Application Internet of Things (IoT) in Healthcare to Optimize Waiting Time Using the Business Process Reengineering (BPR) Approach

Mutia Perwita Sari, Novandra Rhezza Pratama, M.Dachyar
Department og industrial Engineering
Faculty of Engineering
Universitas Indonesia
Depok, Indonesia
mutia.perwitasari24@gmail.com, novandra@ui.ac.id, mdachyar@yahoo.com

Abstract

Both public and private hospitals are increasingly under pressure to improve patient care across all medical disciplines and departments. Hospitals must become patient-oriented, responsive, lean and adequate in order to properly realign and integrate health care processes. One way it is necessary to reform current systems of medical care and improve the efficiency of medical care. The subject of this study was an outpatient service in a hospital. The purpose of this study is to design improvement surgery in outpatient service in a hospital to be more efficient and effective. The research uses the approach of business process re-engineering (BPR) to improve service process time and reduce waiting time. In the BPR approach, two main steps, which are mapping as-is process. The as-is mapping model, the model is created and simulated to examine the current process time of the hospital outpatient pharmacy, and then as-is model is analyzed, and then several to-be models with different scenarios is designed and compared with as-is model. The models are simulated and run using Business Process Modeling Notation (BPMN) in iGrafx software to investigate how much the healthcare services has improved compared to the current condition.

Keywords
Business Process Re-engineering (BPR), Hospital efficiency, Hospital Outpatient services, simulation modeling, simulation modeling.

1. Introduction
Most hospitals in Indonesia are very profit-oriented; a case that often occurs in the healthcare sector is considered to be complex and is characterised by escalating costs because the process is less efficient and causes long waiting times. The community's need for quality that is oriented to customer value encourages hospitals to respond quickly. Every installation in it continues to make improvements. The rapidly changing hospital environment creates a need to re-engineer processes to cope with patient expectations (Khalid Al Badiic 2018). Process re-engineering is a set of tools management and purposeful redesign thinking to produce increasingly dramatic performance measures with process redesign.

The service process in hospital outpatient is yet optimal to meet the requirement to provide fast and appropriate services. In addition, the actual conditions do not meet the Indonesian national minimum standard of hospital outpatient waiting time as stated in the Decree of the Minister of Health Number 129/Menkes/SK/II/2008, namely 2 hours regarding minimum hospital services standard. It can justifiably be said that healthcare has become an extremely complex sector. There are an increasing number of medical specialisations and professions, complex therapies and equipment and often, several service units revolve around different organisations (Bertolini et al. 2011).

As a complex institution, a hospital requires a quality information system to be able to deliver its service effectively and efficiently(Dachyar and Nattaya 2020). The effort to cut time is the most visible and effective method to improve service quality by using IoT support therefore, IoT has been widely implemented in hospitals (Arovah and Dachyar 2020). IoT is able to improve operational efficiency and patient satisfaction through information and operational technologies integration, more responsive services, efficient assets utilization and maintenance, also cost reduction without reducing the service quality (Antonius and Dachyar 2020). This research aims to redesign a process to reduce patient waiting time at hospital outpatient services process through IoT implementation with Business Process Reengineering (BPR) approach. Data collection was carried out by literature studies, observations from a hospital a field study in hospital, interviews with various hospital staff.

The use and adoption of IoT technology in healthcare keep increasing over the years because it is a new trend technology that can be utilized in the healthcare sector to improve healthcare quality, organizational performance, and healthcare society in general. Indonesia is currently being emphasized to be able to compete with foreign hospitals in efforts to improve hospitality in hospitals. One of the efforts to improve hospital service is by implementing technology (Zen and Dachyar 2021)

RSUD Dr R Soedjono Selong is a developing hospital and accredited B. The hospital provides several types of services, one of them being outpatient services. Each installation in it continues to evaluate and improve, both in terms of service to end customers and business processes. Therefore, in making improvements to outpatient services to reduce time in its business processes, a number of management techniques are proposed. One of them is by business processes re-engineering (BPR) by implementing the internet of things (IoT).

