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Designing a new fast solution to control isolation rooms in hospitals depending on artificial intelligence decision

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ABSTRACT

Decreasing the COVID spread of infection among patients at physical isolation hospitals during the coronavirus pandemic was the main aim of all governments in the world. It was required to increase isolation places in the hospital's rules to prevent the spread of infection. To deal with influxes of infected COVID-19 patients' quick solutions must be explored. The presented paper studies converting natural rooms in hospitals into isolation sections and constructing new isolation cabinets using prefabricated components as alternative and quick solutions. Artificial Intelligence (AI) helps in the selection and making of a decision on which type of solution will be used. A Multi-Layer Perceptron Neural Network (MLPNN) model is a type of artificial intelligence technique used to design and implement on time, cost, available facilities, area, and spaces as input parameters. The MLPNN result decided to select a prefabricated approach since it saves 43% of the time while the cost was the same for the two approaches. Forty-five hospitals have implemented a prefabricated solution which gave excellent results in a short period of time at reduced costs based on found facilities and spaces. Prefabricated solutions provide a shorter time and lower cost by 43% and 78% in average values respectively as compared to retrofitting existing natural ventilation rooms.

1. Introduction

The COVID-19 existing crisis in the world is like the severe acute respiratory syndrome (SARS) epidemic in 2003. This newly identified problem has demonstrated the requirement for institutional and hospital preparedness. This preparedness should determine healthcare facilities where patient care can be provided with an appropriate standard of biosafety for other patients, healthcare workers, and the whole community [1,2]. Because COVID-19 can be transferred from person to person and cause life-threatening illnesses and may introduce severe hazards in health care settings and the community, it will require specific control measures, and can be categorized as highly infectious diseases (HID) [3].

The importance of having patients in an adequate hospital environment is a critical issue to limit disease spread in the hospital and/or community. Hospitals should include units with clinical facilities specifically designed to minimize the risk of nosocomial spread. Some countries have proposed a particular type of negative pressure plastic

isolator containing one or two beds [4]. Others insert patients into negative isolation rooms that do not have facilities for highly infected diseases [5]. Also, during severe acute respiratory syndrome, they have created temporary isolation wards [6,7]. Any number of critical care beds, including surgical and specialty unit beds, should be at least duplicated to face the increasing number of patients of the COVID-19 pandemic. Hospitals should manage all produced services, beginning with triaging patients and progressing to high-critical care services such as ICU and/or OT. Best-case estimates suggest the situation of COVID-19 will stress bed capacity, hospital equipment, and providers of health care. Some countries have decided on quarantine, which refers to the separation of not infected individuals who have been exposed to COVID-19 and therefore have a potential to become ill, but isolation refers to the separation of individuals who are suspected and/or confirmed of having COVID-19. All suspect cases should be observed in isolation zones in hospitals with specially designated facilities. People testing positive for COVID-19 will remain isolated till their second samples are tested negative to be discharged.

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Table 1
Questionnaire for required spaces and facilities in infectious / fever/ university hospitals.

#	Item	Yes	No	Notes
1	Can deal with isolated diseases	Specify		
2	Hospital capacity (overall)	Specify		
3	Current hospital capacity / usage /occupation	Specify		
4	Negative isolation room without anti-room			
5	Negative isolation room with anti-room			
6	Isolation rooms in the same building			
7	Isolation rooms in separating buildings			
8	Air exhausted directly to the outside, without HEPA filtration			
9	Having sealing room			
10	Controlled isolation rooms (+ve / -ve)			
11	Restricted access			
12	Having Medical gases			
13	Ability to provide information on intensive care capability			
14	Waste management and treatment			
15	Administrative control			

Table 2
Filling questionnaire for fever hospitals.

#	Item	Yes	No	Notes
4	Negative isolation room without anti-room	✓		less than 5%
5	Negative isolation room with anti-room		✓	
6	Isolation rooms in the same building		✓	
7	Isolation rooms in separating buildings	✓		~ 10%
8	Air exhausted directly to the outside, without HEPA filtration		✓	
9	Having sealing room		✓	
10	Controlled isolation rooms (+ve /-ve)		✓	
11	Restricted access	✓		Manual
12	Having Medical gases	✓		~ 5%
13	Ability to provide information on intensive care capability	✓		~ 15%
14	Waste management and treatment		✓	
15	Administrative control	✓		Via management or using CCTV

Transmission of airborne infections has been implicated in nosocomial outbreaks [8–13]. Due to dispersion via aerosols, it is thought that the high attack rates during norovirus outbreaks [14–19]. About 10–20% of all nosocomial infections are spread by this route [20] which equates to a high cost to implement. Recently, many methods have been developed by researchers to improve mechanical ventilation [21], by using personal protective equipment [22] and the use of Ultraviolet Germicidal Irradiation (UVGI) devices both within rooms [23,24] and in air-conditioning ducts [25]. By using UVGI lamps, the levels of infectious material present in the air have been reduced. Infectious diseases such as influenza viruses and norovirus are problematic in institutions such as hospitals and nursing homes and occur as distinct outbreaks over a short time scale. For example, 1–3 days is the incubation period for influenza, then patients may be infectious for 4–6 days [26].

As a result, has been considered of SARS, patients have been divided into 15% who develop pneumonia and 5% who require ventilator management. So, to reduce the risk of spreading disease, hospital rooms should have adequate technical facilities. Hence, dedicated intensive care beds should be identified as having multi-organ failure for progressing cases. Critical care facilities for dialysis, salvage therapy [Extra Corporeal Membrane Oxygenator (ECMO)], respiratory, renal, and multi-organ failure should be required.

One way to do this is with a negative pressure room, in which a lower air pressure allows outside air into the room; any air that flows out of the room must pass through a filter. By contrast, a positive pressure room

maintains a higher pressure inside the treated area than that outside it. Clean, filtered air is pumped in; if there's a leak, the air is forced out of the room. Positive pressure rooms are usually used for patients with compromised immune systems, while negative pressure rooms are common in infection control, to ensure infectious germs don't spread via the heating, ventilation, and air conditioning (HVAC) system. In this paper, the main objective is to use the scientific basis and academic background with hospital top management to select the most optimum solution through the available resources. The main contribution is to use AI in deciding on which type of solution will be used. Adoption of these intelligent solutions gives the chance to facilitate hospitalization and decision-making.

