Simulation of First Level Health Care Facilities to Reduce Patient Flow Time

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Abstract. This paper presented research on the simulation of first-level health care facilities, Community Health Centers managed by the government and the Main Clinic managed by the private sector. The objectives of this study include identifying patient flow times, locations of congestion, and determining scenarios to improve system performance. This paper used a simulation model as a method to developed using a discrete event simulation approach, the study continued with data collection in the form of flow and volume of patient arrivals and service times at each location. By analyzing statistical data from 30 replications, it shows that there are differences in characteristics between the Community Health Center and the Primary Clinic, in the bottle-neck location and the performance of the Main Clinic is better than the Community Health Center, with patients flowing time, respectively 2516.23 seconds and 4881.03 seconds. However, after repairs were made in the bottleneck location at the Community Health Center and Main Clinic, the flow time of patients was almost the same, respectively 1787.81 seconds and 1731.25 seconds. In conclusion, when congestion sites can be identified, improvements are made to reduce patient time flow from two health care facilities, and even show a relatively equal time.

1. Introduction

The complaints often expressed by patients at the first level health care facility due to the waiting time in the queue is too long. Especially, since the national health insurance program was effectively implemented on January 1, 2014 [1] the number of patients visiting first level health care facilities continued to increase, recorded in 2014, 2015 and 2016 respectively, 66.8 million, 100.6 million, and 120.9 million [2]. The first level health care facilities studied were Community Health Centers and Primary Clinics, because in both facilities there were generally long queues. The results of preliminary observations at several first level health care facilities, both those managed by the government and the private sector, showed that there was always a patient queue in the morning. Long queues are often complain by patients who hope to get service as soon as possible, as well as limited seating provided for patients waiting. Research conducted at the Community Health Center in Cilegon showed that the flow time was 56.58 minutes or equivalent to 3470 seconds, system improvement was done using Lean Healthcare approach through identification emphasizing the identification of Value Added, Non-Value Added, and Necessary Non-Value Added activities [3]. Research at the Pesantren 1 Health Center resulted in patient service times was 55.45 minutes, equivalent to 3327 seconds, the method used in this study was analytic survey [4]. Research at the Mulya Mekar Community Health Center by using Queue Theory, produces expectation of waiting time in the system was 45.45 minutes, equivalent to 2727 seconds [5]. Another study conducted at a hospital in Amman Jordan by using the Six Sigma Approach, resulting in a flow time, was 3394.8 seconds [6]. Research at the King Hussein Cancer Center Hospital using the Six Sigma Approach and Discrete Event Simulation,
resulted in a total discharge time of 216 minutes, equivalent to 12,960 seconds [7]. All of these studies aim to reduce service time from health care facilities, however, each study was only conducted in one health care facility.

Based on these studies, it is necessary to do research and find out how the impact of the implementation of the national health insurance program especially on first level health care facilities, by comparing the characteristics of patient flows and performance in the form of time needed by patients in the system, from Community Health Centers managed by the government and Primary Clinic which is managed by the private sector. The study was conducted with the Simulation Discrete-Event method, this method is increasingly being used to improve the performance of health care services [8].

2. Method
This research was carried out based on discrete event simulation methodology as described by Rajesh Mansharamani including the activities of Event Scheduling, Activity Scanning, Process Interaction, and Summary [9]. The discrete system simulation method can be done with the help of a simulation software tool as described by Harrell, one of the software that utilized is ProModel. It has the ability to provide insightful, relevant, and beneficial answers to engineers [10]. Discrete event simulation methods that are more specific to health facilities are explained by Hamrock including the steps to Determine Goals, Define Objectives, Collect Data, Develop Models, Perform Verifications, Test Scenarios, and Measure Results and Compare them with Baseline [11].

Based on the methods that have been developed previously, this research was conducted in five stages, first setting goals, then collecting data, building models and verifying, conducting experiments, and making recommendations.

3. Result and discussion
Research begins with setting goals, based on a review of Jun, Jacobson, and Swisher, discrete event simulations in health services are effective tools for allocating resources to improve patient flow, minimize costs, and improve patient satisfaction [12]. This research was oriented to improve patient satisfaction by identifying the time of service for health facilities, the location of bottlenecks that cause long queues, and conducting experiments to find alternative solutions. Hypothetically, the smoother the flow of patients through each service location, the shorter the time needed by patients in the system, starting from the registration process to the completion of the drug acceptance process. Based on Minister of Health Decree Number 129 / Menkes / SK / II / 2008, the standard outpatient service time is $\leq 60$ minutes [4].