Based on interviews at Dr. Hospital. R. Soedjono Selong with several pharmacist officers revealed that there were obstacles that occurred in outpatient pharmacy installations such as dispensing errors, drug stocks at the depot did not match the billing data in the warehouse, which caused the waiting time for patients to order the needed drugs, was not detected. medicine when the doctor prescribes medicine

2. Literature Review

2.1 Outpatient Waiting Time

Outpatient services are among the busiest departments in the hospital, and its workload tends to increase over time. Long waiting time is one of the most common problems in this department. Many countries strive to overcome outpatient waiting issues by applying a particular system or technology. A prior study conducted a quality improvement project to reduce waiting time in an outpatient clinic and gained a 4% increase of patients seen by the doctor within 60 minutes as well as a 36.6% reduction in cashier waiting time as a result(Dachyar and Nattaya 2020). Other prior case studies re-engineered outpatient workflow, and the simulation result showed a 20% improvement in time efficiency. (Dachyar and Nattaya 2020).

2.2 Business Process

A business process (BP) is a set of one or more linked procedures or activities executed following a predefined order which collectively realize a business objective or policy goal, normally within the context of an organizational structure defining functional roles or relationships. A process can be entirely contained within a single organizational unit as well as it can span several different organization(Chinosi and Trombetta 2012). Business process collaboration across enterprise boundaries is a complex task due to the lack of unique semantics for the terminology of their BP models and to the use of various standards in BP modelling and execution. Business process management (BPM) provides governance of a business's process environment to improve agility and operational performance. It is a systematic approach to improve any organization's business processes(Chinosi and Trombetta 2012).

2.3 Business Process Re-engineering

BPR Used since 1990 has worked on a large scale and has achieved many benefits, such as lower costs and increased production, improved products, and increased customer satisfaction. There are many definitions for re-engineering processes, and these definitions vary in focus. (AbdEllatif et al. 2018). BPR is defined as a fundamental rethinking and radical redesign of business processes to achieve substantial improvements in all performance metrics such as cost, speed, quality, and service. (AbdEllatif et al, 2018).

2.4Internet Of Things (IoT)

The Internet of Things (IoT) is defined as the physical object network that is embedded with sensors, software, and other technology in order to communicate and exchange data over the internet with other devices or systems. IoT is based on integrations of various processes such as identifying, sensing, networking, and computation(Zen and Dachyar 2021). Internet of things (IoT) makes it attainable for connecting different various smart objects together with the internet. The evolutionary medical model towards medicine can be boosted by IoT with involving sensors such as environmental sensors inside the internal environment of a small room with a specific purpose of monitoring of person's health with a kind of assistance that can be remotely controlled(Khan et al. 2021).

3. Methods

This research was conducted to reengineering current process used BPR approach with the main step, which are mapping as-is process. In mapping, the process as-is, business process flow and standard time are needed for each activity. Find the standard time using the time study method identification of problems from the as-is process in outpatient services based on literature, observations and interviews of experts. Based on the results of problem identification, analyze using the best practice BPR. System development is enhanced using IoT, and for the to-be process, The models are simulated and run using Business Process Modeling Notation (BPMN) in iGrafx software.

4. Data Collection

As many 10 samples were involved to calculate the length of time required in the process business outpatient services. R1, R2 etc shows that there are 10 respondents. Data collection in the form of observation time, which is recorded in the observation form to find out the standard time for each process, calculations are carried out using a time study. Table.1 shows the time of each process with ten samples and the standard time of each process.

Table 1. Actual Time of Each Process

No	Process/Second	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
1	Drug Preparation	31	22	40	17	25	28	33.9	18	19.5	15.9
2	Checking Files in the information center	53	47	42	68	40	90	48	80	57	35
3	File Verification	20	18	32	28.9	26.2	14	15.7	30	26.9	19
4	Counter 1 &2 for making RM & Registration	297	315	330	308	325	326	299	304	301	316
5	Patient Calling	7	4	5.3	6	3.2	6.3	7.7	5	4	5
6	File Verification	12	11	9.8	13	12.3	10.5	16	13.9	10.5	9.6
7	Making the booking on the bride	31	12	14	22	30	18	24	19	12	23
8	Counter 3&4 Delivery of RM or file control	49	50	58	46	48	59	58	58	57	59
9	Delivery RM	34.2	20.5	37	26	20	37.9	25.6	40.1	45	43
10	Collection RM	20	18	21	19	22	18	21	19	21.7	19.6
11	File check at Poli	198	213	303	286	440	222	326	209	187	169
12	Patient Calling	14	28	18.3	18	20.7	22	27	30	29.7	19.9
13	A check-up by a doctor	431.8	325.8	360	311	359	318	326	217	355	215
14	RM Recap	181	209	280	212	198	279	219	281	235	283
15	give the receipt	41	56	50	63	58	70	56	49.9	52	55.1
16	consular check	38	38.4	39	41	38.9	32	37	40	41	32
17	Lab Action	1211	1176	1899	1530	1241	1755	1976	1419	1321	1721