2. Data and methods

Due to the uncertainty of spreading the new coronavirus, it passes through close contact with infected people via the viral droplets expelled when they cough or sneeze, or as air-borne diseases spread easily through the air, like tuberculosis or measles and chickenpox. And because most of the dedicated hospitals (infectious disease hospitals and/or fever hospitals) are not prepared for such circumstances and epidemic situations, a fast-implemented solution together with a general strategy and plan should be executed in a very short time.

In this paper, new fast solutions and scenarios were investigated to keep isolated zones while taking into account available location, space, and facilities and saving time. The required locations are the infectious hospitals and/or fever hospitals, which are the first line of protection that have medical staff trained for such cases and how they can deal with infected patients. Based on the geographic distribution of hospitals, the city's population, and the spread of the epidemic, the number of isolated zones can be estimated together with the training of new staff. If there are no such hospitals in the containment zone, the closest tertiary care facility in government, private, club, or university hospitals should be found. For space and facilities, a short survey/questionnaire should be filled out via hospitals as indicated in Table 1.

This questionnaire should be distributed to infectious and fever hospitals. After filling out the previous questionnaire in forty-five fever hospitals, the following results have been collected as indicated in Table 2.

Based on the various allocations of patient isolation, there are the following techniques:

1. Natural ventilation or isolation facilities (rooms) that have a large window on opposite walls of the door allow a natural unidirectional flow of air and air changes. The natural ventilation principle is to allow the flow of outdoor air by natural forces such as wind forces from one opening to another to achieve the desired air change per hour.
2. Individual isolation rooms with good ventilation.
3. Negative pressure rooms with 12 or more air changes per hour (ACH).

Positive cases (COVID-19 cases) should be isolated in a ward with good ventilation or a negative area. Suspect cases should also be kept in another separate ward. However, under no circumstances should these cases be mixed up. The isolation ward should have a separate toilet with proper cleaning supplies. Because the isolation facility aims to control the airflow in and out of the room to reduce the airborne infectious particles to a level that ensures prevention of the cross-infection with other people, the third type of isolation is the most effective solution to deal with infected and airborne cases.

According to a quick survey of the hospitals studied, there are no isolation rooms with anti-rooms, and the number of isolated areas (without anti-rooms) is small in comparison to total hospital capacities (5%) and is kept in separate buildings (10% of isolated rooms). There are no sealing rooms (capsules), no isolation rooms having air exhausted

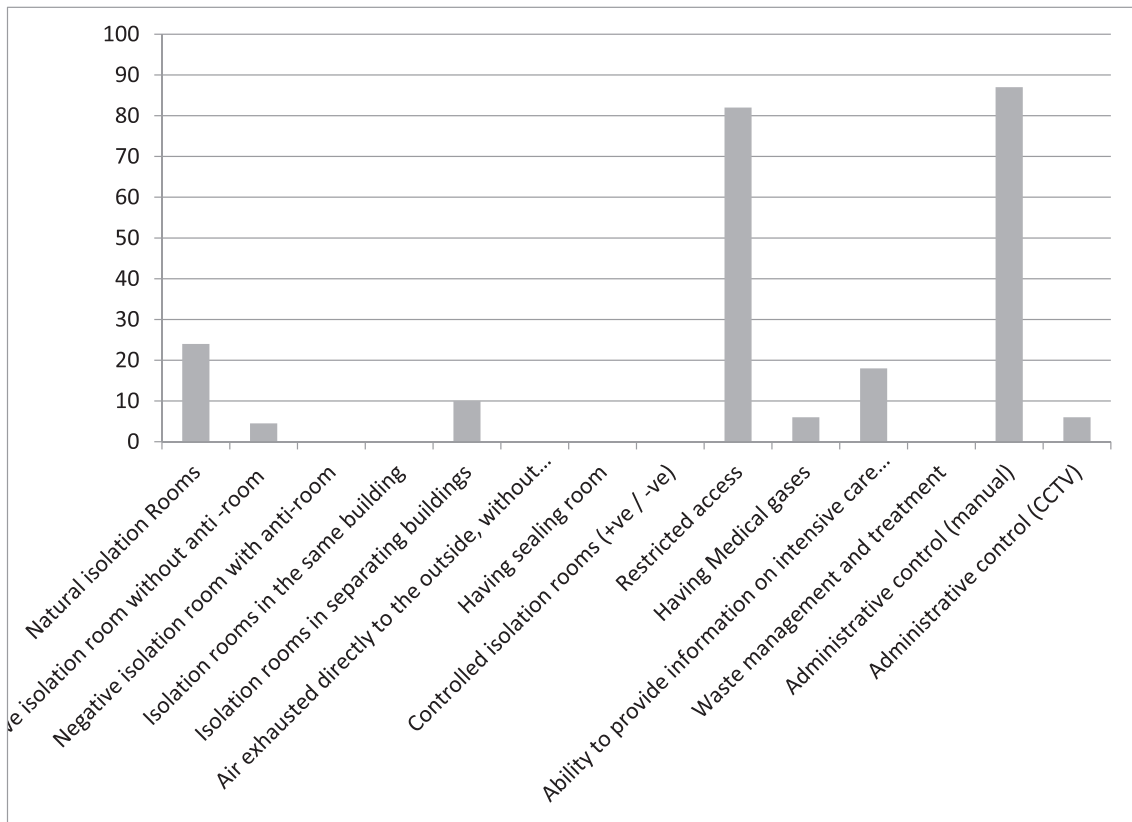


Fig. 1. Filling questionnaire for Infectious hospitals.

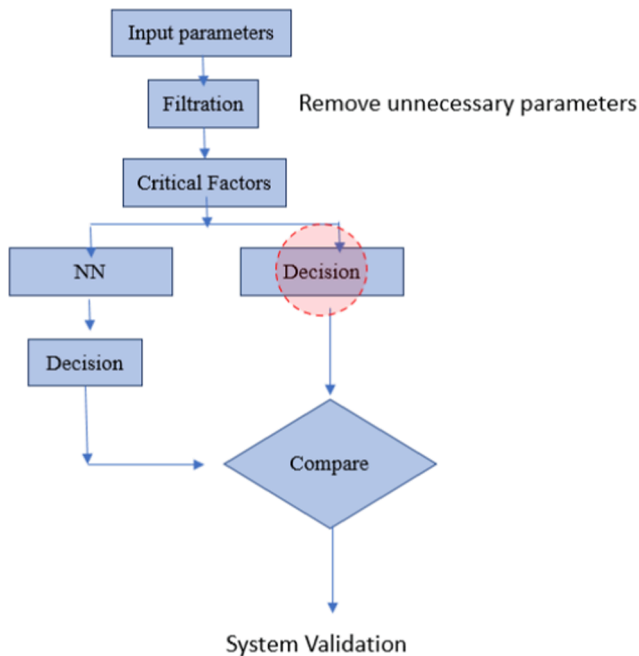


Fig. 2. Proposed technique flowchart.

directly to the outside, and there are no controlled isolation rooms (+ve/-ve) (can be inverted related to the requirement via automatic/manual dampers). Less than 5% of the isolating rooms include medical gases, although 15% of rooms can introduce intensive care capability. As indicated in Fig. 1, a chart shows the percentage related to studied items. Although all hospitals have administrative control (controlling the

patient and their relatives entrance manually via security staff and a CCTV system), they do not have medical waste management or restricted access [27].

