A Knowledge-based Hemodialysis Health-Care Information System with Analytical Functions of Temporal Assessments for Monitoring and Treatment Plan of Hemodialysis Patient

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Abstract

The number of hemodialysis patients in Indonesia with renal failure has increased 5-10% every year. One of the causes is resource-limited infrastructures of the monitoring and treatment systems, while the hemodialysis patients reach end-stage renal failure, they require a good medical assessments of their condition. This paper presents a new hemodialysis health-care application system of the monitoring and treatment plan for the hemodialysis patients with applying a knowledge-based information system. Our health-care system proposed in this paper provides a series of analytical functions to analyze temporal stages of the assessment parameters for a hemodialysis patient. The analytical functions of hemodialysis adequacy monitoring involved in our health-care system are (1) adequacy hemodialysis, (2) small molecules clearance, (3) hemodialysis product, (4) middle molecules clearance, (5) control of general blood pressure (inter dialysis), (6) control of blood pressure (intra dialysis) and (7) nutrition status. Each of seven analytical functions provides a knowledge-base information modelling from the hemodialysis experts. It issues a list of medical treatments which then will be considered by the doctors for the treatment plan of the hemodialysis patients. Our proposed health-care hemodialysis application system performs in the Regional General Hospital Dr. Soetomo Surabaya. We made an experimental study of our proposed system by using 30 data of hemodialysis patients to determine the effectiveness of our application system. Our health-care hemodialysis application system gives contribution for the nephrology doctors and the hemodialysis nurses who have responsibility to provide a good monitoring and treatment systems for the hemodialysis patients.

Keywords: Health-Care Application System, Knowledge-based Hemodialysis Information Modelling, Temporal Assessment of Monitoring and Treatment Plan.

1. Introduction

Kidney disease is a disease in which serious and treatment should be carefully. One of the treatment on ESRD patients is Hemodialysis. Hemodialysis is one of Renal replacement therapy, which is used in patients with decreased renal function, both acute and chronic. The basic principle of Hemodialysis is to implement the process of diffusion, convection, and ultrafiltration on an artificial kidney (membrane), in removing the waste product of the body's metabolism. Hemodialysis is performed routinely, periodically, and longlife.

Regional General Hospital Dr.Soetomo is the largest and the referral hospital in eastern indonesia area. The hospital has several treatment units, including the installation of Hemodialysis. Hemodialysis installations in that hospital is a hemodialysis center that have 25 machines and done about 75 hemodialysis patients per day. Monitoring and treatment plan are usually done manually, and the schedule of patients who will perform dialysis are still not regularly and routinely, also not comparable with the level of patient illness, patients should have a critical illness will get more intensive care than patients whose disease has not entered a critical stage. Monitoring difficultes for evaluation manually are caused by many variables and multiple interactions between variables, and also lack of treatment plan. Patients need a fast service whereas the number of patients becoming more and more that reached 12.5% of the total population of Indonesia, while medical personnel are very limited both in terms of capacity and time and influence to carry out monitoring. Therefore needed a tool in monitoring for a Hemodialysis Patient Care planning and handling so that the service faster and more patients are handled. To do both before and after

Hemodialysis should know the state or condition of the patient. To find the condition required the application that serves as a monitoring tool to determine the success of Hemodialysis.