No	Process/Second	R1	R2	R3	R4	R5	R6	R7	R8	R9	R10
18	Lab Results	59	57	61	55	59.7	59	54	47	53	50
19	Patient Calling	31	42	30.3	29	31.5	27.4	25.1	31.2	37.3	25
20	Give the prescription drugs at the pharmacy	52.3	41.2	40.7	68.4	66.9	50	55	60.8	59.9	63.8
21	Screening administration	100	113	70.2	89.7	77.2	89	87.3	132	138	165
22	Print E-Ticket	86.6	89.4	68.9	70	91.7	80.2	99.2	99.7	88	97.8
23	Taking Medicine and checking availability	56	46	56	55	51	56	57	49	59	54
24	looking at other depots	435	466	487	468	459	380	319	412	497	421
25	Confirm to the doctor	178	143	179	145	188	148	126	166	185	172
26	Drug Preparation	1621	1456	1827	1420	1301	1289	1508	1525	1362	1521
27	packaging the medecine	92	112	98	116	99	115	96	136	108	114
28	Final Verification	147	121	137	124	129	142	144	145	131	129
29	Calling Patient	30.5	55.1	36.1	44	40	37	35.9	29.7	36	42
30	Drug intake and use education	173	169.5	276	294	201	325	274	251	321	106

5. Results and Discussion

5.1 Numerical Results

After knowing the time of each process and then doing a calculation to find out the standard time for each process. Table 2 shows the standard time. P1, P2 etc, representation process1, process 2 etc in the pharmacy installation. shows that there are 10 respondents before knowing the standard time, a data adequacy test and data uniformity test are calculated. The test is carried out to find out whether the data collected is sufficient and uniform.

Table 2. Calculation To Find Out the Standard Time

Process	Standard deviation	Mean	LCL	UCL	Performance Rating	Allowance Time	Normal Time	Standard Time
P1	8.06	25.03	0.86	49.20	1.05	0.05	26.28	27.66
P2	18.02	56.00	1.93	110.07	1.05	0.05	58.80	61.89
P3	6.45	23.07	3.72	42.42	1.05	0.05	24.22	25.50
P4	12.06	312.10	275.92	383.28	1.05	0.05	327.71	344.95
P5	1.42	5.35	1.10	9.60	1.05	0.05	5.62	5.91
P6	2.02	11.86	5.81	17.91	1.05	0.05	12.45	13.11
P7	6.80	20.50	0.09	40.91	1.05	0.05	21.53	22.66
P8	5.25	54.20	38.46	69.94	1.05	0.05	56.91	59.91
P9	9.22	32.93	5.27	60.59	1.05	0.05	34.58	36.40
P10	1.45	19.93	15.57	24.29	1.05	0.05	20.93	22.03
P11	83.51	255.30	4.76	505.84	1.05	0.05	268.07	282.17
P12	5.56	22.76	6.08	39.44	1.05	0.05	23.90	25.16

