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The application of IE for improving the efficiency and quality of emergency department medical services based on Anylogic simulations

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Abstract: *In recent years, with the development of society and the improvement of the level of science, education, culture and health, the medical industry has occupied an increasingly important position in people lives, and a more comfortable and efficient medical experience has also become the common goal pursued by major hospitals. As an important department of the hospital, the emergency department receives patients with urgent conditions, relatively serious conditions, and a large number of patients, so it is of great significance for both patients and hospitals to improve the quality and experience of medical services in the emergency department. This article has found some ways to improve the quality of care by using Anylogic to simulate the emergency department.*

Keywords: *Industrial Engineering; Emergency Department; Anylogic; Human Factors*

1. Introduction

Emergency departments have a high degree of complexity. Factors inherent to the practice of emergency medicine including: the fast paced nature of the work, unpredictability of patients' medical conditions and that of the clinical work flow as well as the frequent use of "high-risk" intravenous medications. [1] Consistent and timely detection of immediately life-threatening conditions, along with expeditious response, is essential in acute care settings. [2]The purpose of this study is to examine a hospital emergency department that is open 24/7, with special attention to the timely treatment of critically ill patients. The objective of the study is how to simulate the operation of an emergency department using Anylogic simulation software to implement a hierarchical zoning of care in an uninterrupted work situation in order to improve the quality of care, ensure that patients can receive timely care, and improve patient satisfaction.

2. The methods

2.1 Simulation process

Data collection and validation: Before proceeding with the Anylogic simulation, ensure that real and accurate hospital data is collected. This includes patient arrival time, consultation flow, and efficiency of medical staff. Verifying the accuracy of the data is very important for the credibility of the simulation results.

Establish a reasonable model: in the modeling process, ensure the reasonableness and accuracy of the model. According to the actual situation, determine the layout, flow and resource allocation of the hospital, and reflect this information in the Anylogic model.

Setting reasonable flow parameters: flow parameters directly affect the accuracy of simulation results. According to the actual situation of the hospital and historical data, reasonable flow parameters are set to ensure that the number of patients and the arrival rate in the simulation match with the actual situation.

Multi-scenario simulation: Considering that the actual situation of the emergency department may be variable, multiple scenarios can be designed for simulation, such as peak period, flat period, and emergencies, etc., in order to comprehensively understand the performance of the emergency

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department and the response strategies under different circumstances.

Introducing randomness: The operation of hospital emergency departments often involves many random factors, such as the type of patient's disease, arrival time, and length of consultation. Introducing randomness in the simulation can reflect the operation of the hospital more realistically.

Optimize the analysis methods of the simulation results: For the output patient density graph, in addition to finding the bottleneck of the flow of people, other data analysis methods can be used, such as queuing time, average waiting time, the success rate of consultation and other indicators, to further optimize the service process of the emergency department.

Integration with hospital practice: When putting forward improvement suggestions, it is necessary to combine the actual situation and practical experience of the hospital, and fully communicate and discuss with the hospital management, medical and nursing staff, in order to ensure the feasibility of the improvement program and the effectiveness of its implementation.

Continuous optimization and improvement: simulation is a process of continuous optimization and improvement. After the simulation results are obtained, timely feedback is given to the relevant personnel for continuous improvement and optimization in order to improve the quality of medical services and patient satisfaction.

2.2 Principle of IE method

IE is a comprehensive application of the knowledge system, through the IE method of systematic quantitative analysis and accurate measurement can facilitate us to grasp the actual situation of the emergency department, and establish a standard model for analysis and improvement.[3] Emergency departments (ED) in hospitals usually suffer from crowdedness and long waiting times for treatment. [4] Systematic facility planning allows for adjustments to the layout of supplies, facilities, etc and the distance that patients, doctors, and nurses have to travel to reach each department can be shortened, reducing transit time. Human factors engineering is an emerging interdisciplinary discipline that is developing rapidly, aiming to optimize the design of systems to make them more suitable for human cognitive, physiological and psychological characteristics, so as to improve the efficiency of the system, safety and personnel satisfaction, in the design and optimization of the hospital environment, it can be used to plan the hospital environment, take care of the patient's psychology, so that the patient is comfortable, more active in the treatment, and to improve the quality of the patient.

2.3 Setting basic model

Based on the predefined sketch and patient information, the following model is created.

