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A Study on the Optimization of the Accommodation Number at Health Examination Center using Agent Based Modeling

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Abstract

The efficiency of moving paths and reduction of waiting time is significant for health examination centers in terms of the convenience of examinees. Thus, this study identified problems of illustrated health examination centers and set the adjustment of the number of service and despair exchange as alternatives by using an index drawn by agent-based simulations. Thus, it could obtain the improved effect of efficiencies such as enormous reduction of time for examination time and rising numbers of people available for accommodation through the test simulation. The moderate setting of the number of services and the area distribution of space greatly affect the reduction of examination time and the reasonable arrangement was effective in cutting the length of the moving path. If this is applied to the phase of architectural design, it will be useful for reasonable spatial arrangement and calculating size with low costs.

Keywords: *Health examination center, Agent based model, Discrete event simulation*

1. Introduction

As income level elevates, interest in health is dramatically growing. The importance of prevention rather than treatment is highlighted. Thus, the dignity of health examination center is built up as an independent medical facility under the subsidiary facility of hospitals and demands is skyrocketing.

However, an excessive quantitative rise in health examination centers will bring intense competition in the medical market. The improvement of the qualitative level, particularly service quality is a key indicator as a tool for ensuring competitiveness.

Although several factors such as medical technology, price, service, and accessibility function in the quality of hospital service, it is not easy to improve the quality due to the limits of the expense compared to productivity.

Contrary to general medical functions, health examination centers have a systematic structure to proceed designated examination subjects by the defined procedure. Since this facility was less influenced by medical technology, it is significantly affected by an environmental factor compared to other factors.

This paper, therefore, aimed to approach the quality of spatial quality of health examination centers in terms of shortening waiting time and increasing numbers of accommodating people. It identified problems of this center by utilizing agent-based discrete event simulation and explored methods of enhancing examination service with the minimal improvement of facilities.

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This study was conducted according to the following methods and sequences to attain its goals.

First, it establishes examination subjects and standard examination procedures for examinee-centered and efficient examination.

Second, it establishes simulation tools that develop evaluation indexes and extract data for analysis.

Third, it identifies problems of examinee congestion and density through a simulation analysis of example space and proposes improved methods that corrected problems such as room rearrangement and service adjustment.

Fourth, it draws the degree of improvement quantitatively through the test simulation.

Even if simulation associated with interpreting the complex system is the identical model, there is a difference in result values whenever simulation is implemented. Therefore, reliability increases by obtaining generalized values through repeated simulations. However, this paper drew data by carrying out one-time simulation as it mainly proposes research outcomes.

2. Rise in Demand and Supply of Examination Service

Medical treatment changes from the previous treatment to prevention and expands from patients to patients, especially ordinary people. Thus, the recognition of health examination centers previously serving as subsidiary functions of main hospitals is elevated as an independent function and there is a hike in demand and supply in conjunction with a variety of nationwide health policies.

If hospitals do not actively respond to the internal or external environmental change due to the intense competition in the medical market, they will face extremely huge risks because of worse management performance. Patient satisfaction should be in top priority to address this problem. Treating diseases as its fundamental purpose as well as the process in hospitals until receiving medical treatments which means medical process are significant factors in customer satisfaction [1].

Although evaluation on the level of customer satisfaction can be accessed in various aspects, convenience, quality, and price can be selected as major factors [2].

Contrary to treatment, health examination centers are largely affected by spatial environments where patients are diagnosed in a cozy environment compared to medical technology. In particular, hospital treatment and the reduction of treatment time are perceived as significant factors in the medical process [3]. Waiting time can give a huge impact on satisfaction since most patients wait under negative situations such as disease treatment in hospitals contrary to ordinary customers who wait under positive situations such as watching films or delicious meals [4].

Although hospitals make diverse attempts to enhance their competitions, they are limited to cost reduction, productivity, and professional medical service. Moreover, they place customer service in an extremely low rank [5]. Although they are fully aware of the importance of shortening waiting time, they encounter difficult situations to expand facilities or hire more doctors and nurses due to the limits of several resources. In addition, they should analyze to what extent they should expand facilities or hire more employees and how optimal effects can be obtained with low costs before they undertake [6].