3. Experimental setup

Due to COVID-19, patients should be kept in single rooms and no rooms are available for such a crisis, so the requirement of increasing the number of isolated rooms in a very short time is a very critical issue. To overcome this situation, it is required to process in multi directions as: -

1. Convert all-natural ventilation rooms (if found) into negative isolation rooms by sealing the window.
2. Removing all non-essential furniture and ensuring the remaining furniture is easy to clean.
3. Every room may have its standalone air-conditioning (not be a part of the central air-conditioning, just an inlet for incoming air from outside).
4. The room may have its medical gas ((O₂, MA, (VAC if applicable)) system to provide intensive care capability with patient monitor connection.
5. The video conference calls may relate to nursing calls to monitor and control the patients.
6. Negative pressure could also be created by having exhaust fans driving the air out of the room based on its air volume (5 Pascal minimum).
7. The isolation ward access may be through dedicated stairs/ lifter.
8. The isolated ward should have a separate entry/exit.
9. The isolated ward should be in a segregated area not accessed by outsiders frequently.
10. Higher rate of air exchange per hour, typically 12 air changes per hour.
11. HEPA filter for exhausting air.

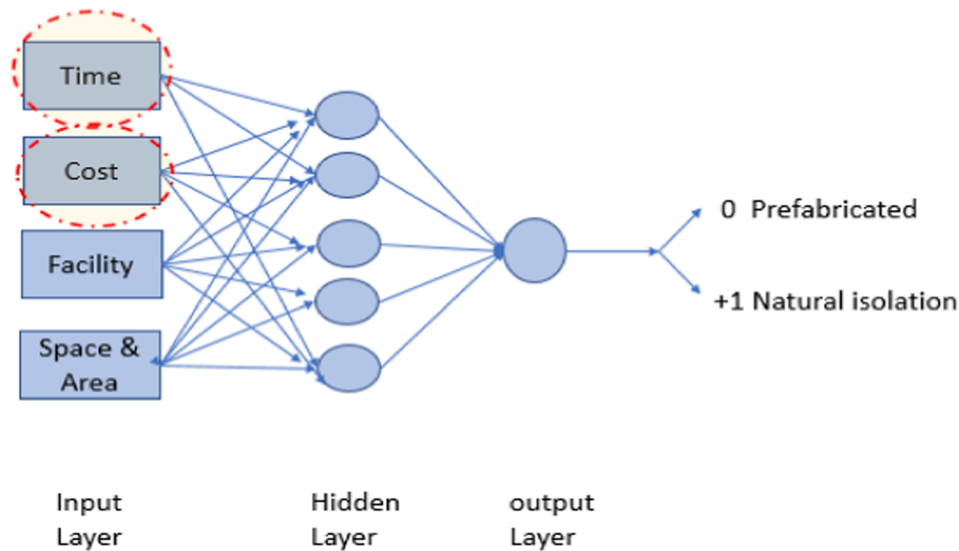


Fig. 3. Studied Neural networks to determine the correct decision.

Table 3
Hospitals and their available parameters.

Hospital	Estimated required Time (Day)	Cost (K\$) Available	Facilities (0–100)	Spaces/ Area ~ M ²
H1	22	50	60	D
H2	21	30	60	C
H3	30	25	70	A
H4	10	30	80	D
H5	15	50	70	B
H6	15	50	60	B
H7	21	20	80	B
H8	30	10	70	D
H9	20	20	80	D
H10	18	10	50	B
H11	10	60	80	C
H12	7	80	80	C
H13	15	50	50	C
H14	15	50	60	A
H15	25	70	40	C

12. Anti-room can be added for available spaces.
13. A mobile UV system will be used before and after patients inside the rooms.
14. UV lamps may be added to AC ducts to sterilize the inlet air.
15. UV lamps may be added to AC ducts to sterilize the outlet air if will be circulated or does not have a HEPA filter (dose per unit area and time should be considered).

Based on available data, it should select one of the two directions.

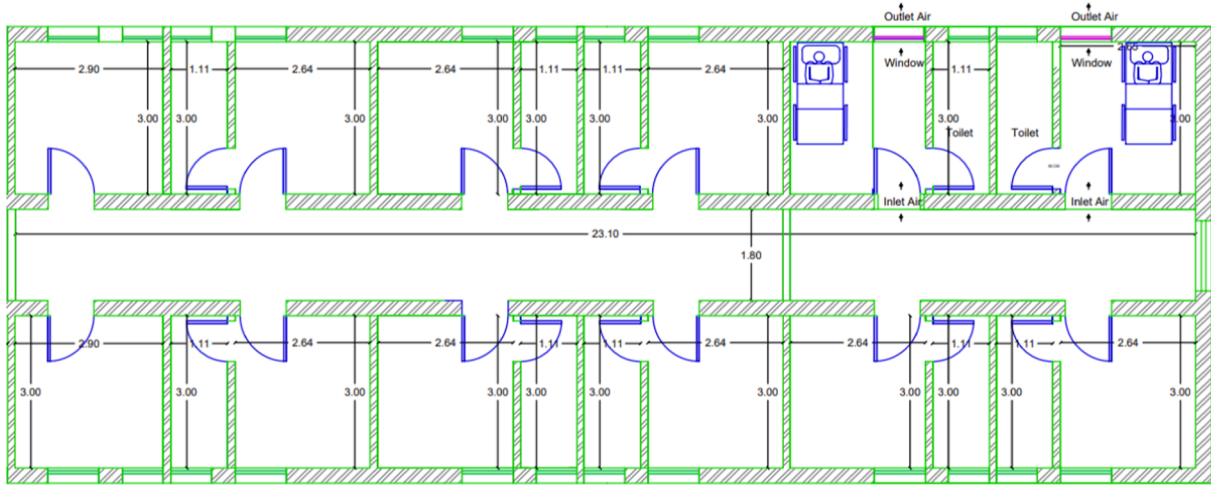
1. Converting the natural isolation rooms into isolation areas.
2. Constructing prefabricated units to be used as an isolation area.

