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The new model for medicine distribution by combining of supply chain and expert system using rule-based reasoning method

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ABSTRACT

The medicine distribution supply chain is important, especially during the coronavirus disease 2019 (COVID-19) pandemic, because delays in medicine distribution can increase the risk for patients. So far, the distribution of medicines has been carried out exclusively and even some medicines are distributed on a limited basis because they require strict supervision from the Medicine Supervisory Agency in each department. However, the distribution of this medicine has a weakness if at one public health center there is a shortage of certain types of medicines, it cannot ask directly to other public health center, thus allowing the availability of medicines not to be fulfilled. An integrated process is needed that can accommodate regulations and leadership policies and can be used for logistics management that will be used in medicine distribution. This study will create a new model by combining supply chains with information systems and expert systems using the rule-based reasoning method as an inference engine that can be developed for medicine distribution based on a mobile hybrid system in the Demak District Health Office, Indonesia. So that a new framework model based on a mobile hybrid system can facilitate the distribution of medicines effectively and efficiently.

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1. INTRODUCTION

The increasing crude mortality rate [1], oupled with the ongoing coronavirus disease 2019 (COVID-19) pandemic and the emergence of new variants add to the increasingly long list of bad ones associated with improving people's health and welfare records [2], [3]. This forces the Indonesian government in 2021 to adopt a policy of imposing restrictions on community activities [4]. Facing this phenomenon requires an appropriate step so that the impact can be anticipated properly, one of which is by ensuring the availability of medicines in the community because medicines are one indicator to control and inhibit the rate of increase in morbidity that can lead to death [5]. The effectiveness of the management and distribution of medicines aims to create a supply of medicines in the right amount and time with minimal costs but still obtain optimal results in accordance with the requirements and purposes of use [6], [7]. Medicine distribution must be carried out efficiently by ensuring the distribution of medicines according to the type and needs of the community to other distribution facilities that have special supply chains based on applicable laws and regulations, including the distribution of hard medicines that must be handled by mean of special distribution [7], [8]. Restrictions on the level of mobility during the COVID-19 pandemic have an effect on medicine activity and distribution although it is partial, medicine distribution has so far been carried out using a special and exclusive distribution system because it must be closely monitored by the Medicine Circulation Supervisory Agency, there are medicines that are distributed freely, there are medicines that are distributed with a lim ited free system and there are even some medicines that are distributed in a limited distribution [9], [10]. However, there are obstacles that must be overcome when a public health center that lacks certain types of medicines cannot request medicines directly to other public health centers, coupled with the unavailability of a framework system to accommodate regulations in regulating the problem of distributing medicines directly from the center. from one health center to another contributed to increasing the likelihood of this happening, thus allowing the availability of medicines to be unfulfilled.

The trend of research developments on mobile hybrid systems continues to increase [11]. By paying attention to the facts about the development of current research trends that lead to the development of a mobile hybrid system, research on medicine distribution through an information system based on a mobile hybrid system [12], which was developed with scientific principles using the rule based reasoning method by involving experts in the pharmaceutical field is part of steps to ensure the availability of medicines effectively and efficiently in accordance with the basic principles of the rules of the supply chain information system [13]. The development of mobile hybrid system technology in this new framework system model can make transactions and medicine distribution supervision done online and real time [14]. The purpose of this research is to create a new framework system model by combining supply chain [15] and expert system [16] regarding medicine distribution using the rule-based reasoning method [17]. The rule-based reasoning method is very suitable to be used in this research because it can adopt the regulations and knowledge of pharmaceutical experts into a system in the form of an algorithm, even the rule-based reasoning method allows experts to be directly involved in research [18]. The result of combining supply chain with information systems and expert systems in this researh is a new framework model based on a mobile hybrid system that can simplify medicine distribution effectively and efficiently.

2. RESEARCH METHOD

The steps to achieve the goals and results of this research go through several stages, as shown in Figure 1. To get a good research product, the research process carried out must comply with procedures in accordance with the system development method used. In this research there are three types of methods used, the first method for conducting research using research and development methods [19]. The second method is to test the correlation of the data using the product moment and to determine the validity of the data using R table, while to test the consistency of the measuring instrument using cronbach alpha. The third method is the scientific method for solving problems by using the rule-based reasoning method [20], [21].

