Modeling on clinical group decision support system for screening and working diagnosis acute respiratory infections

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Abstract. There are cases of patients with Acute Respiratory Infection (ARI) which are not handled quickly and appropriately at emergency department (ED), thus there should be a medium that can assist medical personnel in making decisions. This research proposes the development model of Clinical Group Decision Support Systems (CGDSS) named KLISPA models. KLISPA model can accommodate a screening process to the working diagnosis process of ARI by integrating Case Based Reasoning (CBR) and Groups Decision Support System (GDSS). Screening process completed by CBR using Nearest Neighbor method. This process helps medical personnel such as nurses, co asst doctors, and general practitioners to do screening to patients for determining the early solution to the disease. Meanwhile, the working diagnosis solved by GDSS uses the methods of Eckenrode, Extended TOPSIS and BoostVote. This process accommodates the needs of joint decision-making which involves groups of Decision Maker (DM) consisting of pediatrician, child lung specialist doctor, and the radiologist doctor.

1. Introduction
Acute Respiratory Infection (ARI) is the disease that sometimes happens to children that can lead mortality. It happens since their immune system is still fragile and low, so they need early, quick and appropriate treatment since arriving in the Emergency room[1]. Based on the decision of the Indonesian Minister of Health 856/Menkes/SK/IX/2009, one of the indicators of minimum service standards at the hospital’s emergency department is the response time which standard time is 5 minutes of patient treatment when a patient arrive at the ED by accomplishing the ABCD procedure (Airway, Breathing, Circulation and Disability)[2].

Based on research conducted at the Ansari Saleh Hospital in Banjarmasin, handling ARI patients conducted from the screening process until the working diagnosis. Screening process is done by several medical personnel such as nurses, co asst doctors, general practitioners while pediatricians, child lung specialist doctor, and the doctor radiologist are working through the
diagnostic process. In the process, there are still cases of patients who are not handled quickly and precisely, because the physician is not on duty while there is knowledge limitation of the nurses. Therefore we need a medium that can help medical personnel to do the job in the medical sector by utilizing computer-based systems in making decisions.

Group Decision Support System (GDSS) is a computer-based system that supports groups of people involved in a shared task (or objective) and provides the interface for a shared environment [3]. GDSS requires a model because the model is a tool of simplification and analysis of complex situations or systems. Through such complex models, situations or systems can be simplified without eliminating the essentials in order to facilitate understanding. Creation and utilization of models can provide a management framework for decision making [4].

The GDSS applied in medical field is called the Clinical Groups Decision Support System (Clinical GDSS). According to Mendoca [5] Clinical GDSS is a computer program designed to provide support for experts in making clinical decisions. The objective of this system is to help health professionals to analyze patient data, to make decisions based on the diagnosis, to provide prevention and treatment for health problems. This study proposes a model of Clinical GDSS to accommodate from screening process until to the working diagnostic process on ARI by integrating CBR and GDSS.

2. Related Works

Researches on models of Decision Support System (DSS) in the medical field had been carried out by previous researchers. Anokwa [6] conducted a clinical decision support system design based mobile phone to manage patient care system. Tomar [4] designed a clinical decision support system for the diagnosis of chronic heart failure based on case base reasoning, the system was designed to accommodate four diseases namely coronary artery, rheumatic valvular, chronic cor pulmonare and congenital. Horskyja [8] made a clinical decision support system design to determine the prescription. Flores [9] designed a clinical DSS model by employing openEHR and GDL for identification of Lynch syndrome disease or colorectal cancer at early age. In that model, what developed was a process of screening, referral and testing recommendation. Glotsos [10] designed a decision support system as a diagnostic tool for melanoma-based disease for smartphone. In another research, Adekunle [11] designed clinical decision support systems based on smart system for hepatitis B predictio. Khan [12] designed, developed and integrated pulmonary embolism tools to assist the work of doctors in the clinical examination of the patient.