Process	Standard deviation	Mean	LCL	UCL	Performance Rating	Allowance Time	Normal Time	Standard Time
P13	65.49	321.86	125.39	518.33	1.06	0.05	341.17	359.13
P14	39.52	237.70	119.15	356.25	1.05	0.05	249.59	262.72
P15	7.86	55.10	31.52	78.68	1.05	0.05	57.86	60.90
P16	3.27	37.73	27.92	47.54	1.05	0.05	39.62	41.70
P17	296.00	636.91	636.91	2412.89	1.06	0.05	1616.39	1701.47
P18	4.54	55.47	41.84	69.10	1.05	0.05	58.24	61.31
P19	5.26	30.98	15.19	46.77	1.05	0.05	32.53	34.24
P20	12.87	55.90	17.29	94.51	1.05	0.05	58.70	61.78
P21	30.33	106.14	15.14	197.14	1.05	0.05	111.45	117.31
P22	11.15	87.15	53.71	120.59	1.05	0.05	91.51	96.32
P23	4.01	53.90	41.86	65.94	1.06	0.05	57.13	60.14
P24	57.20	434.40	262.79	606.01	1.05	0.05	456.12	480.13
P25	22.10	163.00	96.69	229.31	1.05	0.05	171.15	180.16
P26	160.32	1483.00	1002.05	1963.95	1.23	0.05	1824.09	1920.09
P27	13.02	108.60	69.53	147.67	1.05	0.05	114.03	120.03
P28	9.33	134.90	106.92	162.88	1.06	0.05	142.99	150.52
P29	7.32	38.63	16.66	60.60	1.05	0.05	40.56	42.70
P30	73.18	239.05	19.50	458.60	1.13	0.05	270.13	284.34

5.2 Graphical Results

As-Is process analysis is part of planning for change. Data were collected by observing the process in order to understand the workflow and each task time. The current outpatient service process was modelled with BPMN. The business process activities were mapped into several lanes representing the process category. The outpatient process model had 30 activities and seven lanes consisting of patient preparation file, information centre, counter registration, polyclinic, therapy, pharmacy, and counter payment, as shown in figure 1

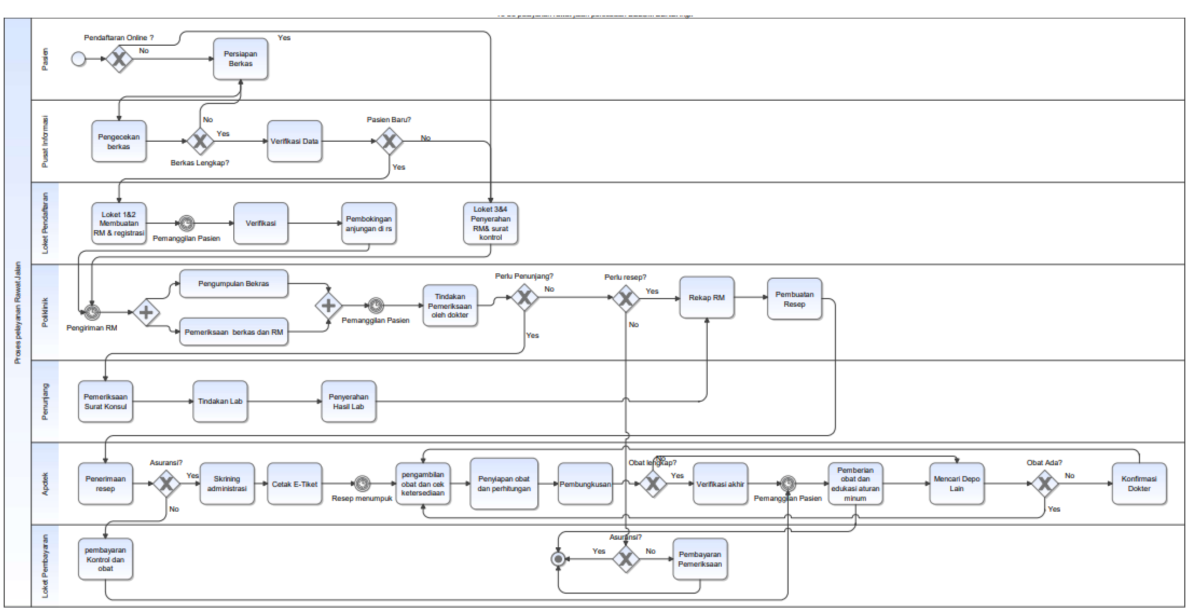

Figure 1. As-Is Model for outpatient Process

The model was a simulation to know the time to get outpatient treatment from end to end. Simulation results for both models (see Table 3) show the average work time for the outpatient process was 3.45 hour and waiting time during 2.68 hours with a capacity of 7 patients during 10 hours.

