of hospital spaces and that take into account the preservation of air quality and the environment interior.

4.1 Hybrid ventilation

Hybrid ventilation is a ventilation method in which natural ventilation and mechanical ventilation are used together in order to obtain a comfortable indoor environmental quality as the indoor air quality is maintained through the chosen ventilation method. The indoor air quality is maintained by the ventilation method chosen. It is controlled as follows, if the surrounding environment is free of pollution and thus the outside atmosphere is clean and free of pollution. Then fresh air from the surrounding outside environment helps to improve indoor air quality. One of the first requirements in hospital buildings is the functional needs. Good ventilation must be achieved for these buildings, as well as high-performance laboratories. Hybrid ventilation is one of the prominent ways to achieve comfort, ventilation and maintain the quality of the indoor environment. Depending on the criteria for achieving internal comfort and also the climatic characteristics of the internal and external environment in terms of climate temperature and air humidity, it is possible for hospital buildings to air-condition well using mixed hybrid ventilation (Mohamed Hamdy and others 2019).
The ideal and simpler model for hybrid and mixed ventilation is the combination of natural ventilation via a natural outlet port and mechanical ventilation via an auxiliary fan together. Naturally, the mere opening of the natural ventilation outlet cannot provide sufficient ventilation, but when the two methods are combined together, it is possible to obtain the required good ventilation. It is already known that just an opening for ventilation purposes cannot provide sufficient ventilation, but when both methods are used together, it can achieve the purpose in a better way. This system is preferable in places where the occupants' movement path is not controlled or allowed to be controlled. In the air in their indoor spaces such as hospitals, it is also considered the most efficient and most cost-effective. Hence, it is the recommended system for use in hospital emergency rooms.

4.2. Demand control ventilation

In the case of a climatic environment with a hot and humid climate, the optimal choice is carbon dioxide-based demand control ventilation (DCV- directional control valve), which is more energy efficient compared to hybrid ventilation. The choice of ventilation system and in the selection of ventilation and air conditioning systems also are temperature and carbon dioxide. The first factor in the measurement effect of the occupancy system ventilation demand control is the level of carbon dioxide in the atmosphere, because carbon dioxide is the best alternative gas to saturate the pollutants that are related to those inside the indoor space. It was concluded that this type of ventilation is one of the most effective solutions, and it is one of the optimal solutions in terms of cost and energy saving as well. The demand-controlled ventilation

system is the most appropriate use for controlling the indoor environment in places where the operating time and the number of space occupants are not constant, such as schools and hospitals. This is because it has some sensors that control the flow of ventilation during the various working times in the place and also during the different numbers of people in the interior space.
These sensors with this type of ventilation are temperature sensors, infrared sensors, carbon dioxide sensors, and also occupancy sensors. Demand-controlled ventilation should be preferred to improve air quality in line with reducing energy consumption. This type of ventilation not only controls the quality of the indoor environment in indoor facilities, but also shows an effective role in reducing energy efficiency. The cost of this type of ventilation is low when compared to the benefit gained from reducing consumption bills. Thus, this type of ventilation is recommended for all places with the same environmental and functional characteristics.

4.3. Energy recovery ventilator (ERV)

This type of ERV ventilation has been used in the recent period on a large scale, especially in various facilities, including industrial, commercial and residential as well. This is because energy recovery is one of the most efficient ways to exchange heat between indoor and outdoor environments. As for the working mechanism of the ERV, it maintains the clean air inside the space, while the polluted air expels it outside, and thus maintains the appropriate humidity levels for those in those spaces. The ERV contains a cycle mold to maintain the appropriate thermal level for the comfort of those in the place, and two filtration devices are attached to it and their optimal location is at the entry point of the air flows, and it also has four tubes in a metal frame that are well insulated. The following figure (Figure 000) shows how the ERV works, how air flows, and how it recovers energy and maintains fresh air and comfort levels within the space.
And about the mechanism of action of the ERV, it works in two dimensions in order to achieve the required comfort levels. The first dimension is in the cooler months and the second dimension is in the warm months. In the cold months, it transfers heat and moisture to the interior, thus the flow of polluted air to the cold air outside. It also does the opposite in the hot months. This system is considered the best and most suitable system for use in places with climatic characteristics where there is a large difference in thermal comfort conditions. The ERV also takes into account the number of people present in the places and the difference in working hours. There are many applications of this type of typical ventilation that achieve the highest levels of comfort in buildings, especially in hospitals in nursing rooms.

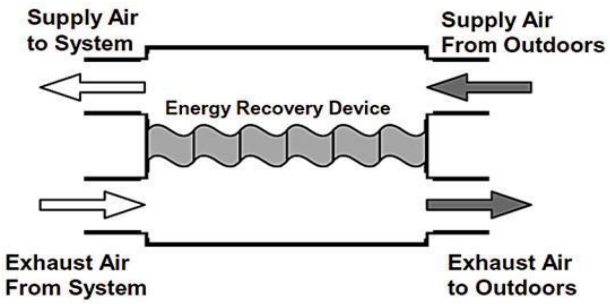

Figure 8 Counter-flow heat exchange pattern

This ventilation technique is the best choice in external environments of low quality, so that it is not preferred to transfer it to the internal environment in the same condition, so it is resorted to moving it inside with some changes that occur in the middle of the conversion path, and then the external environment becomes more suitable for re-conversion inside , according to what was previously studied, ERV is the ideal method, as it is moderate in cost, which is precisely what makes it suitable for medical settings, hospitals and intensive care units, because it is very important to control their comfort levels.