To improve the analytical and predictive capacities of decision support systems (DSS), artificial neural networks (ANN) are being used more and more frequently. This is especially true for model-based and data-driven approaches. In complicated situations demanding quick decisions, ANN-based simulation models linked with DSS greatly improve decision-making [28]. ANNs are among the intelligent systems driving the performance of DSSs due to inherent algorithmic learning, fault tolerance, prototyping, and parallel processing capabilities, among other features. ANN has demonstrated its ability to be an effective tool in DSS in manufacturing, especially for classification and pattern

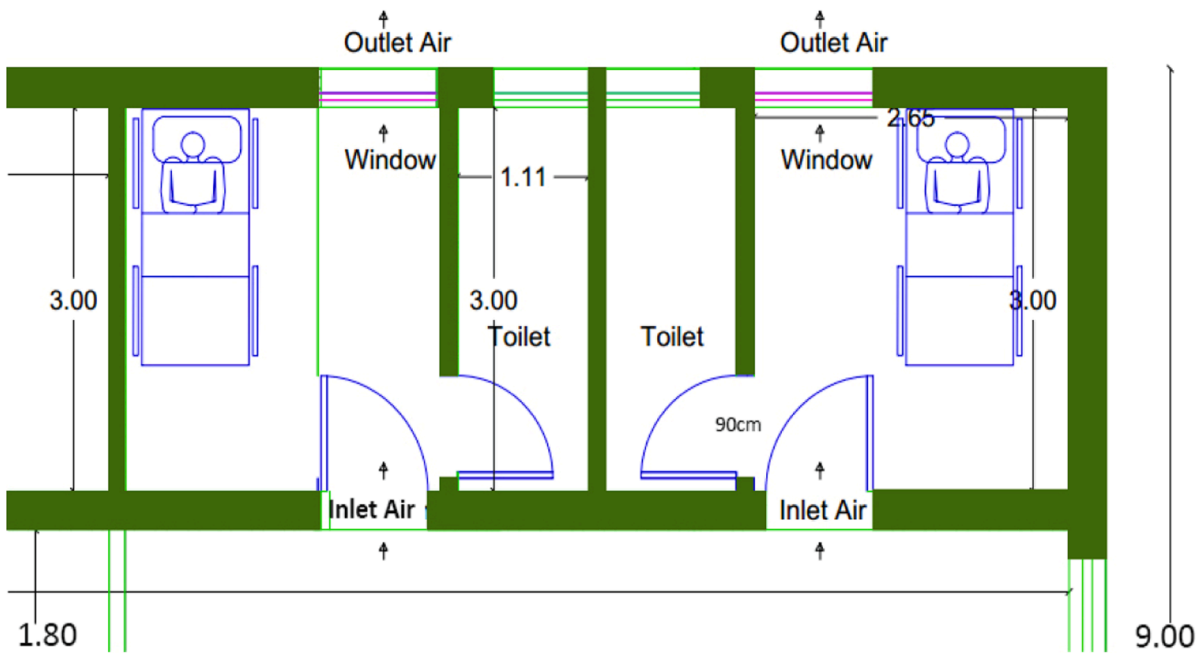
recognition problems [29].

Due to their intrinsic algorithmic learning, fault tolerance, the ability for rapid prototyping, and parallel processing, ANNs are among the intelligent systems enhancing the performance of DSSs. In manufacturing, ANN has proven to be a useful tool in DSS, particularly for classification and pattern recognition issues [30]. ANN- models can present accurate solutions for poorly understood structured and un-structured decision problems [29]. artificial intelligence is projected to be a permanent research field featuring applications as intelligent DSS [31].

In the presented paper, a neural network model as a type of artificial intelligence has been studied before implementation to guide the managers in taking the decision. It will be implemented to find the optimal strategic situations without considering expert knowledge. A supervised learning rule using backpropagation is considered to train such a neural network. Although many parameters can be considered in making the decision. These parameters are minimum damage to the current building; warranty of working after implementation; geographic location; available spaces; connection to services tie-in; available facilities; required bed capacity; hospital equipment; city population; implementation time; and cost. In Multi-Layer Perceptron Neural Network (MLPNN), only four parameters have been considered, which are the most important parameters after the filtration step (parameters have a strong effect after evaluation). The first parameter is time, which is the most critical item that is considered in units per day for a maximum of one month to have a complete solution. The second parameter is the cost, which should be considered although it can be covered within a crisis to maintain respectable healthcare services. The third parameter is the facility which contains medical gases (O₂, Air, Vac), electricity source (normal, UPS), lighting in an emergency, air conditioning having negative pressure, and total exhaust. The third parameter is evaluated as an absolute number based on presented and found facilities within the range of (0–100) with step 10. The fourth parameter is the area/location and available space which satisfy the minimum requirements for spaces related to regulation, either in the hospital building or external (available spaces beside the hospital). This parameter has been assigned to (A (0–100 m²), B (100–200 m²), C (200–300 m²), D (300–400 m²)). The feeding inputs of the model were handled into numbers, reflecting the actual values for each parameter. As indicated in Fig. 2, the flowchart of the presented study. Although many machine learning techniques can be used based on multilayer extreme/probability extreme learning machines [32,33], MLPNNs will be used in this study.



(a) 10 Natural rooms together with internal privet toilets



(b) Circulation of air in natural rooms through the door and window

Fig. 4. The layout of the isolation rooms.