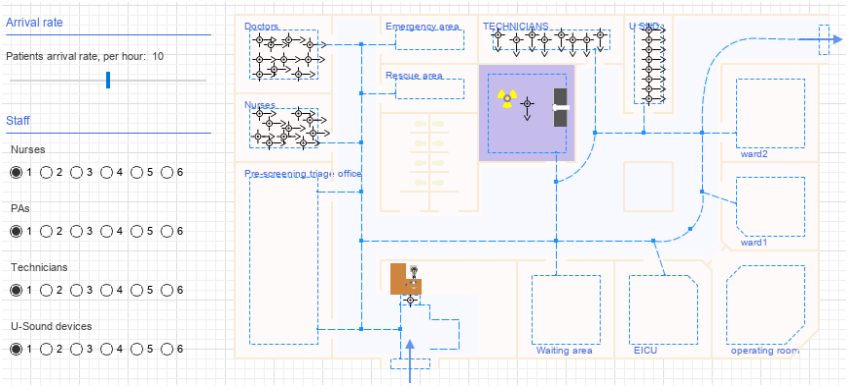

Figure 1: Standard sketch model

Figure 1 shows a standard sketch model and the flow of doctors and nurses and patients and the hospital reception process. Hospitals can use these models as benchmarking tools.[5]

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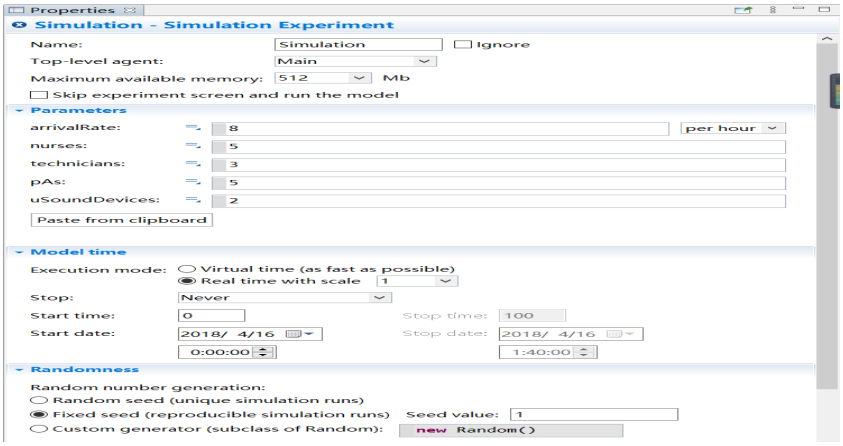

Figure 2: Standard parameter plot

Figure 2 shows a standard parameter plot and the parameters of each intelligence as well as parameter information such as model time, randomness, and so on. The parameters can be adjusted to approximate the real situation or special experimental situations. The average value of admission rate is 150 patients per day for the ED under normal conditions.[6]

3. Results

Figure 3: Model results

Figure 3 shows a standard sketch run of the Emergency Department, which shows the utilization and length of stay in each department, and it is evident that there is still room for some departments to rise in utilization, and optimization measures need to be taken.

3.1 Facility planning and layout optimization

Using the method of facility planning can build a brand new model, remove redundant parts, shorten the moving distance, reduce the transfer time.

3.2 Process optimization and resource allocation

Increasing medical resources, such as additional doctors, nurses, and consultation rooms, to accommodate peak patient flow. At the same time, a more efficient triage system and consultation process should be established to separate the treatment of critically ill patients from mildly ill patients, so that mildly ill patients do not take up too much medical resources and affect the treatment of critically ill patients.

3.3 Optimization of pre-screening and triage

In the pre-screening triage office of the emergency department, the layout and process can be further optimized, and the pre-screening triage office can be set in the area of lower patient density in

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the emergency hall. This can reduce the waiting time of patients in the pre-screening and triage, improve the efficiency of triage, and ensure that critically ill patients can be treated in a timely manner.

3.4 Intelligent admission process design

The introduction of the "Internet +" intelligent admission process allows patients and their families to go through the admission procedures via smartphones or other devices, avoiding unnecessary waiting and queuing and shortening the admission time. At the same time, nurses can improve the efficiency and accuracy of admission procedures through guidance and assistance. This not only saves time, but also reduces the work pressure of emergency nurses and improves patient and family satisfaction.