This study aimed to find methods for reducing waiting time regarded as a major complaint proposed by customers and enhancing the convenience of examinees in the spatial structure, development evaluation index, and test the effect of the improved methods.

3. Design and Analysis of Simulation

3.1. The composition of workflow

The screening procedure was set up based on the examination procedures specified by the Korean Association of Health Promotion Management home page [7] and J. H. Jung's study [8].

The following conditions were set in the course of writing the workflow for the examination procedure coding [7].

Participants were set to arrive at health examination centers by one or two minute intervals and apply for examination with the ratio of men 54.128%: women 45.872% by the National Health Screening Statistical Yearbook.

Examinees select endoscope and upper gastrointestinography and one of five participants (20%) were set to receive upper gastrointestinography and others receive gastroscope.

After performing the endoscope, the recovery room was only provided for examinees in conscious sedation endoscope and one of four (25%) selected this examination.

30 lockers in a fitting room, 20 beds in recovery rooms, three people for ophthalmologic examination at the same time, two people for gastroscope at the same time, and two people for physical measurement at the same time were set depending on the actual examination center environment.

3.2. The composition of workflow

If 50 patients are assumed to comply with the entire procedure of the standard program, re-simulation revealed that the agent who completed the examination within the shortest time took 01:07:27 (4,047.35 seconds) and the last agent took 05:08:25 (18,505.42 seconds). In contrast, the 48th agent took 05:13:30 which recorded the longest time, because there are different types of examinations by gender.

Examination exceeding five hours is inefficient. As shown in the graph on the number of waiting people by time Figure 2 Before, there are many waiting lists in electrocardiography (ECG) and Hearing Test (HT).

For electrocardiography, there are up to 32 people in the waiting line between 9,800 seconds and 10,100 seconds. For Hearing Test (HT), there are 18 waiting people between 6,400 seconds and 6,800 seconds. The waiting time of examinees caused by this process turned out a major cause of increasing examination time.

This implies that the concentration of examinees can be elevated in the south waiting for lines and eastern parts of the northern aisle. Since there is almost no additional waiting space in eastern parts, it is very likely to be congested.

Moreover, complicated moving paths and increasing moving distances due to different examination procedures and service arrangements serve as causes for reducing spatial perception and increasing examination time. To address this problem, service (examination) capabilities at bottleneck intervals need to be enhanced and moving time needs to be shortened by arranging moving paths.

3.3. The composition of workflow

First of all, it simplified moving paths to reduce examination time and facilitate spatial perception. However, it did not change the location of the restroom as an installed facility, minimize the change in wall layouts based on the premise that costs should be minimized, and changed room layouts at the level of maintaining the ratio of common space.

Minimum space was set to exchange mutually by the examination sequence to simplify the overlapped moving path and waiting space is exchanged to reduce the traffic of common space. In addition, space needed for expanding examination service is proportionately increased and redundant parts are diminished.

Therefore, Ophthalmology (O) was moved to a Counseling room (C), the counseling room was relocated to a Hearing Test (HT), the Hearing Test (HT) was relocated to pulmonary function test (PET), and this pulmonary function test (PET) was shifted to Ophthalmology(O), and nurse room was exchanged with nutrition Counseling room(C).

This relocation was in part performed to obtain space to extend service. The number of Hearing Test (HT) and electrocardiography(ECG) in which traffics occur frequently increased one by one, reducing three blood gathering rooms service into two rooms and relocating employees at Blood Gathering room (BG) to Hearing Test (HT) and electrocardiography(ECG) and arranging them.

3.4. The composition of workflow

It compared and assessed results by analyzing improvement (After) and previous flat surface (Before) through the simulation and by producing an index.

As shown in [Figure 1], the previously flat surface showed the average 04:05:01 (14,701 seconds) per person of total examination time for 50 people, while the improved method showed 03:27:06(12,426 seconds), reducing 37.55 minutes.

For the maximum time, the previously flat surface showed 07:09:23 (25,764 seconds), while the improved method showed 05:13:30 (18,810 seconds), reducing 37:55 minutes and saving nearly two hours (01:55:53) and even average examination time of examinees was uniform.