2.1. Research materials and tools

Research materials and tools used in this research are medicines process supply chain and their attributes, the first location is the initial node in this case the Demak District Health Office, the delivery location as the destination node is the public health center *(puskesmas)* and auxiliary public health center (*pustu*). Meanwhile, for experts in medicine problems and at the same time related to supply chain problems of medicine distribution, the researchers consulted with the pharmacist in charge both working at the Demak District Health Office and managing pharmacists working at the public health center and auxiliary public health center as pharmacists at the Demak District Government in Indonesia.

2.2. Stages of research

Starting from preliminary research or pre-research to find out at the same time to determine research opportunities to be carried out, then conduct a literature study to find and determine the variables that will be used in building the model using the preferred reporting items for systematic reviews and meta-analyses (PRISMA) technique on a reputable international journal database Scopus, WoS, PubMed, Springer, Emerald, Ebsco, Science Direct, ProQuest, IGIglobal. Found two independent variables and one dependent variable that will be used in this research and then tested the level of validity and reliability. With three variables, a new framework will be designed in consultation with pharmaceutical experts and at the same time involve policy makers in medicine distribution. Then the design that has been improved with suggestions and corrections from pharmaceutical experts and policy makers will be adopted into a new framework using the rule-based reasoning method in the form of an algorithm as an inference engine.

2.3. Pearson product moment correlation

Pearson product moment correlation [22] was used to examine the effect of independent regulatory variables and logistical management variables on the dependent medicine distribution variable. The data used is ordinal data which is discrete because the distance value between variables cannot be measured with certainty. Data were obtained through interviews, surveys and observations as well as through questionnaires with respondents related to the problem of medicine distribution. The formula used is (1):

$$r_{xy} = \frac{n\sum XY-(\sum X)(\sum Y)}{\sqrt{\{n\sum X^2-(\sum X)^2\}\{n\sum Y^2-(\sum Y)^2\}}} \quad (1)$$

The validity test used in this research is construct validity. Construct validity is the widest in scope compared to other validity, because it involves many procedures including content validity and criterion validity [23]. After knowing the effect, the next test will be carried out to determine the level of confidence in a measuring instrument.

2.4. Cronbach's alpha reliability testing

Testing the measuring instrument in the form of questions to determine the consistency of the data using Cronbach's alpha. Testing the reliability of the measuring instrument in this research was carried out with an internal consistency approach using the Cronbach's alpha formula [24]. The reason for using the Cronbach's alpha formula is that the results are more accurate and can approach the actual results [25]. The formula used is (2):

$$r_{11} = \left[\frac{k}{k-1}\right]\left[1-\frac{\sum\sigma_b^2}{V_t^2}\right] \quad (2)$$

In the Cronbach's alpha formula, the data is split as much as the number of items. The greater the reliability coefficient obtained, the smaller the measurement error, the more reliable the measuring instrument will be. On the other hand, the smaller the reliability coefficient, the greater the measurement error and the less reliable the measuring instrument used [26].

2.5. The rule-based representation

Rule based reasoning is part of a rule based expert system that is used as a way to store and manipulate knowledge to be realized in an information that can assist in solving various problems [27]. The rule-based system in this research uses the knowledge of pharmacists to solve real problems in terms of simplification of medicine distribution which normally requires the intelligence of pharmacists to solve them. Rule based knowledge representation has many of the same characteristics as logical reasoning, and is able to facilitate consistent, transparent, and repeatable decision making [28]. This process can be seen in Figure 1.