3.1. Multi-Layer Perceptron neural networks (MLPNNs)

MLPNN is widely used by medical researchers to classify brain signals due to its ability to learn and generalize in a small training group, quick operation, and easy performance [34,35]. Although MLP is considered one of the deep learning techniques, it may suffer from vanishing or exploding gradients sometimes, which does not happen in the proposed study. In a directed diagram, MLPNN is made up of three layers of nodes, as is quite common as default, each of which is connected to the next layer. Artificial neurons, or nodes, are the main processing elements in MLPNN. Each neuron j in the hidden layer adds its input signals after multiplying them by the strengths of the connection weights and computes its output as a function of the sum, as shown

in equation (1).

$$y_j = f\left(\sum w_{ji}x_i\right) \tag{1}$$

Where f is the activation function that can be radial basis function, sigmoid, signum, or hyperbolic tangent. This function is used to convert the weighted sum of all signals that affect a node. Some approaches have been used to evaluate the extracted errors. The first one is the sum of squared differences between the desired and actual values of the output neurons E which is defined in equation-2:

$$E = \frac{1}{2} \sum_j (y_{dj} - y_j)^2 \tag{2}$$

Where y_{dj} is the desired value of output neuron j and y_j is the actual

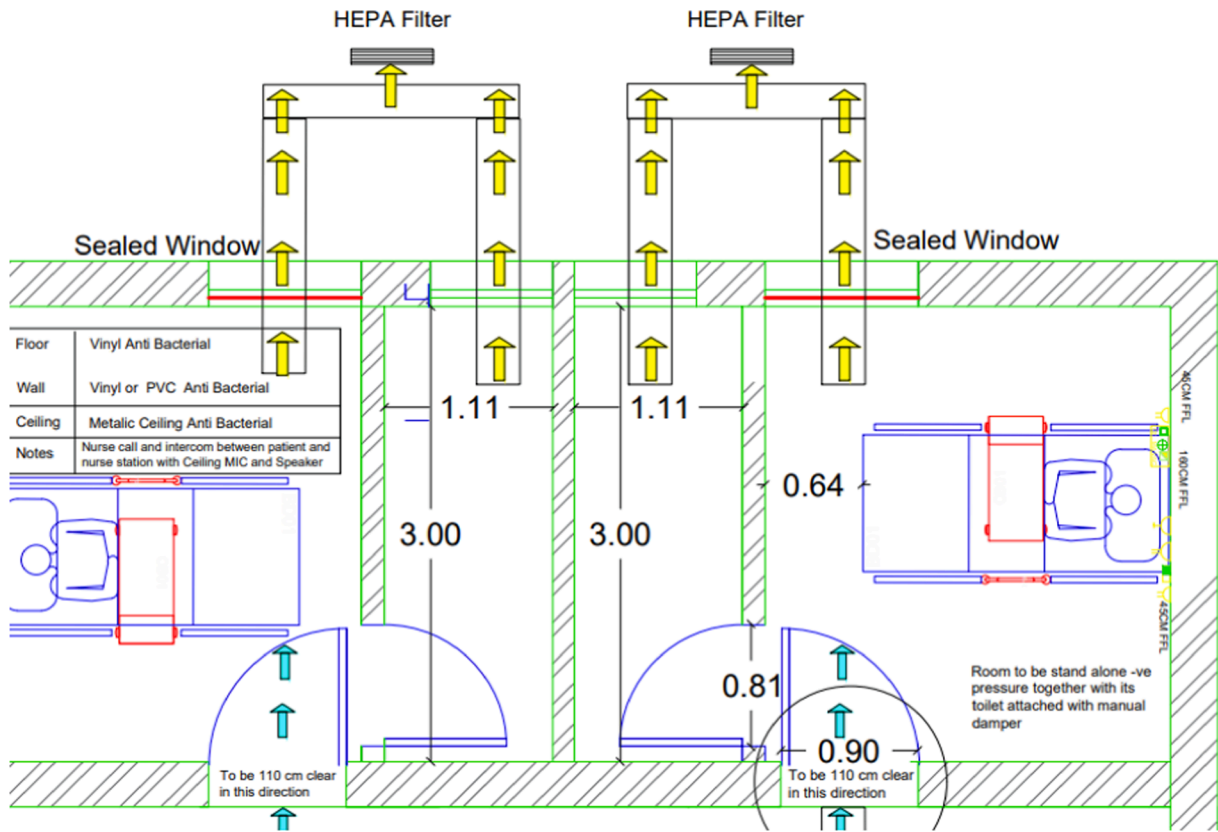


Fig. 5. Indicates the conversion of natural rooms into sealed negative isolation rooms prepared to be ICU and to be a standalone HVAC system.

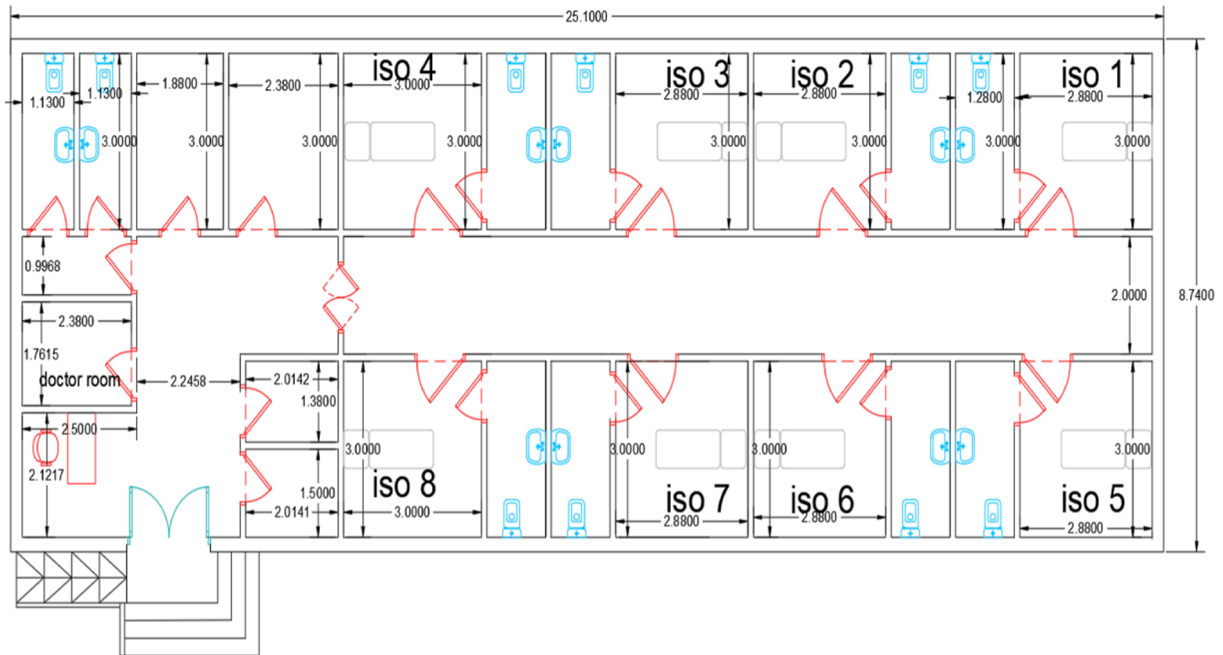


Fig. 6. Prefabricated design including 8 negative isolation rooms prepared to be ICU.

output of the neuron. Each weight w_{ji} is adjusted to reduce E as rapidly as possible. w_{ji} is adjusted based on the training algorithm [35,36]. Another approach is the loss function (cross-entropy) which is used in this study to evaluate how well the model fits the data distribution. By using cross-entropy, the error (or difference) can be measured as defined in equation-3.

$$\ell = -(y_j \log(p) + (1 - y_j) \log(1 - p))$$

where P is the predicted probability and y is the indicator (0 or 1 in the case of binary classes).

