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MEDICAL SERVICE IMPROVEMENT THROUGH PATIENT'S QUEUE DECISION MINING

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ABSTRACT

Since a hospital adapt computer system based service such as patient's profile and disease database, payment, and reservation, the data have been stored and analyzed for better performance of patient's care. Despite of computer based patient's healthcare service which is core service of hospital, one of the major complain comes from patients, the waiting queue is not well solved because of hospital physical resource limitation. In that, an effective service route to reduce patient's queue has been studied in diverse ways. In this research we clarify the service route and find out solution to reduce queue time for better patients service through sample hospital's the orthopedics department patient data. This research utilize ProM software to clarify service process and suggest process innovation via queueing theory not process mining way because only doctor schedule is suitable to change in the process.

Keywords: *Medical Service, Queue Theory, Medical Process, Clinical Pathway*

1. INTRODUCTION

Healthcare industry in Korea is under competitive environment which lead hospital's conative managerial strategy to survive. In that Korean hospitals start to set one's primary object to patient's healthcare service satisfaction [1],[2],[3]. Without different view, a hospital's goal is curing disease. However, beside the goal in the process of curing, there could be various competitive service factors such as kindness of nurse and doctors, time of each process, and waiting time which will be discussed in this research. Especially treatment time and waiting time is recognized to major factors for patient's service satisfaction because patients are under mentally negative circumstance waiting different to waiting customer in other industries such as theater waiting customer or restaurant [4].

Although hospitals recognize the importance of waiting queue time, most of hospitals have limited resources such as number of doctors, and expensive medical equipment [5]. In that today hospitals started to consider and analyze the most efficient resources for medical service satisfaction. In the other industries such as automobile, food, and other having conveyer belt manufacturing facilities have been adapted queueing theory, and other datamining methodologies to solve the efficiency problem about limited resources [6],[7],[8]. However, most of those researches are limited to one process or focused to cost reduction efficiency which could lead lack of treatment and cure satisfaction in healthcare industry [5],[6].

Korean hospitals and other developed countries hospitals has own or country CP(Clinical Pathway) to standardize one's care methodology for diverse diseases and injuries [9]. The CP is considered essential for hospitals to keep treatment quality which terminally leads patient's satisfaction. In that sense, unlike other industries, the process reengineering of healthcare industry should be followed after keep CP [10]. In this research, we firstly clarify the sample hospital's Orthopedics division CP before data analysis to find out which step or node should be replaced or rearranged to advance patient's queueing environment.

In this research, we clarify and suggest advanced process of X hospital's orthopedics division via three months database of the division with considering above environment and features of healthcare industry. The research processes contains three steps. Firstly, clarify the process from the database with ProM software. Second, validate the process with comparing the division's CP. Thirdly, evaluate the process with decision tree, and suggest to advanced process with queueing theory considering CP which secure quality of healthcare service such as treatment and prescription. In order to clarify and evaluate the

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process, one have to figure out related research to understand the way it works.

2. RELATED RESEARCHES

2.1 Clinical Pathway

CP(Clinical Pathway)is based on CPG(Clinical Practice Guideline) for each disease to provide suitable treatment to patients by each hospital [10]. A CP has been made to efficient use of hospital resources, minimize treatment time, and maximize healthcare quality by clarifying standardized process of treatment for each disease and surgery. Different to CPG which is developed in national dimension, CP is developed by each hospital based on CPG, and utilized by doctors, nurses, pharmscist, and hospital dietitian.

Although CP could be different by speicialty of each hospital, in Korean hospital, almost all hospitals has check-list type CP which one can see at Figure 1 [11].