4.4 Laminar airflow system

The use of laminar air flow systems has been proposed by ASHRAE, according to specific guidelines and in order to eliminate bacteria in the atmosphere and foreign particles in the air. Thus, laminar air flow systems are used in hospitals, especially in operating rooms, as it enables us to have a continuous flow of clean air of the required quality, which helps reduce viruses that are contagious once they are in the operating room. Laminar air flow systems have two types: one works with horizontal air flow, and the other with vertical air flow.

In practice, the vertical air flow system is more widely used and has the greatest impact on the ability to protect patients. It consists of HEPA filters that are installed on the ceilings so that the polluted air passes through the HEPA filters installed with the vertical air passage and purifies and cleans it and then directs it to the operation area where the air is of the required quality , sometimes it happens that the air is obstructed due to the presence of some obstacles by the cleaning operations, but it quickly returns to the air duct for treatment through the return air ducts located in the four lower corners of the room.

Another advantage of this type of ventilation is to maintain the highest levels of clean air. And also keep the indoor air from any bacteria or foreign particles. One of the necessities that must be met in HEPA filters is to maintain and clean them in a very organized manner, because any defect in the cleaning or maintenance system will lead to indoor air pollution and be a disaster and endanger the health of those in the place , Previous studies were conducted by focusing on concentration levels T, RH and CO2 in the operating rooms. The laminar air flow system was specially created to control the quality of the indoor environment to reach the optimum comfort levels in the operating room.

4.5. Proposed retrofit design

Ventilation systems are determined differently from others to improve the quality of the internal environment in the required spaces, and the quality of the internal environment is also related to the calculated ventilation rates and the studied thermal comfort.

The cost required for the selected ventilation system is also taken into account. Accordingly, a simple survey was conducted by HVAC consultants in order to compare and develop different systems and technologies and arrange their costs. Accordingly, the system and technology that achieve the most comfort levels in each place in the hospitals were selected as follows, as shown in Table (2) below.

Table 2 . Proposed retrofit techniques

SR. - NO.	Location	Retrofit Scheme	Cost Ranks
1	Emergency Room	Exhaust fan System (Hybrid Ventilation)	Low
2	Operation Theater	Laminar Air flow with ERV System(Recommended DCV)	High
3	Intensive Care Unit	Energy Recovery Unit and DVC	Medium
4	Medical Ward	Energy Recovery Unit and DVC	Medium

Among what was proposed in the design of health facilities for the internal spaces are the following:

For areas that are more crowded with pedestrians and where there is a large functional movement and at the same time need very good ventilation at all times, such as the emergency room in hospitals, it has been suggested to use exhaust fans in order to find the ventilation required at all times. Through these fans, fresh air can be found of high quality at different points in the space and thus leads to an improvement in the movement of air circulation in the spaces.

As for the MW and ICU areas, it is better to use the ERV system, as these rooms are limited to the entry of certain people, and therefore the number of people in the space can be controlled according to the job and achieve comfort together. It is also necessary, while maintaining comfort levels and environmental quality, to conserve energy. consumed in those spaces.

Therefore, the use of the laminar air flow system is used in the OT, as it has been proven from previous studies the importance of using this type of ventilation in the air quality and the indoor environment, especially in operating rooms. Figure 1 shows the aforementioned proposals, as it is a basic requirement to control CFM levels in an indoor vacuum,it is then possible to use laminar air flow systems in conjunction with an appropriate AHU system. In order to maintain the desired comfort levels, the DCV system is likely to be used. And as shown in the following figure, which shows the proposed modification design that can be attached to hospitals in order to achieve optimal comfort levels in terms of air quality, thermal comfort and the quality of the indoor environment as a whole.