As indicated in Fig. 3, the neural network consists of an input layer

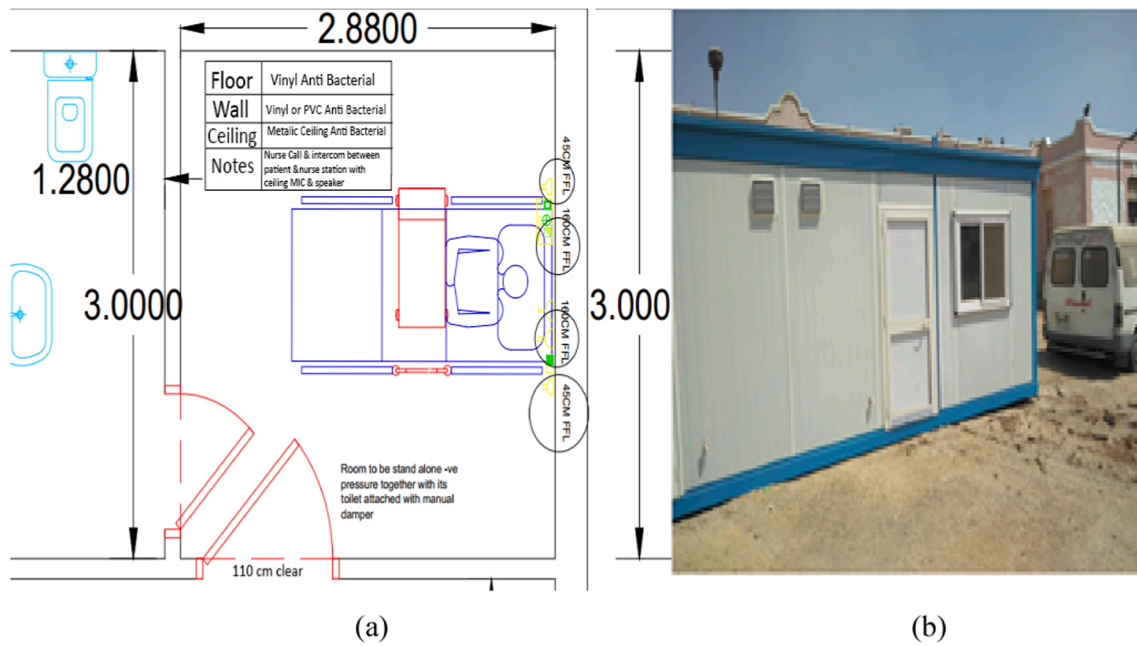


Fig. 7. The inside and outside of the rooms.

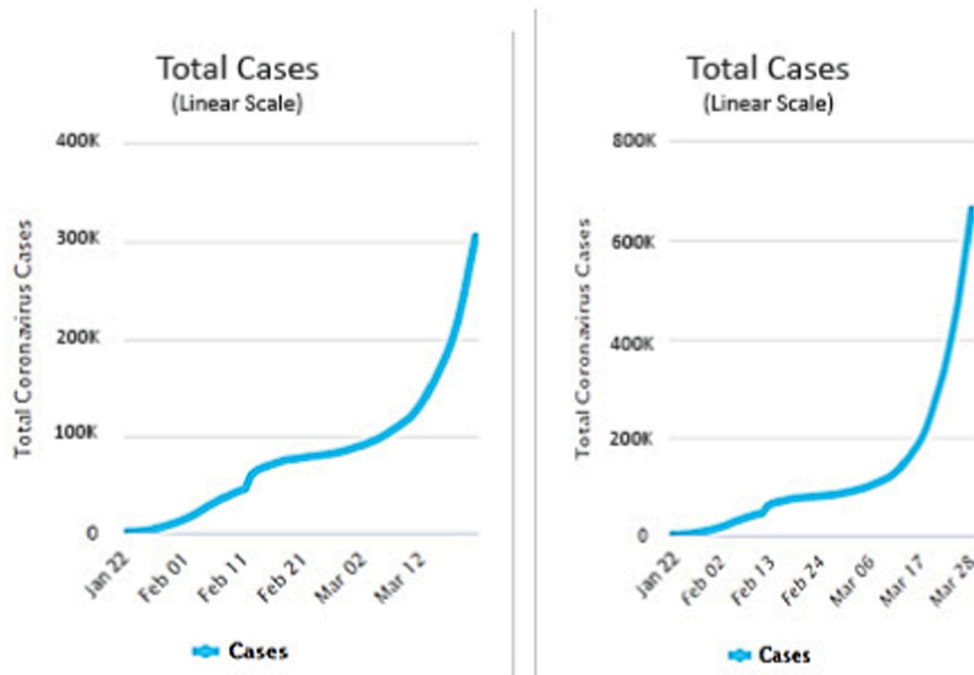


Fig. 8. Number of total cases (22 March) on the left curve, and (30 March) on the right curve.

Table 4
Number of total cases having new cases, total death (22 March 2020).

Country	Total Cases	New Cases	Total Deaths	New Deaths	Total Recovered	Active Cases	Serious Critical	Tot Cases 1MPOP
China	81,054	46	3261	6	72,440	5353	1845	56
Italy	535,578		4825		6072	42,681	2857	886
USA	26,892	2685	348	46	178	26,366	708	81
Spain	25,495		1381		2125	21,990	1612	545
Germany	22,364		84		209	22,071	2	267
Iran	20,610		1556		7635	11,419		245
Egypt	294		10		42	242		3

Table 5
Number of total cases having new cases, total death (30 March 2020).