QUEEN MARY HOSPITAL / CTSD
Clinical Pathway: VATS Lung Surgery

Post-Op Day 1: / /
ORDERS

GUM LABEL

Goal: Control pain & resume normal daily activities
Detect and rectify post-operative complications
Remove attachments except drain → Mobilize

	Management Orders	Doctor Sign. & No.	Checked by Nurse
Nutrition	☐ DAT (or: DM diet kCal/day)		
	☐ Off IV fluids		
Respiration	☐ Wean off oxygen		
	☐ Use Triflow (10 times Q1H; 2 balls up each time)		
	☐ Chest physio		
	☐ Prescribe Mucolytics if smoking pre-op or thick sputum post-op		
Mobility	☐ Sit out all day unless sleeping		
	☐ Mobilize as tolerated		
Investigation	☐ CXR		
	☐ Other:		
Drains	☐ Off suction on water seal chest drain (other:)		
	☐ Gravity Mode on Thopaz chest drain		
	☐ Other:		
Analgesia:	☐ Off PCA Morphine		
	☐ Other:		
Other medications:	☐ Resume all medications		
	☐ Resume pre-op Aspirin/Plavix		
	☐ Other:		
Additional orders:	☐ Off Foley if inserted		

Variance: ❑ Yes ❑ No
Variances Statement:
Continue Clinical Pathway: ❑ Yes ❑ No
If no, please state reason(s)

Dr. I/C	Staff No.	Sign		Nurse I/C	Staff No.	Sign
			N			
			A			
			P			

Figure 1: Sample of Check-List Type Clinical Pathway

In that, in the log data in this research, queueing time is fitted to CP. For example doctor waiting time is treated as a treatment time in the CP.

When handling the hospital log data, CP should be analyzed because not like other process data, hospital data log shows the process comes from restrict CP. In that, after clarifying process with process mining tool, veridating the process from the tool should be performed with CP. In this research, we utilize the sample X hospital orthopedics division's CP to varify the process which we analyze with patient's log database and also utilize to adapt queueing theory by decision tree result because CP is hard to be changed even for efficiency of the queueing time because it is core factor of treatment quality which is main purpose of hospital.

2.2 Process Mining

Process mining is knowledge extraction process from event log in information system which records business process [7]. Process mining is usually utilized to process reenginerring and desigin with statistical methodologies, artificial intelligence, and social network methodologies [13],[14],[15]. When there is not enough information about the process, the mining processes are three steps: discovery-conformance check-enhancement, however, if there are enough information about the process one or two steps could be reduced like this research [7].

The discovery step is discovering process model from event logs that researcher could not recognize and usually used complex processes which is hard to clarify. Conformance check is to coform and find bias the first step's process by comparing real business process. The enhancement step is to changing or extention of the process for better efficiency or business performance. [7]

A start point of process mining is 'event log'. Process mining presume a sequencial log data which is orderly stacked by event time. The event means one work unit which realted to one case. An event log could have additional information that could lead conditional analysis. Almost all hospitals in Korea has EMR(Electronic Medical Record) system that also called HER(Electronic Health Record) system which records all patient's prescription, treatment, and other various records in cluding time event record those would be utilized in this research by sample X hospital's orthopedics division EMR system database.

Early researches in process mining area is usually performed with first step : clarifying business process in complex business process area via Heuristic, genetic, Alpha and Fuzzy methodologies [16],[17]. Recently, an analysis industries are extendted to financial, telecommunication and other area. In healthcare industry, today discrete event log simulation is tried to optimize outpatient clinic schedule, and inversly to create new clinical pathway [16],[17].

There are three representitive process mining tools ProM, Disco, and Reflect those applied to

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diverse industries and companies such as Philips, Deloitte, Ricoh, and the Netherland government facilities. In Korea, process mining is applie to hospital process enhancement, convention route analysis and shipping logistics analysis. In this research, we utilize ProM tool to analsis hospital process to varify event log model fits CP and find bottleneck problem to solve with queueing theory.

2.3 Decision Tree

The decision tree is decision support toll that uses a tree-like graph or model of decision and their possible consequences, including chance event outcomes, resource cost, and utility which display an algorithm [6]. The decision tree is popular methodology for data clustering, prediction and association.