Table 3. Simulation Result for As-Is Model

Count (Patient)	Transaction Statistic (Hours)		
	Avg Cycle	Avg Work	Avg Wait
7	3.45	0.77	2.68

Simulation results of the As-is Process in Table 4 shows that the average total time spent for a pharmacy outpatient is 2.27 hours which is the longest time. For the avg waiting time is 1.43 hours. To improve the processes that occur in services at pharmacies, the researchers designed a to-be process. Before designing the to-be model, the researcher identified the problems that caused the long processing time at the outpatient pharmacy. Identification of problems in outpatient pharmacies (see figure 2) based on literature studies, surveys, and interviews with staff in charge of each process in outpatient pharmacies.

Table 4. Simulation results of As-is Process

Process	Count (Patient)	Transaction Statistic (Hour)		
		Avg Cycle	Avg Work	Avg Wait
Outpatient Service Process/ Information centre	7	0.46	0.05	0.41
Outpatient Service Process/ Patient	7	0.02	0.02	<0.01
Outpatient Service Process/ Payment Counter	7	0.01	0.01	0
Outpatient Service Process/ Pharmacy	3	2.27	0.84	1.43
Outpatient Service Process/Polyclinic	7	1.89	0.23	1.66
Outpatient Service Process/ Registration Counter	7	0.02	0.02	0
Outpatient Service Proces/ Therapy	1	0.5	0.5	0

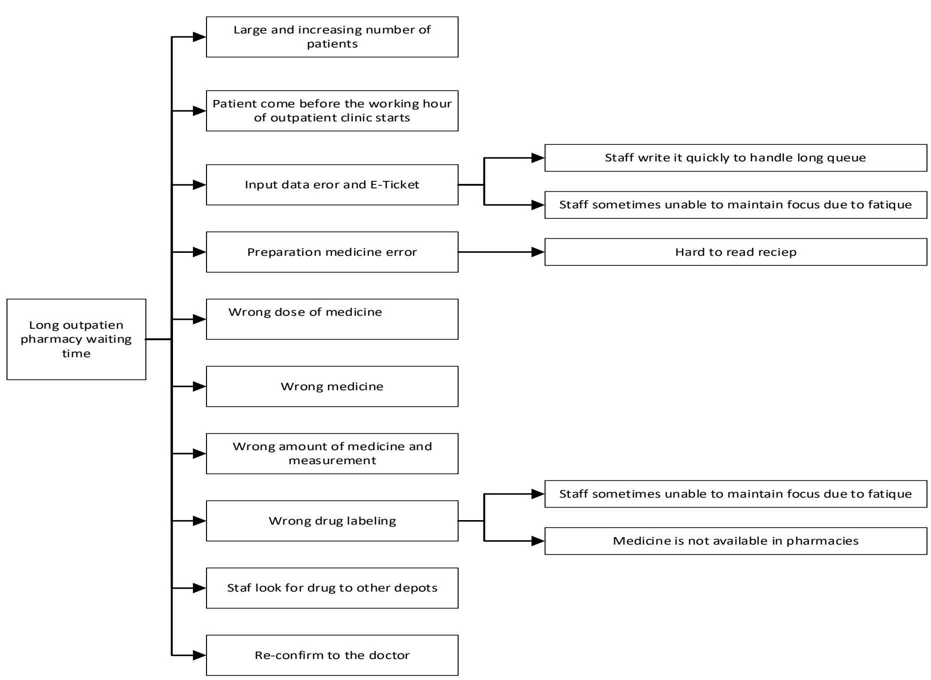

Figure 2. Issue Tree Analysis of As-Is Process

The problem tree diagram is made to identify the cause of the length of time that occurs in outpatient pharmacies so that it has an impact on the length of time used in all outpatient service business processes. Based on the analysis, we use BPR best practices to design several alternatives on the solution for process improvement. IoT-based corrective actions have an impact on more accurate and responsive outpatient pharmacy services. IoT is able to increase patient satisfaction and operational efficiency through the integration of information technology and operations. One of the advancements in IoT technology in pharmaceutical installations is the adoption of Automated Dispensing machines (ADM) and Computerized Physician order entry (CPOE) technology based on the Clinical Decision Support System (CDSS).

CDSS-based CPOE refers to various computer-based drug ordering systems with various common features that can automate the process of ordering drugs from doctors to pharmacies with various sophistications. ADM can reduce patient waiting time and reduce the workload of officers because activities reduce errors in the drug dispensing process, wrong drugs, wrong doses, wrong labels, and wrong amounts.