Raghavan et.al. [4] presented simplified anemia rule for protocol rule generation developing decision support system for dialysis treatment of chronic kidney failure. Titapiccolo et.al. [8] presented table of patient data and HD treatment information in relative blood volume monitoring during hemodialysis in end stage renal disease patients. Buur Tom [1] presented a flexible program for the IBM PC performing a number calculation of relevance for the prescription of hemodialysis treatment. Escandell-Montero Pablo et.al. [10] presented an application of adaptive treatment strategy to optimize ESA (Erythropoiesis-Stimulating Agents) therapy on patients undergoing hemodialysis has been computed using reinforcement learning techniques. M.Edalat-nejad1 & H.shahbazi [9] discussed how the role of software engineering in improved maintenance hemodialysis patients. That the ability of "Virtual Doctor" has the ability to collect information database for patients (including demographic data, graphs dialysis, results of laboratory tests, radiology, etc.), and variables predicting changes in the dialysis parameters (blood flow, dialysis time) to achieve that KTI desirable V. Jinn-Yi, Yeh & Tai-His, Wu [7] presented how a decision-making system to predict patients who will undergo hemodialysis hospitalization. Medical data analysis process includes data collection, pre-processing, evaluation results, favorable interactions, and discussions with a health professional to make a correct analysis of the results. Cornalba Chiara et.al. [5] proposed an attempt to synthesize the knowledge available on the HD domain, the gained experience in years of patients' treatment, and large data set collected over four years of automated monitoring of HD sessions. Chittaro Luca et.al. [2] presented an approach for visual data mining on temporal data and applies it to a real medical problem, i.e. the management of hemodialysis. Molina P. S. C. et.al. presented dialysis access monitoring work discusses two methods based on directional continuous wave Doppler system to evaluate the access blood flow. Martin-Guerero Jose D et.al. [6] presented a reinforcement learning (RL) approach for anemia management in patients undergoing chronic renal failure. Aboui Vahid et.al. presented requires continuous monitoring of blood pressure in dialysis patients and the high ability to predict pressure and estimation of situation of the patient.

2. Proposed Idea

In this paper, we present new health-care hemodialysis application system of the monitoring and treatment plan for the hemodialysis patients with applying a knowledge-based information system. In this application all patients can be monitored and treatment plan. The proposed our health-care system provides a series of analytical functions to analyze temporal stages of the assessment parameters for a hemodialysis patient. Health-care hemodialysis application system engine that can integrate among the assessment of hemodialysis adequacy monitoring, the treatment plan, and the chart of patient development. Knowledge which usually is from the experts now is from engine. Health-care hemodialysis application system to help the nephrology doctors and the hemodialysis nurses know the hemodialysis adequacy assessment which is included the adequacy monitoring assessment and the treatment plan. A new computational present result of adequacy hemodialysis and treatment plan, middle molecule clearance and treatment plan, control of general blood pressure (inter dialysis) and treatment plan, control of blood (intra dialysis), and nutrition status and treatment plan. Figure 1 shows the system architecture of the hemodialysis adequacy assessment.

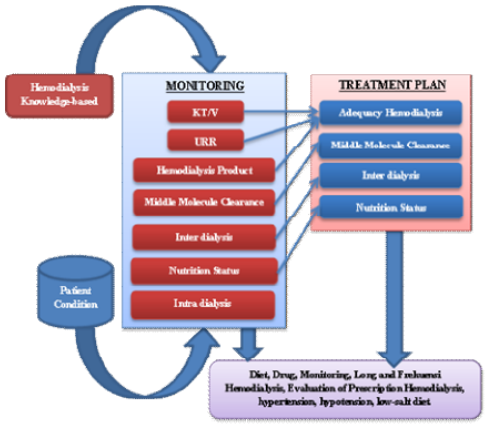

Figure 1. System Architecture of The Hemodialysis Adequacy Assessment

3. System design

A new health-care hemodialysis application system model for monitoring the patients during hemodialysis therapy include before and after hemodialysis, and the treatment plan after hemodialysis therapy. Our health-care system proposed the assessment of hemodialysis adequacy monitoring and the treatment plan. The application can show the chart of patient development. Patient development based on assessment of hemodialysis adequacy monitoring.

3.1 Assessment of Hemodialysis Adequacy Monitoring

The knowledge is used in the design of this application. There are five dialysis adequacy assessments that will be computed, namely:

1. Adequacy Hemodialysis.
2. Middle molecule clearance.
3. Control of General Blood Pressure (inter dialysis).
4. Control of Blood Pressure (intra dialysis).
5. Nutrition Status.

3.1.1 Adequacy Hemodialysis

Adequacy Hemodialysis consists of Small Molecule Clearance and Hemodialysis Product. For more details can be seen in explanation below.

3.1.1.1 Small Molecule Clearance

Small molecule clearances there are 2 outputs, value of Kt/V and value of URR from patient. To calculate the value of Kt/V using the calculation formula as follow:

$$Kt/V = -\ln (R-0{,}0008t) + (4-3{,}5R) \times UF/W \quad (1)$$

Where:

Ln= Logarithm natural

R = Bun Post dialysis / Bun Pre Dialysis

t = Long dialysis (hour)

UF/W = (Weight pre dialysis – Weight post dialysis)/ Weight post dialysis

In the above calculation requires variables Bun Post and Bun Pre from laboratory data, Weight Pre, and Weight Post from tabledialysis data, then long dialysis from hemodialysis data.