Clarifying process is clearly applicable in the context of business process, having knowledge or to make tacit knowledge explicit. In order to analze the choices in a business process, we need identifying those part of model where the process is split into alternative branches, meaning decision point. The decision point corresponds to a place with diverse outgoing arcs. In this research the CP(Clinical Pathway) is strict decision standard which supposed to have not multiple path but one. However, CP is for only one disease or injury that means, patients having multile symptoms could be dealed with multiple CPs. Adapting multiple CP means patients could have multiple diagnosises, prescriptions, and treatments. When execute process mining conformance check from process output to clinical pathway, there could be various alternatives. In that, decision tree is essential to find bottleneck.

After find out a decision point in a process, the second step is to determine whether the decision might be influenced by case. The idea is to to convert decisions point to a classification problem. In order to solve the problem, there are diverse algorithms available representing below.

There are representitive three methodology for decision tree : CHAID(Chi-Squared Automatic Interaction Detector), CART(Classfication and Regression Trees), and C5.0. In this research we utilize CHAID methodology which find variables formal pair, otimized separation, calculate expected queue time, and the most important reason the methodology utilized is it could be used when data does not follow normal distribution. In hospital, patient's visit distribution is not normal because it's not work in perfectly scheduled.

A popular tools for decision tree is statistics tools such as SPSS or Clementine. In this research we utilize Decision Miner plug-in which support ProM tool we utilize for process mining that determines the decision points contained in a Petri net model. The Decision miner shows the model view which provides a visualization of decision points following given process model. The plug-in is quite useful because there are inherited attributes that is retained from process analysis and type of the amount attibute as numeric. The algorithm view of the tool provides full range of parameters either.

2.4 Queueing Theory

In order to enhance bottleneck : problem decision point in decision tree, one could utilize ProM simulation methodology [6],[7]. However, in this research we use the Queueing Theory because the decision point has not alternatives meaning should be fixed via certain environmental limitations reflecting Korean hospital's or sample X hospital's such as special clinic doctor's fixed work time, professor doctor's inflexible time, or special patient's abnormally long clinic time. In that, we applied queueing theory to flexible nodes.

The queueing theory initially released by Agner Krarup Erlang who worked at Copenhagen telephone exchange center. He proposed M/M/1 queue model which suppose telephone call frequency has poisson distribution in 1917 and M/M/S model which presume one node with multiple servers in 1920. The Erlang's queueing theory is seperated to Erlang loss formula also called Erlang B and Erlang delay formula. The Erlang loss formula is under assumption that service call would be disappear when all service providers are serving while the Erlang delay fomula has assumption that service call waits until she could find vacant service provider. In telephone exchange business, service call means telephone call request, and service provider is vacant telephone line. In this research, we utilize Earlng delay because we assume that patient's are not disappear while in the queue. In 1953, David George Kendall released GI/M/K queue by notation called Kendall's notation and Pollaczek solved GI/G/1 queue using interal equation in 1957

Since queueing theroy is released, it's been utilized in oprational management academic part to find problem and optimize factory production coveyer belt line. However, it's for not only product assembling but also utilized in a sense of business process.

In queueing theory service disciplines, there are various scheduling policies could be used in the nodes such as FIFO(First In First Out), LIFO(Last in First Out), processor sharing, high priority first,

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shortest work first and others. In hospital service, there are diverse service formation, almost all clinics are served by scheduled patient's first, and work-in (not reserved) patient's could be get in if there are scheduled patient's not appear. Also, there could be priority if there is emergency patients or some services for high paid patients.

3. RESEARCH METHODOLOGY

We utilize three months EMR(Electronic Medical Record) from X hospitals orthopedic division having 6,281 patient's records. The figure 2 shows the basic research process. The patient's event log and personal clinic record database from EMR is partially encrypted for personal record protection such as social security number, address, and telephone number by law. Process analysis is performed through ProM tool to clarify processes of the sample X hospital orthopedics division.