5.3 Proposed Improvements

Process Improvement by comparing BPR best practices and proposed technology developments are briefly described in table 5. Comparing BPR best practices was used to design improvement solutions throught 3 outpatient pharmacy service improvement scenario. Modeling and simulation were conducted to compare the time and capacity of the as-is process and the proposed process (To-Be process).

Table 5. Description Of To-Be Model Modification

Best Practice BPR	Solution	Improvement	Time Reduction
Task automation, Task elimination, Flexible assignment	CPOE base CDSS	Elimination of the task of doctors writing manual prescriptions because they use a computer system where doctors enter their medical orders to all health workers and their departments	55% (Shojania et al. 2001), (Hajesmaeel Gohari et al. 2021), (Arovah and Dachyar 2020)
		Remove the pharmacist's duty to look for drugs at other depots.	
		Reduce data input errors and print E-Tickets	
		Elimination of the pharmacist's task of confirming drugs that are not available	
Integral Technology, Task automation, Task elimination	ADM	Reduce dosing errors	69% (Arovah and Dachyar 2020), (Risør, Lisby, and Sørensen 2016), (Suryadinata 2017)
		Reduce medication errors	
		Reduce the error in calculating the number of drugs	

5.4 Simulation Result of To-Be Model

The formulation of the to-be model was carried out based on the proposed improvement results based on an analysis comparing using the best practice BPR. In order to reduce patient waiting time at hospital outpatient pharmacies, the analysis proposed 2 IoT technologies that are Automated Dispensing Machine (ADM) and Computerized Physician order entry (CPOE) technology based on the Clinical Decision Support System (CDSS). Three scenarios are designed for each medicine process. Scenario 1 only implement ADM, scenario two implements CPOE base CDSS and scenario three implements bot ADM and CPOE base CSDD.

CPOE base CDSS is a computerized drug prescribing system of varying sophistication. Clinical decision support may include suggestions or default values for drug doses, routes, and frequencies. More sophisticated CDSSs can perform drug-allergy checks, drug-laboratory value checks, drug-drug interaction checks, in addition to providing reminders about corollary orders or drug guidelines to the physician at the time of drug ordering.(Shojania et al. 2001)

ADM is capable of working on several processes simultaneously; when pharmacist enters the medicine needed for the prescription to the system, it will automatically pick the medicine whilst checking the medicine condition with sensors, print medication labels and package the medicine. Reducing time for a pharmacist to recheck prescription towards the end of the process(Arovah and Dachyar 2020). The ADM benefits such as increase staff satisfaction for the nurse and pharmacist, reduce dispensing errors about 35% or up to reducing all dispensing errors, time saving until 50% in peak hours and cost analysis and effectiveness. The cost analysis such as inventory stock reduction, increases the cost saving. (Suryadinata 2017)