To calculate the value of URR using the calculation formula as follow:

$$URR = (1-(\text{Bun Post}/\text{Bun Pre}))*100\% \quad (2)$$

In the above calculation requires variables Bun Post and Bun Pre from laboratory data.

3.1.1.2 Hemodialysis Product

There are two variables to be processed, namely variable IntervalHD=f and LongHD=t, variable IntervalHD and LongHD from patient hemodialysis data.

To calculate the value of Hemodialysis Product using the calculation formula as follow:

$$HDP = f^2 \, X \, t^0 \quad (3)$$

Description:

f = Frequency Hemodialysis/ week

t = Long each Hemodialysis

3.1.2 Middle Molecule Clearance

To find the normal molecule clearance use knowledge from the expert.

Table 1. Category Table of Middle Molecule Clearance

Category	Phosphate, Calcium
Hyperphosphatemia	Phosphate >4.6
Normal	Phosphate <4.6
Hypocalcaemia	Calcium<8
Hypercalcaemia	Calcium >10
Normal	8< Calcium <10
with the risk of calcification	Calcium X Phosphate > 55
normal (without the risk of calcification)	Calcium X Phosphate < 55
Hyperphosphatemia	Phosphate >4.6
Normal	Phosphate <4.6
Hypocalcaemia	Calcium<8
Hypercalcaemia	Calcium >10

There are two variables to be processed to determine the entry in a particular category, namely variable Phosphate and from patient laboratory data. It can be seen in Table 1, and Table 2.

Table 2. Knowledge Table of Middle Molecule Clearance

P, Ca Level	Assessment
Phosphate>4.6 && Calcium<=7.9 && PhosphateXCalcium>55	Hyperphosphatemia and hypocalcaemia with the risk of calcification
Phosphate>4.6 && Calcium<=7.9 && PhosphateXCalcium<=55	Hyperphosphatemia and hypocalcaemia without the risk of calcification
Phosphate<=4.6 && Calcium<=7.9 && PhosphateXCalcium<=55	Hypocalcaemia without the risk of calcification
Phosphate>4.6 && Calcium>10 && PhosphateXCalcium>55	Hyperphosphatemia and hypercalcaemia with the risk of calcification
Phosphate<=4.6 && Calcium>10 && PhosphateXCalcium>55	Hypercalcaemia with the risk of calcification
Phosphate>4.6 && Calcium>10 && PhosphateXCalcium <=55	Hyperphosphatemia and hypercalcaemia without the risk of calcification
Phosphate<=4.6 && Calcium>10 && PhosphateXCalcium <=55	Hypercalcaemia without the risk of calcification
Phosphate>4.6 && Calcium>=8 && Calcium<=10 && PhosphateXCalcium<=55	Hyperphosphatemia without the risk of calcification
Phosphate>4.6 && Calcium>=8 && Calcium<=10 && PhosphateXCalcium>55	Hyperphosphatemia with the risk of calcification
Phosphate<= 4.6 && Calcium>=8 && Calcium<= 10 && PhosphateXCalcium <= 55	Normal
Phosphate>4.6 && Calcium<=7.9 && PhosphateXCalcium>55	Hyperphosphatemia and hypocalcaemia with the risk of calcification

3.1.3 Control of General Blood Pressure (inter dialysis)

Saturation, Ferritin	Assessment
Saturation>=20 && Ferritin>=100	Enough
Saturation <20 && Ferritin >=100	Anemia Deficiency Fe functional
Saturation >=20 && Ferritin <100	Anemia Deficiency Fe relative
Saturation <20 && Ferritin <100	Anemia Deficiency Fe absolute

To find the control of general blood pressure (inter dialysis) use knowledge from the expert. There are one variable to be processed to determine the entry in a particular category, namely variable blood pressure (Systolic post) from patient tabledialysis data. It can be seen in Table 3.