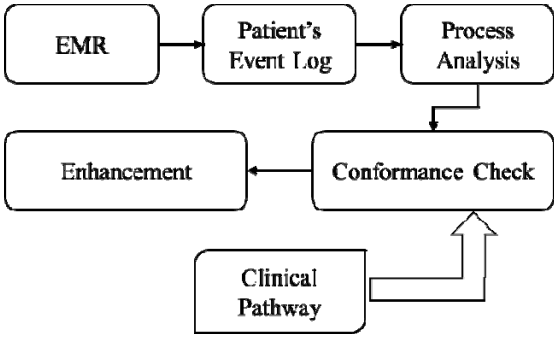

Figure 2: Analysis Process of Research

In order to utilize process mining too, data cleansing step should be performed because the EMR data is raw data that means, there are every tables and columns at each table having time sequence array. The data utilized in this research is only three months data but raw data has over twenty thousand of records with columns that we don't need for this research. In that, we filtered columns to reservation data, check-in time for each node: registration, nurse registration, doctor for diagnosis, doctor for prescription, nurse for medical examination, payment and other nodes.

The standard process of orthopedics division patient's clinic has four steps. First, visit reception desk whether reserved or work-in and get registration number. Second, go to nurse station to give registration number and wait for own turn to meet doctor. On third, if doctor order certain examination such as X-ray, MRI, blood test, and others then visit clinical laboratory, else get prescription from nurse station. Lastly, if one has examination at laboratory, meet doctor again and visit payment station else visit directly and pay, then service is finished. Although these are formal and recognized to patients as popular steps for hospital service, there are diverse processes in real world because many patients are not having initial treatment but continuous meaning they could go laboratory first if one has to get improvement examination before meet doctor or many other cases could occur.

After process analysis, conformance check compares the process types to clinical pathway. The figure 3 below shows the way to conformance check in this research. Patient's prescription record from EMR could matched to clinical pathway with disease and injury code. Clinical pathway has recommended route process for each disease or injury and the process is defined to code for this research. For example, 'bone fracture' clinical pathway has five steps: registration station, nurse station, laboratory examination (X-ray), doctor for prescription and treatment (depends on level of injury, could be nurse treatment not doctor), and payment & reservation for next time care. In order to match clinical pathway and patient's record, if patient's record shows 'bone fracture', column name 'type' is defined to 'RNDP' and 'RNDNP' meaning registration, nurse, doctor, (nurse), and payment which is defined same in clinical pathway record. Analyze patient's time sequence visiting station when patient is diagnosed to 'bone fracture' and define the time sequence as station name and put it into patient's column in same way.

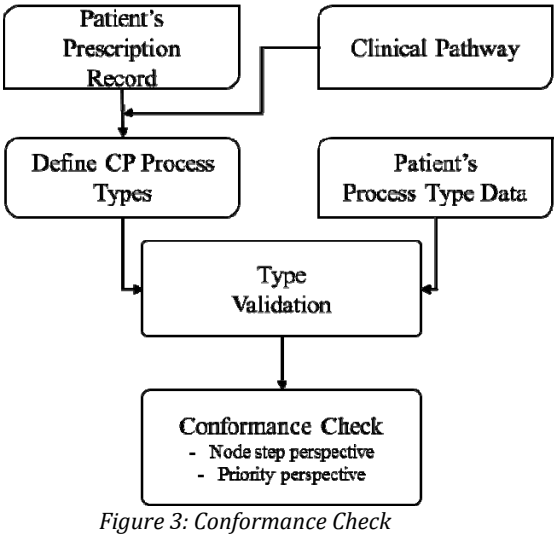

Figure 3: Conformance Check

Table join with key 'diagnosis name' patient's table and clinical pathway table to compare patient's time sequence record that reveals process to clinical pathway. In this research,

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patient's time sequence type is defined with process mining tool when clarify the process of the sample data. Type unmatched data should be analyzed with other perspective that special node such as family doctor case or emergency patient case. In this research those kind of extra ordinary cases are analyzed to find out it is not ordinary case or staffs did not follow clinical pathway.