The second stage was collecting data from two locations, at the Community Health Center in Cimahi and the Primary Clinic in Bandung. The data collected includes the volume and flow of the patient’s arrival, the location of the service and the time of service, and the process passed by the patient from arrival to discharge. The collected data is then processed statistically to determine a suitable probability distribution. This is an important element in the development of simulation models as the basis for generating random variables used in experiments [13]. Data processing obtained from Community Health Centers and Primary Clinics can be seen in Table 1 which shows that there are differences in the distribution of patient arrivals and service times between the first two health facilities, the number of patient arrivals at the Community Health Center was higher than the Primary Clinic, this also influenced by primary clinical policies that divide services into two sessions per day, so patients are distributed in the morning and evening sessions. Another difference was the type of clinic services provided, in the Community Health Center there is an elderly poly, while midwifery is available at the Primary Clinic.
### Table 1. Comparison of results of data processing at Community Health Centers and Primary Clinics

|                                | Community Health Center | Primary Clinic |
|--------------------------------|-------------------------|----------------|
| **Arrival Rate**               | Exponential             | Exponential    |
| **Registration Service Time**  | Pearson 6, 19, 1.3, 2.48, 36.3 | Pearson 5, -156, 5.7, 1730 |
| **Poly Family Service Time**   | Lognormal, 490.7, 17933.3 | Lognormal, 174.1, 6707.5 |
| **Elderly Poly Service Time**  | Pearson 5, 14.2, 7.63, 1960 | -               |
| **Midwifery**                  | -                       | Pearson 5, 121, 1.45, 320 |
| **Poly Dental Service Time**   | Pearson 5, -1.33, 16, 8900 | Beta, 1.3, 3.32, 159, 2010 |
| **Pharmacy Service Time**      | Lognormal, 173.5, 366.4 | Gamma, 18, 1, 107 |

The third stage begins with building models including Locations, Entities, Arrival, Processing, Network Paths, and Shifts. In the Community Health Center model there are 15 locations while in the Primary Clinic model there are 13 locations. The difference is at the location of the initial examination and acceptance of the doctor's prescription. Layout simulation model for Primary Clinic as shown in Figure 1.

![Figure 1. Layout of Primary Clinical Simulation Model](image)

Verification of the simulation model is carried out with 30 replications on each model. On average 99.03 patients are served by Community Health Centers in one day, this output is close to the target number of 100 people per day, on average 52.5 patients are served by the Primary Clinic which is quite close to the target of an average of 50 people per day. So, this model was considered sufficient to represent the actual condition.
The experimental stage begins by using the actual conditions, resulting in a comparison of the performance of the first two health care facilities as shown in Table 2. The flow time of the Community Health Center is slower than the Primary Clinic, 4881.03 seconds compared to 2516.23 seconds. This is related to the policies of the Primary Clinic which opened two service sessions. A maximum of 150 patients can be served by the Public Health Center, while a maximum of 76 patients can be served by the Primary Clinic in one session. Bottlenecks in the Health Center simulation model occurred at the location of doctor's examination and pharmacy services with a maximum queue of 31.16 and 11.87 patients respectively, while bottlenecks on the Primary Clinic simulation model occurred at the registration location with a maximum queue of 33.5 patients.

Table 2. Comparison of Actual System Performance Metrics between Community Health Center and Primary Clinic

|                                | Community Health Center | Primary Clinic |
|--------------------------------|-------------------------|----------------|
|                                | Max  | Avg  | Max  | Avg  | Unit       |
| Number of Patients             | 115  | 99.03| 62   | 52.5 | Patients   |
| Average Time In Systems        | 11372.4 | 4881.03| 8950.8 | 2516.53 | Sec       |
| Registration queue (max)       | 1.6  | 0.02 | 33.53| 13.32| Patients   |
| Waiting Room (max)             | 31.16| 10.53| 11.84| 2.73 | Patients   |
| Pharmacy queue (max)           | 11.87| 7.16 | 1    | 0.13 | Patients   |

Many scenarios can be used to improve the performance of health care facilities, for example repositioning service locations with the intention of reducing transportation time, this was chosen in research at the Community Health Center in Jombang [3], or by adding pharmacists on duty, as chosen in the study in a hospital in Amman, Jordan [6], or with simplified and standardized processes such as those implemented at the King Hussein Cancer Center [7]. This study chose experiments with scenarios to increase location capacity, to compare impacts on both health care facilities. Based on the experimental results of the actual model, scenarios are developed to improve system performance. The improvement scenario for the Community Health Center is to add service units at the Elderly Poly and Pharmacy, because the utilities of these two locations are the highest, 71.94% and 72.36% respectively. While the scenario for Primary Clinic is to add one unit to the registration service. Experiments using these scenarios resulted in improved performance both for the average service time, the number of patients served, and the average queue. The average service time of the Community Health Center can be reduced by 63% to 1787.81 seconds, the number of patients served increased by 4% to 103.17, the average queue of examinations was reduced by 64% to 3.83 patients, and the average queue in pharmacy decreased 78% to 1.55 patient. The average service time of Primary Clinic was reduced by 31% to 1731.25 seconds, the number of patients served increased by 18% to 62.13 patients, the average registration queue was reduced by 39% to 8.06 patients. An important finding from this study is that after improvements to the simulation model, the patient's time in the system of both is similar, each less than 30 minutes (1800 seconds), faster than the standard time which is less than 60 minutes.

4. Conclusion

There are differences in the characteristics of the service system between the Community Health Center and the Primary Clinic covering the number of service locations. The Community Health Center has more service locations, namely the initial examination of family poly patients and the prescription taking counter. Another difference is in locations that cause bottlenecks, at the Community Health Center queues occur at the doctor's examination and pharmacy services, while at the Primary Clinic the queue occurs at the registration location. Performance improvements for the Community Health Center can be done by adding a medical examination unit and pharmacy services, while for Primary Clinics the priority
is the addition of registration service units. The time of flow of patients from trials using this scenario shows that the performance of two health facilities is relatively the same. The Community Health Center was 1787.81 seconds and the Primary Clinic was 1731.25 seconds.

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