Table 3. Knowledge Table Control of General Blood Pressure (Inter dialysis)

Blood Pressure	Assessment
Blood Pressure >141	Hypertension Stage 2
>=131 Blood Pressure <=140	Hypertension Stage 1
>=121 Blood Pressure <=130	Pre Hypertension
>=110 Blood Pressure <=120	Normal Blood Pressure
Blood Pressure < 110	hypotension

3.1.4 Control of Blood Pressure (intra dialysis)

To find the control of blood pressure use knowledge from the expert. There are five variable to be processed to determine the entry in a particular category, namely variable Blood Pressure (Systolic pre, Systolic 1, Systolic 2, Systolic 3, and Systolic 4) from patient table dialysis data, as shown in Table 4.

Table 4. Knowledge Table Control of Blood Pressure (intra dialysis)

Systolic	Assessment
Systolic 1 – Systolic Pre > 20	hypertension
Systolic 1 – Systolic Pre < -20	hypotension
Systolic 2 – Systolic Pre > 20	hypertension
Systolic 2 – Systolic Pre < -20	hypotension
Systolic 3 – Systolic Pre > 20	hypertension
Systolic 3 – Systolic Pre < -20	hypotension
Systolic 4 – Systolic Pre > 20	hypertension
Systolic 4 – Systolic Pre < -20	hypotension
Systolic post – Systolic Pre > 20	hypertension
Systolic post – Systolic Pre < -20	hypotension

3.1.5 Nutrition Status

To find the nutrition status use knowledge from the expert. There are two variable to be processed to determine the entry in a particular category, namely variable Saturation and Ferritin. Variable Saturation, as shown in Table 5, is variable after calculate between variable Serum iron and TIBC, where variable Serum iron and TIBC from patient laboratory data; whereas variable Ferritin (Fe) is variable taken directly from patient laboratory data.

Table 5. Saturation Variable

Saturation Variable
Saturation = (Serum Iron/TIBC)*100%

Table 6. Knowledge Table of Nutrition Status

3.2. Treatment Plan

The knowledge is used in the design of this application. There are four treatment plan that will be computed, namely:

1. Adequacy Hemodialysis.
2. Middle molecule clearance.
3. Control of General Blood Pressure (inter dialysis).
4. Nutrition Status.

3.2.1 Treatment Plan of Adequacy Hemodialysis

Treatment Plan Adequacy Hemodialysis use knowledge from the expert. It can be seen in Table 6.

3.2.2 Treatment Plan of Middle Molecule Clearance

Treatment Plan of Middle Molecule Clearance use knowledge from the expert. It can be seen in Table 7.

Table 6. Knowledge Table of Adequacy Hemodialysis Treatment Plan

	KTV < 1.2	>=1.2 KTV <=1.7	KTV > 1.7
HDP < 20	Increase long and frequency of hemodialysis	Increase long and frequency of hemodialysis	Evaluation of nutritional problems
HDP > 20	Increase long and frequency of hemodialysis and Evaluation of Hemodialysis prescription	Evaluation of Hemodialysis prescription	Hemodialysis is optimal

Table 7. Knowledge Table of Middle Molecule Clearance Treatment Plan

Assessment	Diet	Drug	Monitoring
Hyperphosphatemia and hypocalcaemia with the risk of calcification	Low-Phosphate Diet	Phosphate binders	Levels of Calcium and Phosphate
Hyperphosphatemia and hypocalcaemia without the risk of calcification	Low-Phosphate Diet	Phosphate and D5 binders	Levels of Calcium, Phosphate, and IPTH
Hypocalcaemia without the risk of calcification	High-Calcium Diet	Calcium Supplements, D3	Levels of Calcium, Phosphate, and IPTH
Hyperphosphatemia and hypercalcaemia with the risk of calcification	Low Phosphate and calcium Diet	Phosphate binders non Calcium (max 4 mg)	Levels of Calcium and Phosphate
Hypercalcaemia with the risk of calcification	Low calcium Diet	Steroids and do Hemodialysis	Levels of Calcium and Phosphate and look for other causes of hyper calcium
Hyperphosphatemia	Low	Phosphate	Levels of

and hypercalcaemia without the risk of calcification	Phosphate and calcium Diet	binders non Calcium, D3	Calcium, Phosphate, and IPTH
Hypercalcaemia without the risk of calcification	Low calcium Diet	Steroids (when in distress get)	Levels of Calcium and Phosphate and look for other causes of hyper calcium
Hyperphosphatemia without the risk of calcification	Low Phosphate Diet	D3	Levels of Calcium, Phosphate, and IPTH
Hyperphosphatemia with the risk of calcification	Low Phosphate Diet	Phosphate binders	Levels of Calcium and Phosphate
Normal	Normal	-	Levels of Calcium and Phosphate

3.2.3 Treatment Plan of Control General Blood Pressure (Interdialisis)

Treatment Plan Control of General Blood Pressure (Inter dialysis) use knowledge from the expert. It can be seen in Table 8.