4. ANALYSIS RESULT

4.1 Process and Clinical Pathway

The clinical pathway of sample X hospital orthopedics division is confidential to outsider although most of those follows national standard though. In this research, we utilize decision mining with ProM meaning decision tree methodology that needs four control parameters we define: two type of patients (first, revisit), reservation route, day, type of doctor (general, orthopedic specialist, special clinic). Before we figure out the process concerning parameters above, we clarify all processes occurs in real as you can see at table 1.

Table 1: Station based process define

Type	Number of Matching CP	Case Count
RNDLDP	5 diseases, 4 injuries	887
RNDLNP	2 injury	68
RNDLP	13 diseases, 18 injuries	2,149
RNDP	6 diseases, 6 injuries	1,373
RNLP	3 diseases, 6 injuries	866
NDLDP	3 injuries	533
NDLP	3 inruries	308
NDP	None	56
RLNDP	None	16
RLDP	None	5
LNDP	None	8
LNP	None	1
Others	None	11
Summation		6,281
R: Registration Station, N: Nurse station, D: Doctor Station, L: Laboratory, P: Payment		

There are 97 clinical pathway unclarified processes in the 6,281 sample patient record. Those are only 1.5% of records and eliminated before next analysis steps. We checked all process cases and have a result that almost all none CP cases are recorded by mistake such as administration failure, worker's mistake but not computer recording system failure at all. After unexpected variables are clarified, we checked patient's disease or/and injury code which could multiple to compare patient's real process type to clinical pathway defined process type. The clinical pathway process type is also defined to same way what have done to patient's process type like table 1 type field.

The disease or injury number at table 1 could be overlapped because there could be multiple processes in clinical pathway because even if one disease could have different process ways depend on clinic progress. For example, if 'bone fracture' injury patient firstly visit, in X hospital clinical pathway, RNDLDP is common process and RDLDP is emergency process while RNDP is common at revisit and last visit. In that, conformance check in this research could have limitation because progress of disease or injury is not concerned. The three months EMR data utilized in this research is only outpatient orthopedics clinic data in that, clinical pathways need surgery or co-work is not reflected.

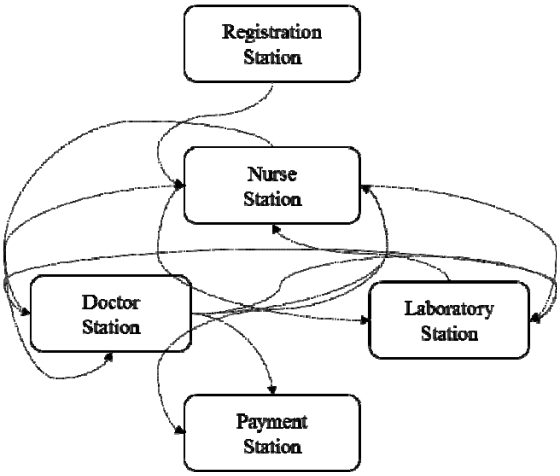

Figure 4: Station unit based process

The Figure 4 shows station unit based process that clarified in this research. A node based process is skipped because it's hard to be demonstrated in one paper. As one can see in the figure, orthopaedics outpatient division clarified having five stations: Registration, Nurse, Doctor, Laboratory, and Payment. The registration station is first step for all first visit patient and the most of re-visit patients while the X hospital has recently reengineered outpatient's process