3. Model Of Clinical Group Decision Support System

The proposed clinical decision support system model group consists of components of data management, model management and user interface. The components are described as follows. Data management in the model of clinical decision support system is the process of arranging and maintaining the data used by the system in a database. The database contains data such as symptom data as criteria, disease data as an alternative, match rating data, system users, therapy, and patient medical records. In addition, data management is also carried out for data related to the establishment of case bases. The data access is done by the user via the interface. The management model is employed to set up and maintain the models of clinical decision support system, which are divided into two (2) phases of interrelated parts, namely: 1) The first part: the screening process as the initial solution for ARI patients using CBR; 2) The second part: the process of working diagnosis using GDSS. The user interface is a tool that is used to allow users to communicate with the system. While for detailed process of Clinical GDSS model architecture (model KLISPA) from screening to diagnosis process work can be seen in Figure 1.
3.1. Screening Process using the Case Base Reasoning

Figure 2 part I indicated that in the part of the screening process stages. Process screening of patients is a series of activities in a preliminary assessment of emergency for patients who are brought to ED. The process of screening at ED performed by medical personnel such as general practitioners, co asst doctors and nurses based on their experience. The idea why CBR is used for the completion of the screening process is because CBR solves problems using knowledge based on previous experiences to solve new problems. On a new case, screening process settlement using the CBR follows these steps:

1. Case Representation

Case representation is very important in solving problems in CBR, as it provides important information for reasoning. The case referred to in this study is medical records data of patients with specific ARI pneumonia in children and toddlers in a certain condition and time. Cases were represented in features that characterize the case and the solution to handle the case. The stored features were parameters to get the solution. These features were be obtained from knowledge acquisitions such as interviews with experts, or with other data collection methods. The following Table 1 shows the case representation.

| Case Code   | Medical Record Number |
|-------------|-----------------------|
| K4          | A111111               |

**Indication:**

1. Cough with fast breath: 1
2. Retraction: 1
3. Fever: 1
4. Wet Ronchi: 0
5. Leukocytosis: 1
6. Cyanosis: 1
7. Grunting: 1
8. Torax photos: 1
9. Head Nodding: 0
10. Seizures: 0
11. Not Able to drink: 0

**Patient Data**

Age: 3 Month

**Screening Disease**: Pneumonia
2. Indexing Case
The indexing cases process allows users to effectively retrieve all the records that qualify a search on the search key field of the index. This study used a simple indexing by giving the code number for each case by sex and age.

3. Retrieval Process
Retrieval process approach used in this study was the assessment of surface similarity which is an approach based on characteristic appearance, similarity on each case of new issue, presented as a real number in the range [0,1] calculated in corresponding measure of similarity provided. This study used Nearest Neighbor method.

Local similarity value indicated problem attribute meaning similarity on the same attribute of a case. Local similarities were divided into two types: symbolic and numeric local similarities [13]. Local similarity calculation if there were numerical features[13].

Global similarity was used to calculate the similarity between a problem and a case stored in the case base. One global similarity measurement method frequently used was Nearest Neighbor [13].

3.2. Working Diagnosis Proses using the GDSS
Figure 2 part II indicated that in the part of the working diagnosis process stages. Building a GDSS requires a criterion and an alternative, and therefore there are some diseases pneumonia which can be used as an alternative (A1=Pneumonia, A2=Severe Pneumonia and A3= Non Pneumonia) and some of the symptoms which can be used as a criterion (C1= Cough with fast breath, C2= Retraction, C3= Fever, C4= Wet Ronchi, C5= Leukocytosis, C6= Cyanosis, C7= Grunting, C8= Torax photos, C9= Head Nodding, C10= Seizures, C11= Not Able to drink) in favor of making a decision support system model of the clinical group.

Value of a criterion against the alternative provided by the DM refers to Scoring Respiratory Distress (RDS) System [14][15].

Completion on stages of the working process of diagnosis for patients with ARIs, especially pneumonia in children and infants in this study, used a group decision support system (GDSS) referred to Figure 1. The symptoms experienced by the patient become the criteria in the GDSS, whereas possibilities of the doctor’s diagnosis become alternative decisions on the GDSS. Decision Makers (DM), which have roles in the decision-making group are a pediatrician as DM1 and child lung specialist doctor as a specialist radiology DM2 while radiologist doctor only act as a conduit on radiology laboratory results.