Table 8. Knowledge Table of Control of General Blood Pressure (Inter dialysis) Treatment Plan

	Hypotension	**Normal Blood Pressure**	**Pre Hyper tension**	**Hypertension Stage 1**	**Hypertension Stage 2**
Drinking water <= 500 ml/day	Do drinking water <= 500 ml/day	Keep drinking, diet, and anti-hypertension that had been done	Do drinking water <= 500 ml/day	Do drinking water <= 500 ml/day	Do drinking water <= 500 ml/day
Low-Salt Diet	-		-	Do Low-Salt Diet	Do Low-Salt Diet
Anti-hypertension drugs	Don't be taking anti-hypertension drug		-	-	Do consumption of anti-hypertension drugs

Note : If the patient is already taking anti-hypertension drug, the drug should remain in the drink according to the doctor's instructions

3.2.4 Treatment Plan of Nutrition Status

Treatment Plan Nutrition Status take from two algorithms, namely algorithm terapi besi and algorithm terapi ESA. It can be seen in Table 9.

Table 9. Knowledge Table of Nutrition Status Treatment Plan

Assessment : Enough Treatment Plan: **1.** ESA therapy phase correction Epoetin A or Epoetin B: 2000-5000 IU, 2X a week or 80-120 IU/KgBB/week C.E.R.A: 0.6 yg/KgBB or 50-70yg every 2 weeks. **2.** The target Hemoglobin response increased 0,5-1,5g/dl in 4 weeks, if: **a.** Reached , maintain the dose of ESA until the target of Hemoglobin is reached (Hemoglobin 10-12 g/dl). **b.** Has not been reached, then the dose is increased 25% every 4 weeks and if it has not reached then look for the causes of ESA inadequate response. **c.** Exceeding the target, **1)** If Hemoglobin >13 g/dl then STOP ESA and evaluate one month. If Hemoglobin 12-13 g/dl or Hemoglobin increase 1.5 g/dl in 4 weeks the dose reduced 25% and evaluate one month.
Assessment : Anemia Deficiency Fe functional Treatment Plan: Iron Therapy Continue therapy ESA and delay Iron Therapy, observation in a moth. If Hemoglobin does not rise, it can be give Iron Sucrose or Iron Dextran 100 mg 1x/4 weeks, 3 months observation. Iron therapy was delayed. Look for a possible infectious cause of inflammation.
Assessment : Anemia Deficiency Fe relative Treatment Plan: Required further consultation to the expert (nephrology doctor).
Assessment : Anemia Deficiency Fe absolute Treatment Plan: Included in the group IRON PHASE CORRECTION. Give Iron Sucrose/Iron Dextran (100mg 2x/week) for 10x. After that every week check Ferritin and Saturation.

4. Experimental Study

To perform a new health-care hemodialysis application system of the monitoring and treatment plan for the hemodialysis patients, we divide 3 experiment are Experiment Assessment of Hemodialysis Adequacy Monitoring, Experiment treatment plan, and Experiment The Chart of Patient Development.

4.1 Experiment Assessment of Hemodialysis Adequacy Monitoring

Figure 2. Adequacy Monitoring Assessment

4.2 Experiment Treatment Plan

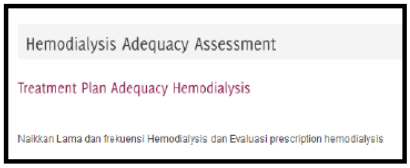

Figure 3. Treatment Plan for Adequacy Hemodialysis

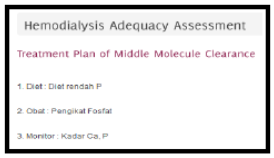

Figure 4. Treatment Plan Middle Molecule Clearance

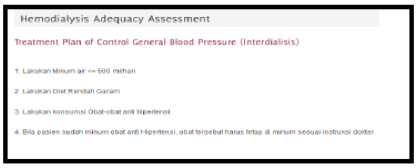

Figure 5. . Treatment Plan for Control General Blood Pressure (inter dialysis)