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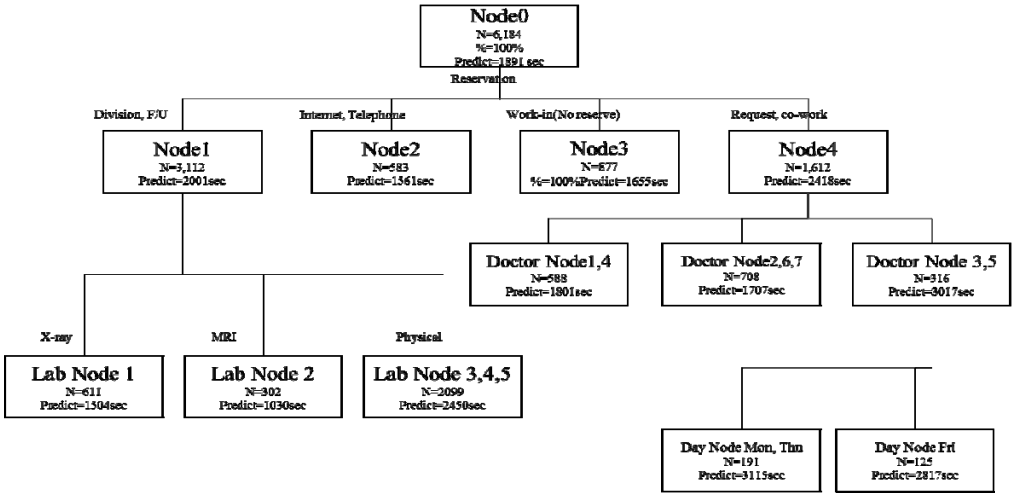

Figure 5: Decision mining result

with one registration desk and one payment desk.

The registration stations has six nodes, while doctor station does seven nodes with fifteen nurse stations works. Different to other nodes in each station, the laboratory station has not person based node, but examination type node such as X-ray, MRI, and others because problem point in waiting queue occurs not by person but the examination or physical treatment machine's working time especially orthopedics outpatient division. As you can see at the conclusion part of this research, the laboratory station has not much problem node because queue at certain examination or treatment machine is easy to be watched meaning clear to be supply to managers especially physical treatment machine.

As a result of process mining analysis, we find two problem nodes at doctor's station and one problem node at laboratory station those have X-ray, MRI examination and physical treatment clinics. The problem nodes is doctor node3, doctor node 7 and laboratory node 3 those takes much more waiting time then other nodes meaning occurs bottleneck. Nodes having problem found as a process mining result, however, is analysed under full data condition meaning control parameters such as reservation route, a day patients visit, and type of doctors. In that, we performed decision tree based mining

4.2 Decision Tree

In order to decision tree analysis, we set three control parameters. Figure 5 shows the result of decision tree mining. The decision tree methodology has diverse types of techniques while this research utilize CHAID(Chi-Squared Automatic Interaction Detector) not others such as CART(Classification and Regression Trees) and C5.0. The CHAID technique find familiar pair, optimize separation, and calculate a prediction time even data does not follow normal distribution. It is the most suitable technique because hospital patient arrival time does not follow normal distribution and we also need prediction time.

In the result of decision tree analysis, one can find doctors node 3,5 and laboratory node 3,4,5 has abnormal predict time meaning queueing time.

Doctor 3,5 are specialty doctor those invited to sample hospital as a professor because the sample hospital is university attached hospital. In that, there clinic day is only Monday, Thursday and Friday, and also number of patients they meet is not many because they work as a part time when they do not have university class. In the respect of their speciality, the sample hospital usually ask request or co-work to other division patients which means the patients may have complex disease or injury need multi division treatment. In other word, the doctor node 3,5 mainly deal with difficult patients having complex disease or injury, are under condition that queueing time would long because treatment time would be longer than other patients. The overall predict queue time is 1891sec while doctor node 3,5 predict time is 3017sec, over fifty percent higher than average.

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Although there is are precise reason that doctor node 3,5 has longer predict time than others, one could not say reducing queueing time is not necessary.

In other hand, the laboratory node 3,4,5 has serious long queueing time when it comes to division own or front unit reserved patients. Unlike doctor node's problem. It has solution for the problem because reservation rout is division itself and front unit that means division registration station. First, division and front unit reservation time term would be too short especially for patients those have physical treatment service in there clinical path way such as RNDLDP pattern. However, in this research, laboratory stations actually has two kind of nodes having totally different role: examination and treatment.