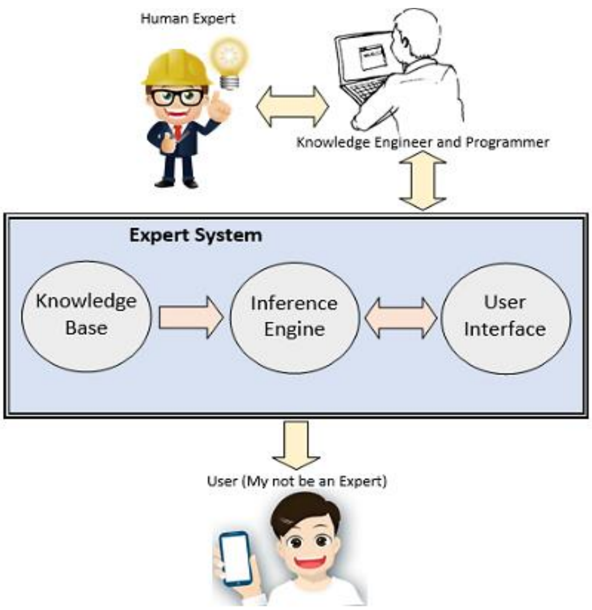


Figure 1. Rule based expert system

Some of the advantages of representing knowledge in a rule-based form are having the flexibility to adapt quickly to new knowledge [29]. Pharmacists' knowledge will be adopted into a new framework system to simplify medicine distribution in the form of an algorithm. Example:
R1: IF [Request Quantity < Medicine Stock] THEN [Action Accepted]
R2: IF [List of Medicine = NULL] THEN [Process Removing]
R3: IF [Expire Date OR Defective = TRUE] THEN [Process Delete]

3. RESULTS AND DISCUSSION

This section will discuss the results of research on the process of simplifying the supply chain model of medicine distribution through a new framework based on a mobile hybrid system [30]. The model developed using the rule based reasoning method is a representation of a real process involving experts in the pharmaceutical field [31]. The development of model starts from the search for ideas, bibliometric analysis, mapping of existing research to comparing with the closest research. So that the process model can ensure the availability of medicines effectively and efficiently in accordance with the basic principles of supply chain information systems [32].

3.1. Mapping the originality of research ideas

This research comes from an idea that is found from a problem. Originality of an idea is needed to underlie a research. Originality of ideas in information systems research can be seen from five aspects according to the computing curicula [33] and *Kerangka Kualifikasi Nasional Indonesia* (KKNI) Aptikom [34], among others are: i) topic area is included in the supply chain category, ii) research trends using a mobile hybrid system, iii) scientific methods in the field of expert systems with rule based reasoning methods, iv) the object of research in government agencies and v) the research priority emphasizes the health sector with a concentration on medicine distribution. In this research, the position of the originality of the idea is depicted by a small yellow color right in the middle which intersects with five aspects surrounded by circles. The originality of the idea based on five aspects can be seen in Figure 2.

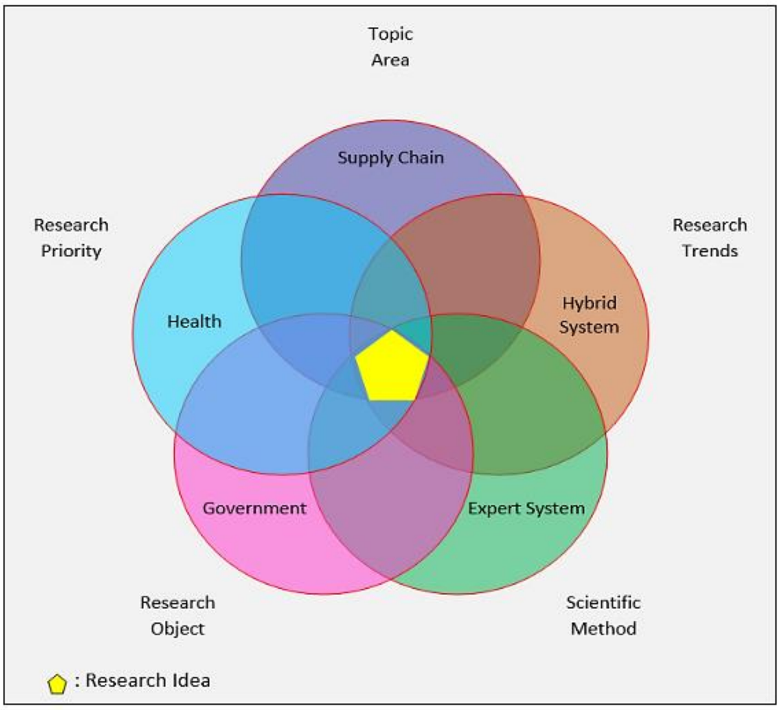
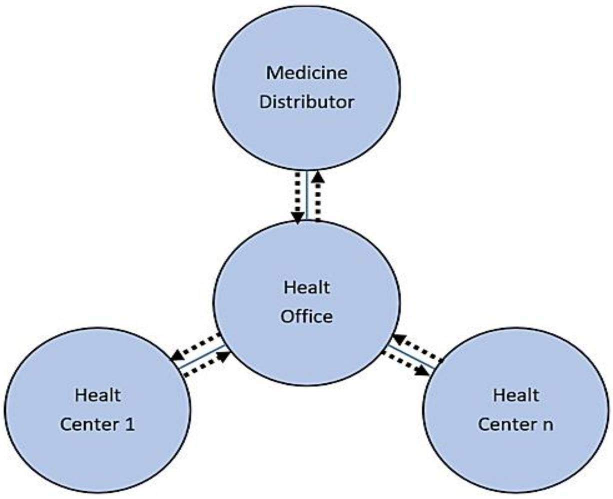