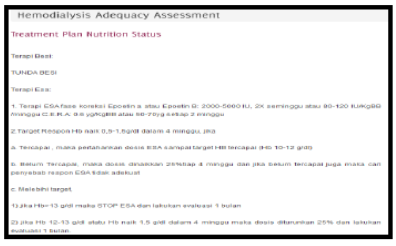

Figure 6. Treatment Plan for Nutrition Status

4.3 Experiment The Chart of Patient Development

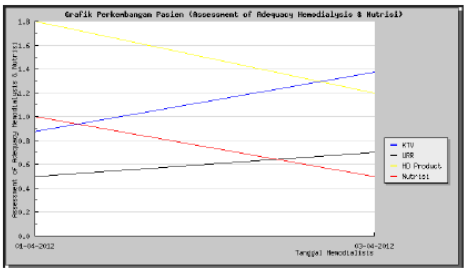

Figure 7. Adequacy Hemodialysis and Nutrition patient development

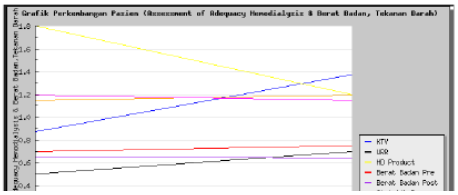

Figure 8. Adequacy Hemodialysis and Systolic,weight patient development

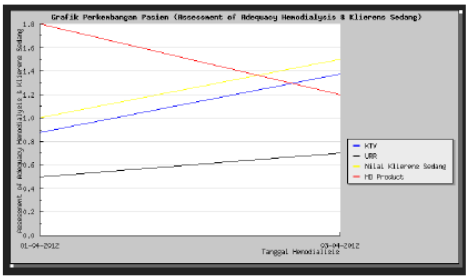

Figure 9. Adequacy Hemodialysis and Middle Molecule Clearance patient development

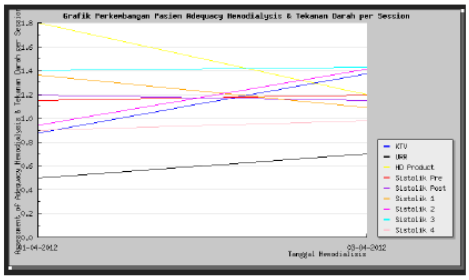

Figure 10. Adequacy Hemodialysis and Middle Molecule Clearance patient development

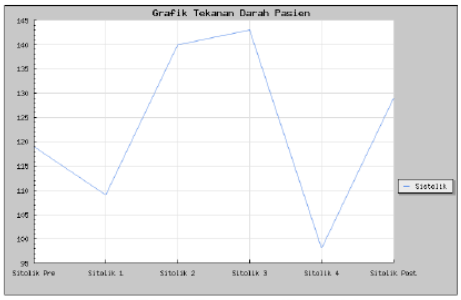

Figure 11. Blood Pressure (Systolic) patient development

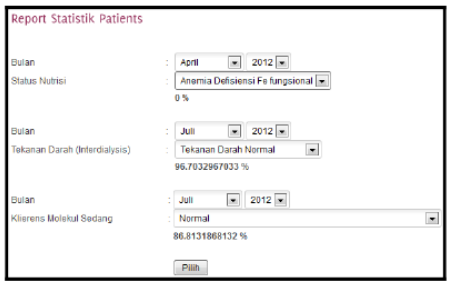

Figure 12. Report Statistic Patients

Figure 2 presents the assessment of hemodialysis adequacy monitoring. In this final project assessment which computerized is KTV, URR, Hemodialysis Product, Middle Molecule Clearance, Control of Blood Pressure (inter dialysis), Control of Blood Pressure (intra dialysis), and Nutrition Status. But not all assessment will be evaluated the treatment plan, assessment which evaluate the treatment plan is Adequacy Hemodialysis (KTV, URR, and Hemodialysis Product), Middle Molecule Clearance, Control of Blood Pressure (inter dialysis), and Nutrition Status. For more the detail treatment plan can choose the treatment button.