Country	Total Cases	New Cases	Total Deaths	New Deaths	Total Recovered	Active Cases	Serious Critical	Tot Cases 1MPOP
USA	140,256	16,678	2457	237	4435	133,364	2970	424
Italy	97,689	5217	10,779	756	13,030	73,880	3906	1616
China	81,439		3300		75,448	2691	742	57
Spain	80,110	6875	6803	821	14,709	58,598	4165	1713
Germany	62,095	4400	525	92	9211	52,359	1979	741
France	40,174	2599	2606	292	7202	30,366	4632	615
Egypt	609	33	40	4	132	437		6

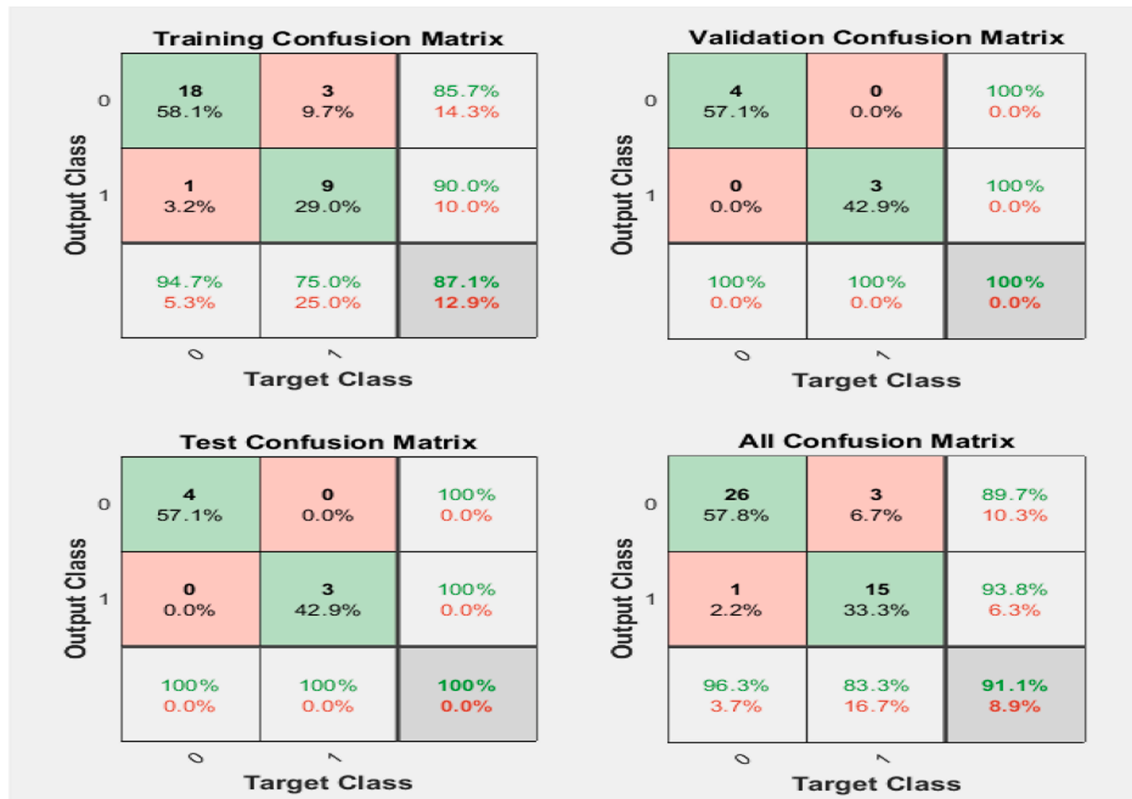


Fig. 9. Confusion matrix of training, validation, test and all the system.

having four inputs (Time, Cost, Facilities, Space), a hidden layer, output layer (two states) to take the decision; either prefab or converting a natural room into an isolation room.

The multi-layer perceptron neural network, as shown in Fig. 3, is one of the most widely used neural network models. MLP has been selected because it can learn linear and non-linear models and to deal with online models. It has not considered any assumptions regarding probabilistic information. As shown in Table 3, the available data and parameters of the studied hospitals indicate the required time of implementation of every site/hospital together with the cost dedicated for this implementation. Also, the calculated score of available facilities is in addition to the used area limit. The neural network was used to classify the recorded and estimated data into two target categories; converting the natural isolation rooms into isolation areas or constructing prefabricated units to be used as isolation areas. The activation function in the hidden layer was the sigmoid function. During using the neural network, the training samples were randomly divided into three kinds of samples: 70% for training, 15% for validation, and 15% for testing. Training samples (31 samples) were used to train the network, which is adjusted according to its error. Validation samples (7 samples) were used to assess network generalization and to halt training if generalization improvement stopped based on the number of iterations and

performance indicators. validation can only be used during training. Testing samples (7 samples) were used to provide an independent measure of network performance during and after training. Although the neural network generally performs better with larger training datasets, it can be performed on the available data based on the pandemic situation to have an indicator for the required direction. As a research team examined the impact of training set size on NN classification accuracy in the early 1990 s [37]. Their conclusion demonstrates that NN only require significant data samples that can describe the general shape or picture of the case to get improved classification accuracy [38,39]. The accuracy of the model during training does not increase as the training set size increases [40].

The back-propagation training algorithm is the most used, which means the artificial neurons are organized into layers and send their signals forward, and then the errors are propagated backward. 4-10-1 MLPNN was the optimum model for the classification of the available features. NN aims to determine the correct direction to go through. After implementing NN, the output is to have a prefab direction instead of converting the current natural room into an isolated area. The result of the model is to go with the prefabricated method due to saving time by 43%, but the cost is roughly the same or a 12% reduction with a consumed time of less than one second. Here is the implementation of