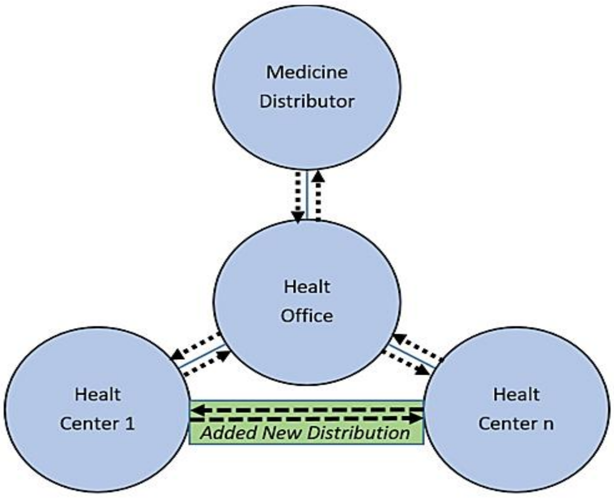
Figure 2. The originality of research ideas

3.2. Medicine distribution system comparison

The system that has been running so far is that the medicine distribution process will be carried out from the medicine distributor which will be submitted to the health office then will be file and stored in the pharmacy warehouse belonging to the healt office then will be distributed to each public health center which is still under the supervision and responsibility of the healt office according to requests made every certain period, this process can be seen in Figure 3(a). However, this will cause a new problem, namely when one of the public health centers runs out of stock of medicines and requires certain types of medicines, they cannot request medicines in real time to other public health centers, thereby increasing the risk to patients. The solution obtained in this research is if the public health center has run out of stock of medicine supplies, it can ask directly to other public health centers while still taking into account the regulations and policies of the health office, so that the function of the health office as a policy holder and supervising the distribution and distribution of medicines can still be carried out even more effectively and efficiently because it can be done online and in real time based on a mobile hybrid [29], [35]. This solution can be seen in Figure 3(b). The supply chain for medicine distribution becomes simpler by adding new distribution facilities as shown in Figure 3(b), so that it can overcome the problem of possible medicine shortages for patients is shown in Figure 3(a).



(a)



(b)

Figure 3. The supply chain for medicine distribution; (a) medicine shortages, and (b) adding new distribution facilities

3.3. Validity and reliability testing

The process of validity and reliability in this research is a test carried out before conducting the interview process and providing questionnaires as a research instrument to respondents to determine the quality and scientifically accountable variables to be used to design a new framework for medicine distribution [36], [22]. Test the validity of this research using the Pearson product moment technique which is done by correlating item scores with a total score on one variable, to determine its significance by using an R table with a significant level of 0.05 on a two-sided test. If $r_{xy >= } r_{tabel}$ the result is valid and if $r_{xy <} r_{tabel}$ the result is not valid. The results of this test can be seen in Table 1.

The measuring tool to determine the variables that will be used in making a new framework for simplification of medicine distribution in this research is a questionnaire. Questionnaire as a measuring tool can be tested for consistency with reliability test using Cronbach's alpha. This reliability test will use 9 valid results because the previous test found 1 invalid questionnaire. Determining the coefficients in this reliability test using the Guilford coefficient. The results of this reliability test can be seen in Table 2.