3.5 First aid process optimization

Standardizing first aid processes and training are established to ensure that medical staff are familiar with and accurately execute first aid measures. The first aid process includes steps such as condition assessment, rapid treatment, and efficient transportation to ensure that patients receive timely and professional treatment in the emergency department.

3.6 Data analysis and optimization

A data statistics and analysis system is established to regularly analyze and optimize the operational data of the emergency department. Through data analysis, the distribution pattern of patients' medical conditions can be found, which will lead to a more reasonable deployment of resources and improve the quality and efficiency of medical services.

4. Discussion

4.1 Layout Strategy Adjustment

Findings show low satisfaction levels for space allocations for emergency department, lab, surgery, and wound care. [7] The pre-screening and triage area, which is the pathway for all patients, is placed directly in front of the entrance and then leads to the other departments, which effectively reduces redundant paths, and the placement of the waiting area and the emergency area at the back of the pre-screening and triage area is undoubtedly the shortest pathway. In addition, the operating room, resuscitation area, nurse's office and doctor's office are also vertically closer to their destinations according to this principle. In the new scheme, the surgeon and resuscitator are located on the shortest path, which can be reached vertically without detouring. Subsequently, the EICU is set behind the resuscitation area as a ward for critically ill patients, which makes it convenient for patients who have been resuscitated to enter the EICU directly to observe their conditions, and for EICU patients to enter the resuscitation area in time to receive resuscitation and timely assistance when their conditions deteriorate.

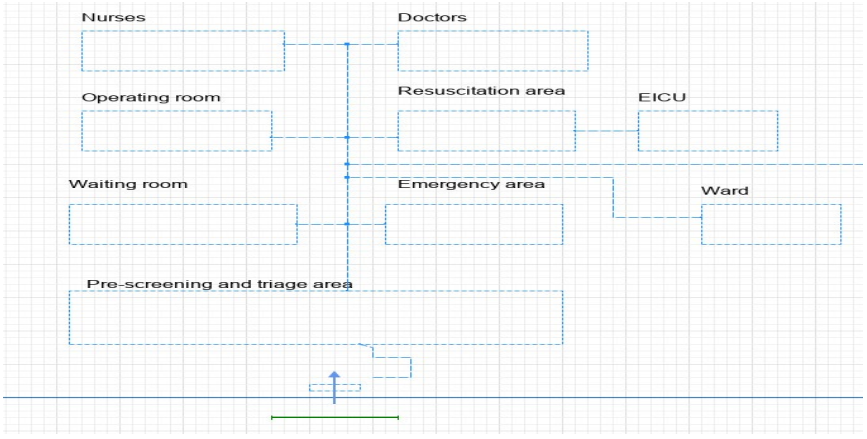

Figure 4: Layout adjustment drawing

Figure 4 shows a layout adjustment drawing. This drawing is a sketch of the adjusted facility layout

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after applying the facility planning tools, this drawing shows the adjusted facility layout and routing options.

4.1.1 Analysis of adjustment results

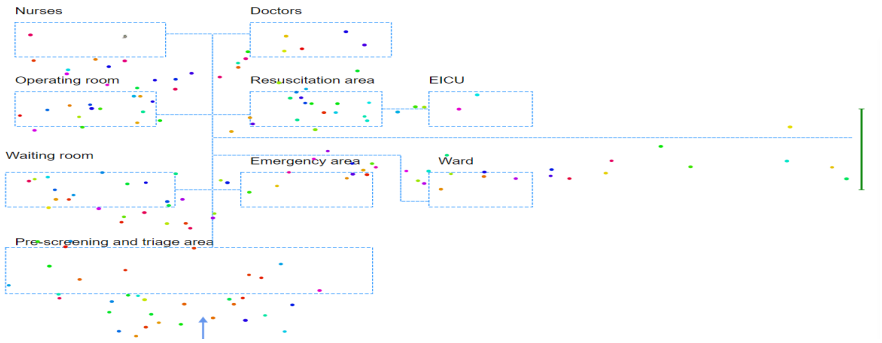

Figure 5: Adjusted run chart

Figure 5 shows the adjusted run chart. This figure is a sketch run chart of the facility arrangement, this figure shows the movement of the intelligences after the facility arrangement. It is possible to corroborate the conclusion that facility planning leads to the shortest path from this figure.