Figure 3 presents the Treatment Plan of Hemodialysis Adequacy. This Treatment plan is influenced by KTV and Hemodialysis Product. Figure 4 presents the Treatment Plan of Control General Blood Pressure (Inter dialysis). There are 3 items in this Treatment plan such as drinking water, low-salt diet, and anti hypertension drugs. Figure 5 presents the Treatment Plan of Control General Blood Pressure (Inter dialysis). There are 3 items in this Treatment plan such as drinking water, low-salt diet, and anti hypertension drugs. Figure 6 presents the Treatment Plan of Nutrition Status. The knowledge-based of this treatment plan use ESA Therapy Algorithm and Besi Therapy Algorithm. Figure 7 presents the chart of Hemodialysis Adequacy and Nutrition Status Patient Development. The chart compares assessment between Hemodialysis Adequacy and Nutrition Status. Hemodialysis Adequacy consists of KTV, URR, and HD Product. KTV is presented blue line, URR is presented black line, HD Product is presented yellow line, and Nutrition Status is presented red line. Each assessment, if the line increases means the patient development progresses; whereas, if the line decreases means the patient development does not progress.

Figure 8 presents the chart of Hemodialysis Adequacy, Weight, and Blood Pressure Patient Development. The chart compares assessment among Hemodialysis Adequacy, Weight, and Blood Pressure. Hemodialysis Adequacy consists of KTV, URR, and HD Product. KTV is presented blue line, URR is presented black line, HD Product is presented yellow line, Weight Pre dialysis is presented red line, Weight Post dialysis is presented purple line, Systolic Pre dialysis is presented orange line, and Systolic Post dialysis is presented pink line. Each assessment, if the line increases means the patient development progresses; whereas, if the line decreases means the patient development does not progress.

Figure 9 presents the chart of Hemodialysis Adequacy and Middle Molecule Clearance Patient Development. The chart compares assessment between Hemodialysis Adequacy and Middle Molecule Clearance. Hemodialysis Adequacy consists of KTV, URR, and HD Product. KTV is presented blue line, URR is presented black line, Middle Molecule Clearance is presented yellow line, and HD Product is presented red line. Each assessment, if the line increases means the patient development progresses; whereas, if the line decreases means the patient development does not progress.

Figure 10 presents the chart of Hemodialysis Adequacy, and Blood Pressure per Hour Patient Development. The chart compares assessment among Hemodialysis Adequacy, and Systolic Pre, Systolic 1, Systolic 2, Systolic 3, Systolic 4, Systolic post. Hemodialysis Adequacy consists of KTV, URR, and HD Product. KTV is presented blue line, URR is presented black line, HD Product is presented yellow line, Systolic Pre dialysis is presented red line, Systolic Post dialysis is presented purple line, Systolic 1 dialysis is presented orange line, Systolic 2 dialysis is presented pink line, Systolic 3 dialysis is presented cyan line, and Systolic 4 is presented magenta line. Each assessment, if the line increases means the patient development progresses; whereas, if the line decreases means the patient development does not progress. Figure 11 presents the chart of blood pressure Patient Development. Blood pressure (Systolic) is monitored per session such as Systolic pre, Systolic 1, Systolic 2, Systolic 3, Systolic 4, and Systolic Post. Figure 12 presents report statistic patients. Report statistic patient consist of Nutrition Status, Control of Blood Pressure (inter dialysis), and Middle Molecule Clearance.

5. Conclusions

In this paper we have presented new hemodialysis health-care application system of the monitoring and treatment plan for the hemodialysis patients with applying a knowledge-based information system. Our system proposed in this paper provides a series of analytical functions to analyze temporal stages of the assessment parameters for a hemodialysis patient. To perform feasibility and applicability of our proposed application system, we made a series of experimental study with applying our system for analysing 30 hemodialysis patients in Hemodialysis Installation at Dr. Soetomo Regional General Hospital, Surabaya. Our proposed application system provides sets of assessment monitoring and treatment plans for the hemodialysis

patients depending on the critical status of their renal failures. Through a series of health-care hemodialysis temporal assessment parameters provided in our proposed system, the nephrology doctors and the hemodialysis nurses may take care easier to the renal-failure patients for monitoring and treatment plan.

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