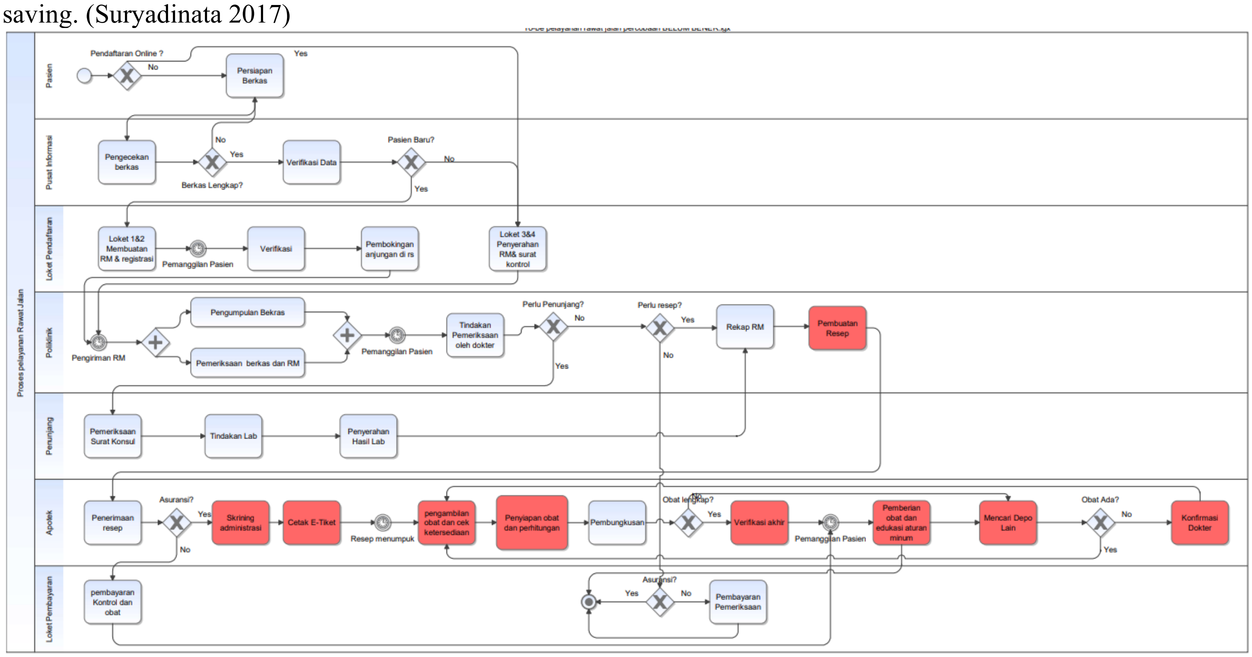

Figure 3. To-Be Model for outpatient Process

The IoT-based patient monitoring system that was proposed can help speed up time in the pharmacy department. ADM was able to reduce the time for process print E-ticket, Packaging medicine, and final verification. While CDSS was able to reduce the time for giving a recipe, Screening administration, taking medicine and checking availability, looking at another depot, doctor's confirmation and giving medicine and education on drinking rules and giving medicine and education on drinking rules. To-be model simulation result recapitulation (see Table 6) shows that scenario 3 give a time reduction of 0.35 Hours than scenario 1 give a time of 1.72 hours, and scenario 3 give a time of 1.88 hours.

Table 6. Description Of To-Be Model Modification

Process	As-is (Hours)	To-be (Hours)		
		Scenario 1	Scenario 2	Scenario 3
Outpatient Service Process/ Pharmacy	2.27	1.72	1.88	0.35

The to-be model used is scenario three because it gave the best result with combined scenarios 1 and 2 by using ADM and CPOE base CDSS to create a significant improvement. Implementing only ADM in Outpatient pharmacies will not benefit the pharmacy in reducing patient waiting time because it reduces errors in drug preparation. On the contrary, implementing CPOE base, CDSS will benefit in pharmacy in reducing patient waiting time because it reduces errors in process administration including when the doctor prescribes drugs. Clinical decision support can perform drug allergy checks, drug-laboratory value checks, drug-drug interaction checks, in addition to providing reminders about corollary orders or drug guidelines to the physician at the time of drug ordering and all of that is done computerized. But there are obstacles in the implementation of the technology, one of which is the possibility that the system or machine error it will hinder the operation of the pharmacy, and it is likely for pharmacy personnel or other stakeholders to have difficulty in adapting to using new technology. Implementing both technologies concurrently at the outpatient pharmacy will impose a greater risk than implementing one at a time, as both technologies in terms of cost require an immense amount of capital (Arovah and Dachyar 2020)

6. Conclusion

This study succeeded in designing Application Internet of Things (IoT) to improve process outpatient in a hospital, especially in outpatient pharmacy services, to become faster and more responsive. by reengineering exixting business process, to reduce waiting time for outpatient services in pharmacy installations. The improved processes were designed based on the BPR approach through three kinds of scenarios. The process resulted in the capacity increase and work time reduction through 3 proposed scenarios. The simulation result showed that the best scenario was scenario 3. That is scenario that provides the greatest time reduction is scenario 3 (CPOE base CDSS and ADM); from the as-is process, it took 2.27 hours to 0.35 hours on the to-be design. it will be a consideration for hospital to implement IoT in the form of CPOE base CDSS and ADM to reduce waiting time in process that exist in outpatien pharmacy.