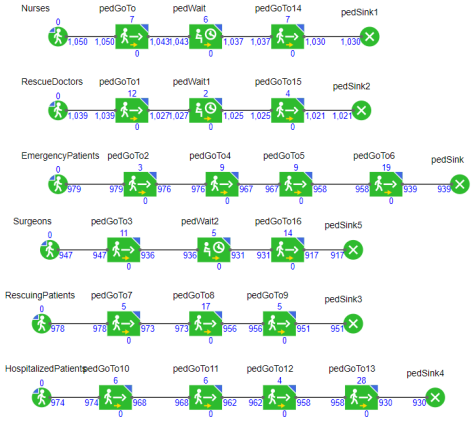

Figure 6: Model results

Figure 6 shows a graph of the model results. This figure is a graph of the resultant data obtained from the operation after the adjustment of the facility planning, which shows a significant reduction in the number of stranded persons, reflecting an increase in the number of people received, and proves that the adjustment of the facility planning can significantly improve the efficiency and the utilization of each section.

4.2 Sensory Control Management Strategy Adjustment

In order to minimize the density, proximity and contact hours of patients in the Emergency Department, and thus effectively reduce the risk of nosocomial infections in patients, our team has developed a series of optimization plans for sensory control management strategies. These strategies are based on an in-depth analysis of the current functional setup, spatial layout, and service flow of the ED in order to enhance the quality of healthcare services and patient experience in the ED.

4.2.1 Ground-level directional signs

We plan to add ground-level directional signs in the emergency hall to effectively disperse patient flow and reduce personnel congregation by directing patients to enter the waiting area from the right-hand corridor, thus avoiding excessive contact between patients and reducing the risk of nosocomial infections.

4.2.2 Additional windows

During the peak hours of patient consultation in the ED, we plan to temporarily add two additional windows on top of the existing two registration and charging windows to shorten the waiting time for

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registration and charging, and to reduce patients' anxiety and waiting pressure. This flexible strategy of adding temporary windows can better cope with fluctuations in patient flow.

4.2.3 Rationalize the location

We consider appropriately adjusting the location of the pre-screening triage office by setting it in an area with lower patient density in the emergency hall. By rationalizing the location, the Pre-screening and Triage Unit can more effectively conduct initial assessment and triage of patients, while avoiding the need to conduct condition inquiries and treatment instructions in crowded areas, thus reducing direct contact between patients.

4.3 Internet + Intelligent Admission Process Design

The traditional emergency admission process is very cumbersome, resulting in a significant increase in the time required for patients to go through the admission procedures, which not only takes up valuable treatment time, but also creates potential safety hazards for the patient's family members when they leave the bedside to go to the hospital billing center to go through the hospitalization procedures due to the lack of family members accompanying them, which can easily produce anxiety, fear and other negative emotions, and even increase the risk of falls and other adverse events in the hospital. In order to solve these problems, we can use the strategy of "Internet+" to optimize the admission process.

4.3.1 Informatization-optimized admission process

Through the introduction of information technology, we have successfully reduced the time spent by patients' family members queuing up for hospitalization procedures at the check-in and check-out center and avoiding the cumbersome filling out of information cards and waiting time in line. Overall, these measures have greatly shortened the time for emergency critical patients to be admitted to the hospital, and bought more valuable time for patients to receive timely treatment.

In addition, optimizing the admission process also enables healthcare staff to pay more active attention and care for patients, enhancing nurse-patient communication and humanistic care. Compared with the passive way of service, we pay more attention to provide patients with a warmer and more intimate medical experience. With such an optimized process, healthcare professionals have more time to accompany and take care of patients, as well as to communicate effectively with patients and their families, thus further reflecting our humanistic care and concern for patients.