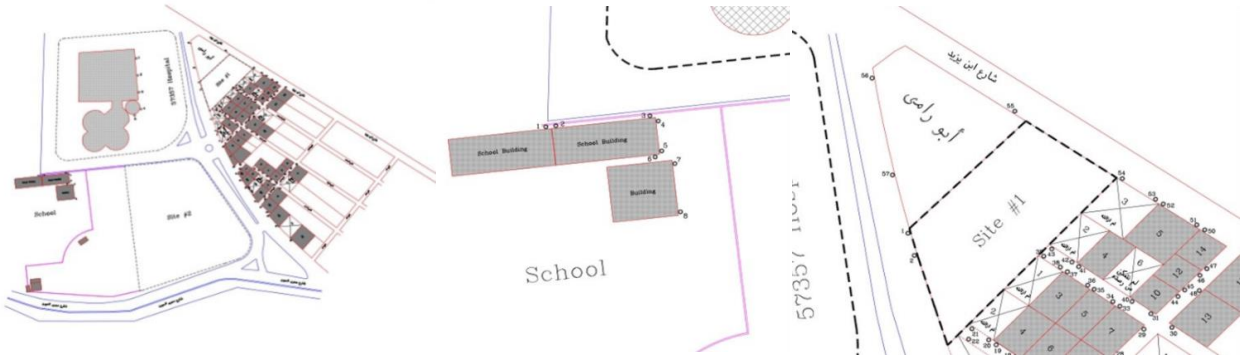

Figure 9 shows the hospital location

5. CONCLUSIONS

The simulation represented in this study shows A clear difference in the current and desired results for Ventilation in selected hospitals. Calendar Ventilation rates strongly support the requirements Modify the design at the selected sites, the discussed retrofit proposal is classified. It can help improve IEQ in hospitals and health care buildings, this study can help the hospital to Pay attention to IEQ and create a suitable retrofit strategy that ensures a relaxed atmosphere for patients as well as for the medical staff.

6. RECOMMENDATIONS

This study aims primarily to urge attention to indoor air quality and the indoor environment as a whole, and achieve this through developing appropriate strategies and plans that seek to achieve the highest levels of indoor comfort, which in turn is reflected in providing a comfortable atmosphere for patients, as well as the medical staff and workers in the place and the quality of work in the end.

And because the newly built facilities do not allow easy application of the selected ventilation systems, but hospitals can transgress and add some design proposals through which it is possible to achieve the required internal quality,

It is also important to know that the climatic data collected includes the transition time from summer to autumn, which may result in some changes for application in the summer and winter seasons.

One of the important recommendations of this research is to conduct the same assessments and studies for the most severe weather in the winter season, for example, in order to find the best solutions that are completely suitable for the place.

The quality and comfort of the place for users, whether patients or workers, It is possible in the future to study some other solutions and technologies that are lower in material cost so that they are suitable for developing and poor countries, but that meet the required internal quality and thermal comfort required to be available in the spaces inside the hospital.

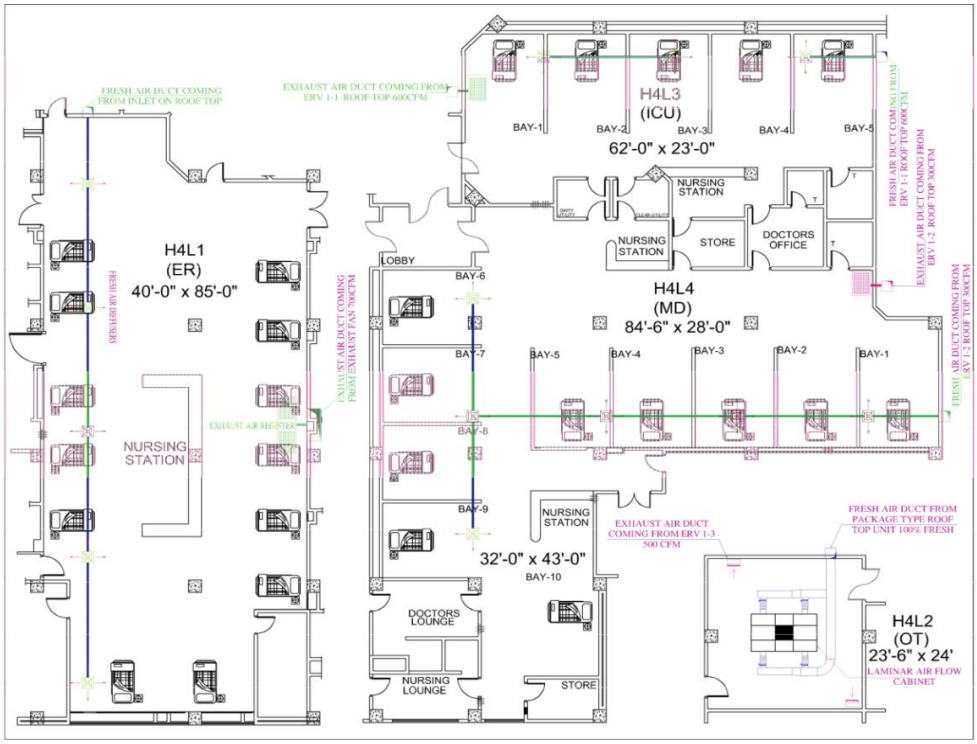

Figure 10. Treatments in the health facility through artificial intelligence

The interior design of health facilities and building services must be modified according to advanced technology and artificial intelligence strategies, and this will necessarily contribute to improving energy efficiency in the internal spaces of health facilities and achieving thermal comfort for its occupants.

Especially, improved air quality and improved thermal comfort in a healthcare facility from energy use because improving airflow and ventilation, maintaining humidity and CO2 levels can improve the HVAC system and ensure less load on equipment, better IEQ is achieved after factors are removed Harmful and toxic from cellular particles and agents that can cause allergic reactions, sneezing, congestion, itchy throat and irritation of the eyes, improved IEQ and controlled thermal comfort help eliminate these potential for discomfort and increase the chances of a speedy recovery.

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