There are obstacles in the implementation of the technology, one the likely for pharmacy personnel or other stakeholders to have difficulty in adapting to using new technology

References

AbdEllatif, Mahmoud, Marwa Salah Farhan, and Naglaa Saeed Shehata. "Overcoming Business Process Reengineering Obstacles Using Ontology-Based Knowledge Map Methodology." *Future Computing and Informatics Journal* 3(1): 7–28. https://doi.org/10.1016/j.fcij.2017.10.006. 2018

Antonius, Nathanael, and Muhammad Dachyar. "The Internet of Things (IoT) Design for Cardiac Remote Patient Monitoring Using Business Process Re-Engineering." *Proceedings of ICAE 2020 - 3rd International Conference on Applied Engineering*. 2020

Arovah, S., and M. Dachyar. "Outpatient Pharmacy Improvement Using Internet of Things Based on BPR Approach." *International Journal of Advanced Science and Technology* 29(7 Special): 3597–3604. 2020

Bertolini, Massimo, M. Bevilacqua, F. E. Ciarapica, and G. Giacchetta. "Business Process Re-Engineering in Healthcare Management: A Case Study." *Business Process Management Journal* 17(1): 42–66. 2011

Chinosi, Michele, and Alberto Trombetta. "BPMN: An Introduction to the Standard." *Computer Standards and Interfaces* 34(1): 124–34. http://dx.doi.org/10.1016/j.csi.2011.06.002. 2012

Dachyar, M., and Nashira Nattaya. "Collaborating Internet of Things (IoT) and Electronic Medical Record (EMR) to Reduce Healthcare Waiting Time. Outpatient Cardiology Service Case: A BPR Approach." 144(Afbe 2019): 88–95. 2020

Hajesmaeel Gohari, Sadrieh, Kambiz Bahaadinbeigy, Shahrad Tajoddini, and Sharareh R. Niakan Kalhori."Effect of Computerized Physician Order Entry and Clinical Decision Support System on Adverse Drug Events Prevention in the Emergency Department: A Systematic Review." *Journal of Pharmacy Technology* 37(1): 53–61. 2021

Khalid Al Badiic. "Discrete Event Simulation and Pharmacy Process Re-Engineering." *International Journal of Health Care Quality Assurance* 7(4): 1–40. 2018

Khan, Haider Ali, Raed Abdulla, Sathish Kumar Selvaperumal, and Ammar Bathich. "IoT Based on Secure Personal Healthcare Using RFID Technology and Steganography." *International Journal of Electrical and Computer Engineering* 11(4): 3300–3309. 2021

Risør, Bettina Wulff, Marianne Lisby, and Jan Sørensen. "An Automated Medication System Reduces Errors in the Medication Administration Process: Results from a Danish Hospital Study." *European Journal of Hospital Pharmacy* 23(4): 189–96. 2016

Shojania, K. G. et al. "Making Health Care Safer: A Critical Analysis of Patient Safety Practices." *Evidence report/technology assessment (Summary)* 2001(43). 2001

Suryadinata, Haryman Utama. "The Benefits of Automated Dispensing Machine for Hospital Pharmacy in Indonesia: Situation, Implementation, and Feasibility." *GHMJ (Global Health Management Journal)* 1(1): 15. 2017

Zen, Sanyadwia Ghinasni, and M. Dachyar. "Intensive Care Unit (ICU) Patient Monitoring Improvement Using Internet of Things (IOT) Based on BPR Approach." *Proceedings of the International Conference on Industrial Engineering and Operations Management*: 1572–83. 2021

Biographies

Mutia Perwita Sari is a graduate student of Industrial Engineering at Universitas Indonesia, Depok, Indonesia. She earned her Bachelor of Engineering in Industrial Engineering Ahmad Dahlan University, Yogyakarta, Indonesia. Her research interests include lean, especially for lean services, strategic management, business process re-engineering and maintenance management.

Novandra Rhezza Pratama is a lecturer at the Industrial Engineering Department of Universitas Indonesia. Mr Novandra completed his doctorate in Industrial Engineering from the Tokyo Institute of Technology. His research interests are related to Industrial Management, Information Systems, and Business Process re-engineering

M. Dachyar is a Professor and Head of Management Information System and Decision Support (MISDS) Laboratory, Industrial Engineering Dept. Universitas Indonesia. His research focused on information systems, decision support systems, operations management, and Business Process re-engineering.