4.3.2 Optimizing the admission process by focusing on emergency and critical patients can improve patient satisfaction

As an important department for admitting and treating patients with urgent and critical conditions, the emergency department is often in a state of emotional agitation and easy provocation for patients and their families. The working environment of the emergency department is noisy, the number of patients is huge, and the workload of nursing staff is enormous, which results in the needs of patients and their families sometimes not being met in a timely manner. In addition, patients and their families are unfamiliar with the hospital environment and the process of medical treatment, and often need to go back and forth between different departments or divisions in the hospital, which can easily make the patient's family lose patience, thus reducing the satisfaction of patients and their families. The situation has changed positively through the optimization measures we have undertaken. Through the use of "Internet+" technology, patients' families no longer need to repeatedly travel between hospital departments, and the time spent in queuing for admission procedures has been significantly shortened, making the process more convenient for patients and their families. In addition, the nursing staff of the emergency department pays more attention to the needs of patients during the admission process and provides attentive nursing services, which enhances the communication and understanding between doctors and patients, and further improves the satisfaction of patients and their families.We believe that optimizing the admission process by focusing on emergency critical patients is a beneficial initiative, which not only improves the efficiency of the emergency department and reduces the burden of medical staff, but also enhances the trust and understanding between doctors and patients. Under such an optimized process, the satisfaction of patients and their families is significantly improved, which demonstrates the comprehensive ability of the hospital in terms of quality of care.Compared with the traditional process, the "Internet+" admission process in this study is more centered on emergency critical patients, optimizing the process of patients' medical treatment and nursing management process. The advantages of information technology are fully utilized. In the process of hospitalization of patients' family members, online payment was realized, avoiding the need for patients' family members

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to go back and forth to the wards, the check-in and check-out center and the emergency department several times, thus significantly shortening the time of patients' hospitalization and significantly improving patient satisfaction.

However, some problems were revealed during the implementation process. The online admission process increases the workload of emergency nurses. In response to this problem, swipe card service or cash service can be used to meet the needs of patients' families who are not familiar with cell phone applications. For the characteristics of emergency department patients, such as acute onset, changing conditions, poor physical tolerance, and poor psychological tolerance, a visiting card system can be implemented to improve the standard of triage and examination, build an informationized management platform, and strictly implement the one-doctor-one-patient system, so as to make it convenient and orderly for patients to visit the clinic and get timely and effective treatment. In addition, the introduction of facilities such as self-service registration machines, self-service payment terminals, self-service recharge, self-service printers for test reports, etc., has greatly shortened the time for registering, paying fees, and fetching test reports at the window, effectively ended the phenomenon of long queues for registering and paying fees for outpatient and emergency services, reduced the pressure on the staff, lowered the bad moods of the patients and their families, and improved the patients' satisfaction with the hospital and the nursing work.

4.4 Novel SOAP triage method utilization

Traditional triage methods rely primarily on visual assessment by the triage nurse and subjective judgment by the emergency department nurse. Due to the large number of emergency department visits and heavy workload, traditional triage methods often have a certain degree of randomness, so their accuracy is low.

In order to solve the problems of traditional triage methods, this study adopted the novel SOAP triage method, which is a patient-centered method of comprehensive assessment and categorical triage through four steps: detailed complaint, observation, assessment, and planning. The specific steps are as follows:

Subjective: When the patient arrives at the emergency department, the emergency triage nurse, through appropriate induction clinic, enthusiastically and in detail asks the patient or his/her family members about the disease, main symptoms, clarifies whether the patient has any other related medical history, and obtains the patient's first diagnostic information.

Objective: Emergency triage nurses conduct detailed observation of the patient, including the color of the face, breathing, speed of speech, eyes, movements, state of consciousness and other aspects. At the same time, the patient's special odor will be identified, with particular attention to the presence of pesticide odor or other special odors. In addition, the patient's body will be touched to deal with high fever or body cold in a timely and effective manner, and to clarify whether the patient is in pain and whether the site of pain is fixed.

Assess: On the basis of comprehensive observation and assessment of the severity of the patient's illness, the emergency triage nurse comprehensively analyzes and understands the patient's brief complaints and description of his/her condition, in order to help carry out a preliminary diagnosis or accurately determine the patient's disease category, as well as to select the appropriate consultation department.

Plan: Triage patients according to their condition and direct non-emergency patients to other departments. For patients with serious heart disease, the emergency triage nurse will contact the cardiologist in the cardiology room to conduct an electrocardiogram and measure vital signs such as blood pressure, heart rate, and respiratory rate at the same time, which will provide a reliable basis for the clinician's resuscitation measures.

Before implementing the SOAP triage method, this study evaluated the emergency department nurses and selected nursing staff with high seniority and rich clinical experience for training. The training included SOAP triage process, data writing, anticipatory nursing interventions, etc. The efficiency of the nurses was improved through scenarios, theoretical lectures, case practice discussions and emergency nursing interventions.

In summary, SOAP triage method, as a new triage method, emphasizes the accurate assessment of patients by emergency triage nursing staff in the shortest possible time, and realizes the identification and classification of patients for triage, inquiry about their condition, nursing assessment, placement in

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treatment departments, and preliminary diagnosis, thus effectively improving the efficiency of emergency treatment. The introduction of the SOAP triage method provides a more scientific and efficient means of triage in the emergency department, which is expected to further improve the comprehensive capacity of the hospital, as well as improve the patient experience and satisfaction.