X-ray and MRI(Magnetic Resonance Imaging) examination (Node 1,2) has totally different specification to physical treatment such as therapy and muscle massage. In that, lab node 3,4,5's predict time at figure 5 could be normal when we separate examination and physical treatment. However, in sample hospital we deal with at this research, has one station for them meaning the administrational staffs, and queue line is same or mixed for them therefore hard to figure out what exactly causes long queue time inside the station process by EMR data.

As a result, the decision tree analysis shows that rearranging patient's at doctor node 3,5 is necessary while physical treatment could not share their work to laboratory 1 and 2 because of it's specialty. To solve the problem and check the answer could show enough performance, we utilize the queueing theory. Theoretically, extending doctor node 3,5's work time or move their clinic day could be a solution. However, as we mentioned, they are professors running special clinic and could not extend their clinic time and arrange the day neither.

4.3 Queueing Theory

The queueing theory M/G/1 model is adapted to the analysis because the model assumes that service request is not leave when service provider could not answer and it is same at hospital service condition because the most of patients wait until their clinic time when they get to hospital for cure.

The queueing theory analysis is performed by three steps. Firstly, check problem doctor node queue time, Secondly, check other doctors in same level meaning same reservation type, in this research doctor node 1,4 and 2,6,7 as the figure 5. Lastly, resume that doctor node 3,5 and doctor node 1,4 or 2,6,7 is mixed and adapt queueing model to check it shows better performance.

Table 2,3 shows the result that doctor node 3 is merged to doctor node 1 and doctor node 5 is merged to doctor node 5. We adapt queueing theory to other doctor nodes in node 4 and merging solution is the most suitable when merges doctor 3 to doctor 1 and doctor 5 to doctor 4. In actual environment, merging person is not possible, in that sense 'sharing patients' could be right expression in this case. Doctor nodes problem in Node 4 could be solved as one can see table 2,3. However, laboratory node problem in Node 1 is not possible because of insufficient data that does not separate examination lab and treatment lab.

Table 2: Doctor 3 queue improvement

Index	Node3 (prob)	Node 1	Node 1+3
Average Patients in queue	12	31	33
Average Patients in system	14	36	39
Average wait time	50mins	10mins	21mins
Average time in system	55mins	12mins	27mins

Table 3: Doctor 5 queue improvement

Index	Node5 (prob)	Node 4	Node 4+5
Average Patients in queue	11	32	33
Average Patients in system	14	36	35
Average wait time	52mins	11mins	23mins
Average time in system	55mins	12mins	27mins

5. CONCLUSION

In this research, we utilize process mining technique and decision tree as decision mining

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and also performed queuing theory not process mining simulation model because there are lots of limitations in hospital to run overall process mining simulation.

As a result of process mining and conformance check to clinical pathway, we found 98.5% patients cases are treated according to clinical pathway. However, there are limitations that those patterns are overlapped when patient has complex multiple diseases or injuries. In decision tree analysis we found two doctor node under request and co-work reservation patient condition and three laboratory node under division and front unit reservation have problem with patients queue. The laboratory nodes problem could not be solved in this research because laboratory station have totally different nodes in the same station: examination and physical treatment. However, doctor station problem could be solved in this research by merging nodes, meaning sharing patients to the other doctor nodes.

6. LIMITATION AND FUTURE RESEARCH

Although this research suggest the solution to enhance patient's queue, there are limitations left. First, the EMR data is only three months meaning could not reflect seasonal variables and time series trend. Second, there are some nodes those have insufficient data quantity that lead insufficient result. Third, as we mentioned above, the laboratory data is not enough to solve problem even it definitely has problems. Lastly, data insufficiency lead queuing theory solution, meaning whole process mining analysis is not possible and could lead ineffective solution.