GDSS settlement process at first constructs a matrix X performance rating as shown in Table 2 with the dimension of the matrix (m x n) where m is the number of alternatives and n is the number of criteria. Matrix columns are X 11 ... X m1 and matrix rows are X 11 X 12 ... X 1n. X mn matrix elements. are provided with score values refers to Scoring Respiratory Distress (RDS) System [15].

| Alternatives       | Cough with fast breath (C1) | Retracti on (C2) | ...No Able to drink (C11) |
|--------------------|-----------------------------|------------------|--------------------------|
| A1=Pneumonia       | X11                         | X12              | ...                      |
|                    | X11                         | X12              | ...                      |
|                    | X1n                         | A2=Severe Pneumonia | ...                      |
| A3=Non Pneumonia   | Xm1                         | Xm2              | ...                      |
|                    |                             |                  | Xmn                      |
For example if there was a clinical case incident from the examination of a doctor, based on Table 8 above, there are three steps to complete the process of GDSS in this study, namely: 1) stage of weighting by Eckenrode method; 2) ranking stage decision alternative using Extended TOPSIS method; and 3) voting stage using BoostVote method. These stages will be described in the following.

3.2.1. Stages of Weighting using Eckenrode Method. One of the steps taken to complete the process of GDSS in this study is to determine the value of weight criteria. Doctors have an importance level of a symptom (criteria) for determining decision on their diagnosis. Doctors as Decision Makers (DM), which have a role in giving weight to the criterion is pediatrician as DM1, a child lung specialist as DM2. Referring to ordinal scale measurements on Statistics for epidemiology [16], the ordinal scale for the assessment of criterion weight (simply influential =1, influential=2 and very influential=3).

Based on Table 3 there are several criteria provided with value of the weight based on importance level of criteria. For example, criterion C1 is Cough and Fast breathing, since they are considered very important criteria, thus DM1 gives a score of 3 (very influential). Criterion C2 is Retraction which is very important, thus DM1 gives a score of 3 (very influential). Criterion C3 is Fever which is an important criterion, then DM1 gives a score of 2 (influential). The other criteria are treated in the same way to weight the importance [7].

3.2.2. Ranking Stages of Decisions Alternative using Extended TOPSIS Method. The ranking stages is the second phase in accomplishing GDSS process. Ranking process of decision alternatives employs the method of Extended TOPSIS. Extended TOPSIS is a development of TOPSIS method, the basis of the development of this method is how to calculate the distance of data having ordinal scale features. According to Wachowicz [17] and Lahby [18], Minkowski Distance is employed to calculate the distance of ordinal scale data, which thus with the idea of $4^{th}$ stage in TOPSIS method for calculating distances using Euclidean Distance it is modified using the Minkowski Distance to match the method used with the data type.

Extended TOPSIS method is employed to solve multiple criteria to give a solution of a number of possible alternatives by determining each alternative with best alternative and worst alternative ranking. This method can also solve decision problems practically. The concept is simple and easy to understand; the computing is efficient and has the ability to measure relative performance of decision alternatives into simple mathematical forms [15].

According to Table 3 criteria performance rating matrix on alternatives, the decision alternatives are determined. Decision alternative ranking process steps are as follows[15]:

1. Step One: to calculate the normalized matrix.
2. Step two: to calculate the value of normalized weighted matrix.
3. Step Three: to define ideal positive solution value and ideal negative value.
4. Step Three: to calculate the distance of each alternative toward ideal positive solution value and ideal negative solution using Minkowski Distance Method. At this stage, modification is conducted for corresponding the method that is used with the type of variable. Generally, TOPSIS used Euclidean Distance method for quantitative variable. Extended TOPSIS is suggested to use Minkowski Distance which can be used to calculate ordinal variable or quantitative [18][9][15].
5. Step Five: to define maximum and minimum value from the result obtained in stage 4.
6. Step Six: to define alternative rank value, from the result which obtained in the stage 4 and 5. Results from alternative ranking from each DM will be processed by BoostVote voting method in order to generate group decision alternative.
3.2.3. Voting Stages using BoostVote Method. The voting process is required to determine which
decisions can be recommended as an alternative for group decisions. In this process the doctor who
acts as the decision maker (DM) in decision-making is a pediatrician as DM1 and child lung
specialist doctor as DM2. Stages of the voting process in this study employ the method of BoostVote
[19].

4. Conclusion
This research proposes the development model of Clinical Group Decision Support Systems
(CGDSS) named KLISPA models. KLISPA model can accommodate a screening process to the
working diagnosis process of ARI by integrating CBR and GDSS. Screening process completed
by CBR using Nearest Neighbor method. Meanwhile, the working diagnosis solved by GDSS uses
the methods of Eckenrode, Extended TOPSIS and BoostVote.

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