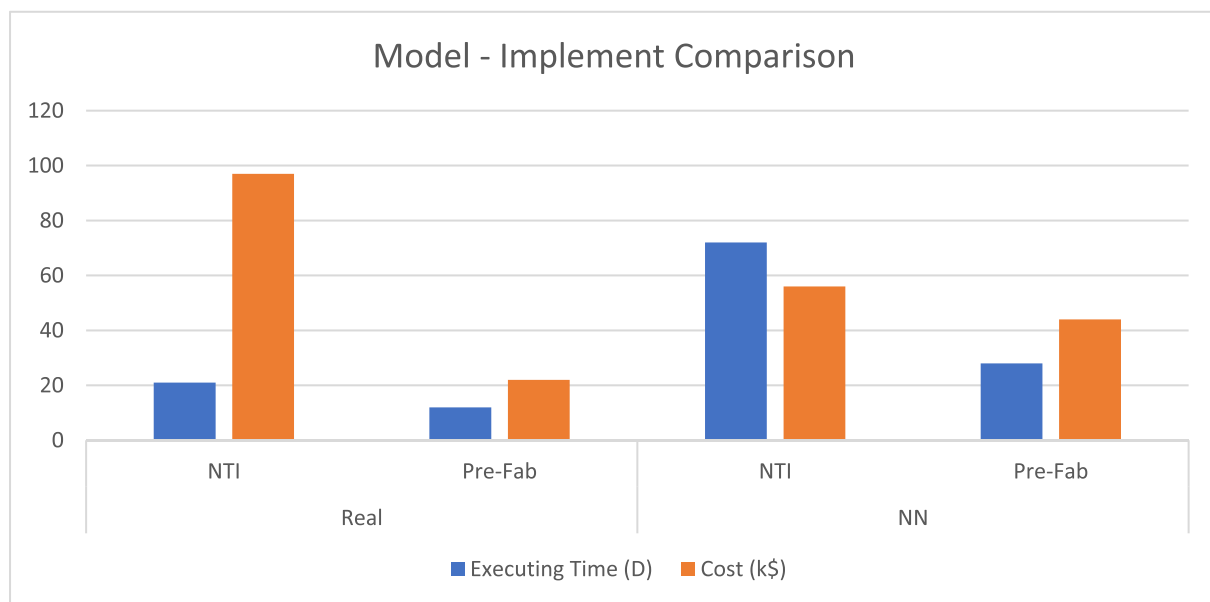


Fig. 10. Comparison between NTI and prefabricated solutions extracted from NN mode and current implementation.

the two scenarios. The two scenarios have been applied and compared to having the maximum number of isolation rooms to overcome the current crisis.

3.2. Converting the natural isolation rooms into isolation areas

In this scenario, twenty-four natural isolation rooms, as indicated in Fig. 4 (ten rooms attached with toilets), will be converted into a negative isolation zone for hemodialysis in the same building. The building has 20 rooms attached with their toilets and one bay area together with their services for doctor's room, staff room, store, dirty utility, and staff change area. As indicated in Fig. 4-b, a zoom-in of the two upper right corners shows the existing patient bed positions, door, and window opening.

Regarding the pathogens and to facilitate the implementation, isolation rooms may not require an anteroom although it serves as a controlled area for the transfer of supplies, equipment, and persons. It acts as a barrier against the potential loss of pressurization and where people can gown before entering or exiting the isolated area. Negative pressure rooms prevent air from the bathroom or patient area to escape into the corridor. It is achieved by exhausting a greater quantity of air than that of the inlet air. A well-designed exhaust system is necessary for the negative pressure isolation room. This system has been implemented and after covering the main problem of having a large number of isolated rooms in much tided time, it can be supplied by a pressure gauge and alarm system to alarm when pressurization has not been achieved. All walls are PVC without separation and antibacterial metallic false ceilings have been selected and anti-bacterial vinyl is for all floors except toilets. As indicated in Fig. 5, the door opening has been inverted, the patient bed rotated by 90-degree, the window sealed, and standalone mechanical ventilation implemented by centralized (inlet can be standalone system) inlet air and dedicated fans to create pressure drop by -ve collected from patient space and toilet.

3.2.1. Prefabricated sections

On the other hand, a prefabricated section is a fast solution, as indicated in Fig. 6, to respond with urgency to the pressing need for hospital isolation rooms during the COVID-19 pandemic. It includes eight isolated patient rooms together with a reception area, doctor's room, staff change, services, toilet, and stores. The patient area has a restricted door, and the main building has stairs and a ramp with an

admin/control area. This solution can be classified easily into airborne infectious isolation (AII) rooms with negative pressure and protective environment (PE) rooms with positive pressure if needed via automatic dampers for the inlet and outlet of AC.

As indicated in Fig. 7, (a) is the design for an isolated room as a fabricated scenario while (b) is the final image after implementation in the fever hospital. as indicated in Fig. 8 and Tables 4, and 5, the data has been collected within one week to indicate the increasing number of cases and the need to respond to this need in very limited time [41].

4. Results and discussions

According to Fig.8, where the total number of cases has been duplicated within eight days while altering the order of counties depending on the total number of instances, this is exactly what happened. Quick deployment is thus ideal; prefab solutions should be built with minimum labor and be pre-wired inside walls, with self-closing doors as well as 100% fresh air intake and exhaust HEPA filtered air. A smooth antimicrobial coating, chemical and disinfectant resistance, noise abatement, and scratch resistance should be installed on the walls. In this study, two approaches have been achieved; the first approach was to transform the natural isolation areas into negative isolation areas, while the other was to create prefab sections with isolated patients and their services. To decide which approach to select, the NN model has been applied to select the best scenario. Four main parameters have been considered in this model: time, cost, facilities, and space. The result of this model is to go with the prefabricated method as indicated in the Fig. 9 confusion matrix (confusion matrix of training, validation, test and whole picture), which leads to the conclusion that the prefabricated solution is the best one. An extra step has been applied to fix three parameters and change one only. When the time had been changed by fixing all parameters (average value of parameters), the result was to use pre-fab to save time by 43%. While changing costs led to a 12% reduction by using pre-fab.

The two approaches have been implemented in real life. The result is to implement NTI into negative isolation wards in 21 working days with 97.2 k\$, while the prefab technique with eight isolated patients and their services in 12 working days with 22.7 k\$. A comparison between the two studied scenarios has been presented to highlight the results of the estimated model and implementation. Prefabricated solutions provide a shorter time and lower cost by 43% and 78%, respectively, in average

values, as indicated in Fig. 10. The fever hospital was able to expand the number of isolation rooms in a short period thanks to these strategies. In terms of price, the NTI is predicted to be five times more expensive than the prefab.

5. Conclusions

Two quick solutions for isolating patient beds during the COVID-19 pandemic. The first solution depends on converting natural isolation areas in hospitals into negative isolation wards in only 21 working days. The second one is done by prefabricating or building parts with eight isolated patients and associated services within 12 working days. Both methods were successful. The fever hospital was able to expand the number of isolation rooms in a short period. These solutions have helped the fever hospital to increase the number of isolated rooms in a very short time. The neural network is used in the presented paper as a type of artificial intelligence technique. Regarding the cost, the neural network is predicted to be five times more expensive than prefabricating owing to all essential utilities against the temporary solutions. The hospital was able to make the best possible choice with the aid of the analyzed neural network model. Despite the two methods being designed to have as many isolation rooms as possible, the prefabricate method is the most cost-effective (22 k\$ instead of 97 k\$ for converting natural isolation areas) and time-efficient option based on the research model and execution.

CRedit authorship contribution statement

S. Khaled Ahmed: Conceptualization, Methodology, Software, Supervision. **R. Mohammed Ali:** Data curation, Writing – original draft. **M. Maha Lashin:** Visualization, Investigation. **F. Fayroz Sherif:** Software, Validation, Writing – review & editing.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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