This research suggests process mining based queue problem solving. Further research would be made with sufficient laboratory data with fully process mining methodology with simulation methodology to suggest enhanced process because separated research tool may occur unexpected results especially datamining. In that, process mining tool output rather than queueing theory is recommended for further research while considering other factors such as fixed doctor time, treatment type for multi disease case, and other factors could affects to result. Analyzing other department data is also necessary for future research because CP and administration code could be totally different by departments.

REFRENCES:

[1] Dansky, K. H., & Miles, J. "Patient satisfaction with ambulatory healthcare services: Waiting time and filling time". Hosp Health Serv Adm, Vol.42, 1997, pp. 165-177.

[2] Knudtson, N., "Patient satisfaction with nurse practitioner service in a rural setting". JAANP, Vol.2, 2000, pp. 405–412.

[3] Pitt, D., Noseworthy T., Guilbert., J., & Williams, J. R., "Waiting List: Management, Legalities and Ethics". Can J Surg, Vol.46, No.3, 2003, pp. 170-175.

[4] Park, S. H., "Analysis of factors delaying on waiting time for medical exmination of outpatient on a hospital", J Korean Soc Qual Assur Health Care, Vol.8, No.1, 2001, pp. 56-72.

[5] Oh G.E, Bak W.S, Han S.S, Park S.C, and Lee S.C., "Developing Innovation Index of Hospital Service Using 6 Sigma and SERVQUAL". J Korean Soc Qual Management, Vol.41, No.4, 2013.

[6] Yeo H.J, Park W.S, Yoo M.C, Park S.C, and Lee S.C, "Evaluation of Patients' Queue Environment on Medical Service Using Queueing Theory", J Korean Soc Qual Management, Vol. 42, No.1, 2014.

[7] Lee D.H.., Park J.H., and Bae H.R., "Comparison between Planned and Actual Data of Block Assembly Process using Process Mining in Shipyards", The Journal of Society for e-Business Studies, Vol.18, No.4, 2013, pp.145-167.

[8] Van der Aslst W.M.P. and Basten T., "Inheritance of workflows : An approach to tackling problems related to change", Theoretical Computer Science, Vol.270, No.1, 2002, pp.125-203.

[9] Coffey RJ, Richards JS, Remmert CS, LeRoy SS, Shoville RR, & Baldwin PJ. "An introduction to Critical Paths", Quality Management in Health Care, Aspen Publishers, Inc., 1992.

[10] National Medical Center, and Ministry of Health and Welfare, "CP development guideline for regional public hospital Ver 1.0", 2015.

[11] EB Medicine, https://www.ebmedicine.net

[12] Alan D.L. Sihoe, "Clinical Pathway for video-assisted thoracic surgery: the Hong Kong story", Journal of Thoeracic Disease, Vol.8, 2016, pp.13-21.

ISSN: 1992-8645 www.jatit.org E-ISSN: 1817-3195

[13] Vullers, Jasen M.H., van der aalst, W.M.P., and Rosemann, M. "Mining configurable enterprise information systems", Data and Knowledge Engineering, Vol.56, No.3, 2006, pp.195-244.

[14] de Medeiros, A.K.A., Weijters, A.J.M.M., and van der Aalst, W.M.P., "Genetic Process Mining : An Experimental Evaluation, Data Mining and Knowledge Discovery", Vol. 14, No. 2, 2007, pp.245-304.

[15] Rozinat, A, and van der Aalst W.M.P., "Decision Mining in ProM, Proc", 4th Int. Conf. on Business Process Management, 2006, pp.420-425.

[16] de Weerdt, J., Schupp, A., Vanderlock, A., and Baesens, B., "Process Mining for the multi faceted analysis of business processes - A case study in a financial services organization", Computer in Industry, Vol. 64, 2013, pp.57-67.

[17] Goedertier, S., de Weerdt, J., Martens, D., Vanthienen, J., and Baesens, B., "Process discovery in event logs : An application in the telecom industry", Applied Soft Computing, Vol. 11, 2011, pp. 1697-1710.