4.5 Regulating the hospital environment based on a human factors engineering perspective

4.5.1 Results of Human Factors Engineering in Hospital Environments

Human factors engineering studies and understands patients' behavior and needs in the hospital environment from the patients' perspective. Through in-depth observation and investigation of the patient's medical process, human factors engineering experts are able to identify potential problems and barriers, such as long waiting times, irrational departmental layouts, and unclear navigation, thus providing targeted improvement solutions for hospital architecture and service design. By analyzing the workflow and workload of medical staff, human factors engineering can optimize the department layout and equipment configuration to improve the efficiency and job satisfaction of medical staff. For example, the location of medical equipment can be rationally arranged so that healthcare workers can access and use the equipment more conveniently in the process of diagnosis and treatment, and reduce unnecessary walking and waiting time. From the perspective of human factors engineering, regulating the hospital environment is of great significance to the diagnosis, treatment and rehabilitation of patients. The indoor and outdoor environments of hospital buildings need to be warm and comfortable, not only concerning the daily life behaviors of inpatients, such as dining, sleeping, defecating, bathing, socializing and relaxing, but also involving the medical behaviors of outpatients, such as registering, waiting for medical treatment, consulting, checking and moving. A safe and comfortable medical environment can enhance patient satisfaction and treatment experience.

In addition, recent studies have shown that a healthy living environment itself also has a considerable healing function, especially for advanced cancer, old age intellectual disability and other modern medical technology is difficult to cure the disease, its role should not be ignored. Therefore, hospital building design should not only focus on improving the efficiency of medical care, but also need to focus on improving the health environment, to provide patients with beneficial treatment and rehabilitation environment.

In addition, human factors engineering also pays attention to the impact of the hospital environment on human psychology and emotions. By creating a comfortable and cozy hospital atmosphere, such as the use of soft lighting, warm tones and natural elements in the design, human factors engineering helps to reduce patients' tension and anxiety and enhance their treatment experience and satisfaction. For healthcare workers, a good working environment and humanized facilities can also increase job satisfaction and reduce occupational fatigue.

When designing hospital buildings, architects not only need to familiarize themselves with advanced medical processes, but also must have an in-depth understanding of patients' life experiences. In practice, architects can adopt the principles of ergonomics to optimize the design of the internal and external environments of hospitals from the perspectives of patients and healthcare workers. For example, the layout and spatial design of the hospital can be rationally planned to ensure that patients can easily and quickly find the departments they need, reducing unnecessary disorientation and waiting time. At the same time, the interior decoration and furniture selection of the hospital should be comfortable and cozy to create a pleasant atmosphere for medical treatment in order to relieve patients' tension and anxiety. In addition, design elements of natural light and greenery are used to give hospitals more natural environments, which can help enhance patients' psychological pleasure and healing effects. In addition, through technological means, online reservation, self-service registration, medical information inquiry and other services are provided to optimize the medical process, reduce patients' waiting time and improve the efficiency of healthcare.

5. Conclusion

When the manufacturing system does not achieve the expected results as it is supposed to achieve, the study is conducted to find out the problems and control and manage them. When the results achieved by the manufacturing system are insufficient or the operation is inconvenient, and it is necessary to improve part of the system, we study ways to improve the system. When a new situation occurs that makes it difficult to achieve adequate results with the original system, we look for

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requirements and study and design a new system. Establishing the emergency department simulation model, and then analyze the model, so you can get suggestions for improvement, using a variety of methods, you can improve the fit between the emergency department simulation and the reality of the situation, for a better model can be proposed to improve the suggestions more in line with the actual situation, the use of these suggestions can be effective to improve the quality of health care services in the emergency department and experience, and to find ways to improve the quality of health care.

6. Expectation

Our research attempts to construct feasible improvement programs for hospitals by applying industrial engineering theory and scientific management methods. This study, if supported by hospitals and more actual data, may be able to bring the standard model closer to reality, obtain better data, and thus suggest more effective and promising improvement strategies. After all, the discrepancy between actual OR efficiency and standards used for planning of surgical facilities represents a challenge.[8] Overcoming the gap between modeling and reality must rely on more real data.

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