So, the previously flat surface cannot accommodate up to nearly 30 people to complete the examination within the morning, while the improved method can handle up to about 50 people during the examination.

This improved effect was largely affected by the adjustment of waiting lines. The sum of a maximum number of waiting for people before and after the change is equivalent to 65(mean 4.64). However, a drop in waiting time resulted from transferring hearing tests to the wider place considered as the biggest cause of delayed examination and rapidly reducing waiting for lines by increasing the number of a relatively affordable hearing test and electrocardiography (ECG) service.

For the increased manpower, two people at a blood gathering room where service was cut as there was no one on the waiting list were distributed to hearing test(HT) and electrocardiography (ECG), no additional workforce is needed.

As shown in [Figure 2], it is possible to figure out intuitively causes of decrease by comparing the previous flat surface (Before) with the improved method (After). The previous flat surface is primarily concentrated in electrocardiography (ECG), while the improved method is distributed to Blood Gathering (BG), electrocardiography (ECG), and Pulmonary Function Test (PFT) and the peak number of people in the waiting list dropped from 32 to 19.

Although there was a rise in blood gathering and pulmonary function in which almost no waiting line appeared, greatly improved effects were found in a comprehensive perspective since the average examination time by person and total performing time in examination work were dramatically reduced.

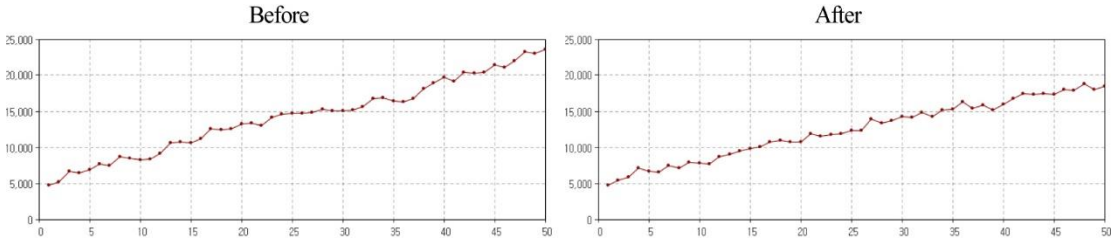

Figure 1. End time by agents

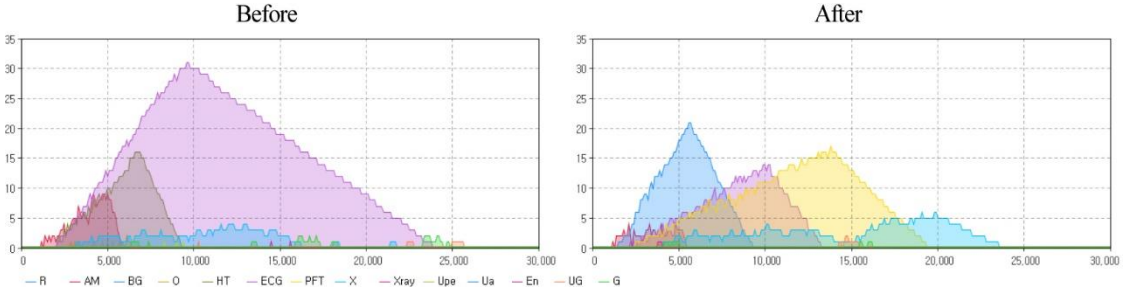

Figure 2. Change in waiting lines by time

4. Conclusion

The major cause of prolonging examination time can be classified into the generation of excessive waiting lines and the rise in moving paths. Therefore, appropriate distribution of traffic for waiting for lines not to be packed in certain service such as a check-up room is a good way to shorten the entire examination time.

Accordingly, it found excessive facilities and insufficient facilities by using agent-based simulation, improved problems, and qualitatively identified the improved effects through the test simulation.

This study concluded by conducting a respective experiment on the previously flat surface and improvements as preliminary research on the development phase. The updated research will be mainly carried out focusing on improving reliability with data obtained from more than ten times repeated simulations and understanding the spatial network structures according to the service rearrangement.

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