Table 1. Product moment validity testing

No	r_{xy}	r_{tabel}	Status
1	0.518	0.514	Valid
2	0.605	0.514	Valid
3	0.522	0.514	Valid
4	0.537	0.514	Valid
5	0.531	0.514	Valid
6	0.321	0.514	Not valid
7	0.618	0.514	Valid
8	0.731	0.514	Valid
9	0.589	0.514	Valid
10	0.637	0.514	Valid

Table 2. Cronbach's alpha reliability test results

Reliability coefficient	Interpretation
0.765	Reliable

With these results, the regulatory variables, logistics management and medicine distribution are declared valid and reliable so that the variables can be used to create a new medicine distribution simplification framework model. The distribution of respondent data can be seen in Figure 4. The distribution of the data is normal and the data will be illustrated with a bar chart. The stem height is a Likert scale 1-5, while the length reflects the number of respondents (15) and the depth represents the (10).

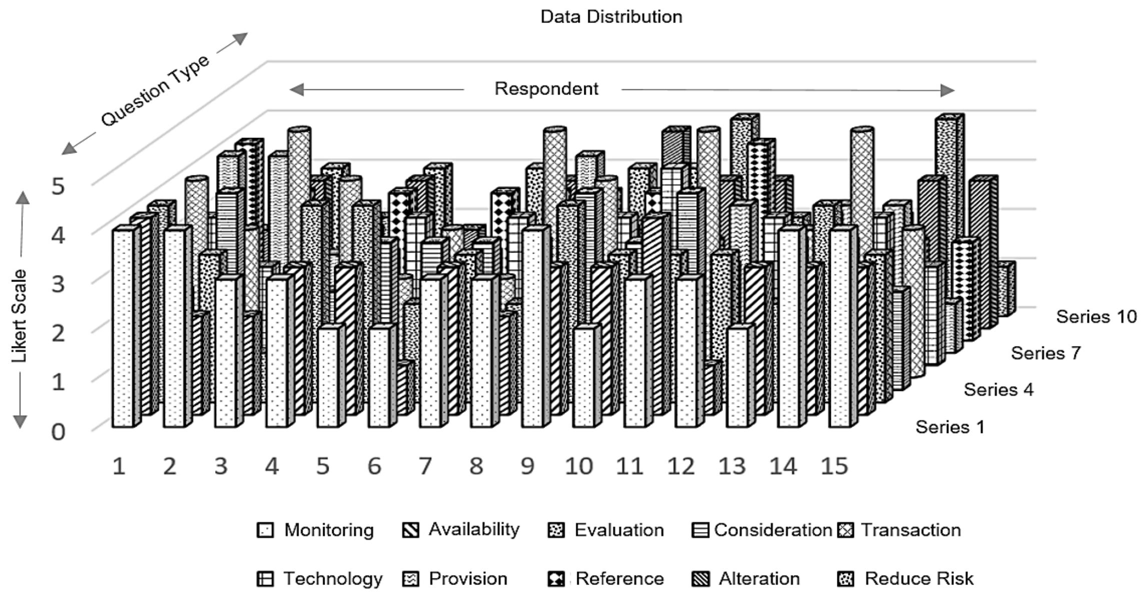


Figure 4. Label and relation of data to the three forming variables x: respondent, y: Likert scale and z: question type. Series 1-3 relation with questions type about logistics management, series 4-7 relation with regulation and series 8-10 relation with medicine distribution

3.4. The combining of supply chain and expert system

The supply chain has an important and active role with the information system in forming a system framework in the form of a medicine distribution supply chain information system [37], [38]. Within the framework of this new system, the application of computational algorithms through the rule-based reasoning method will be applied to create a new framework for supply chain expert systems [27]. Rule based itself is formed from a knowledge base that will always develop according to needs which will be driven by an inference engine so as to produce useful information through the user interface [39], [40]. Likewise, the output in the system itself can be the input for the supply chain information system. Combined framework of supply chain and expert system using rule-based reasoning method can encourage better system work [17], [41]. The combined architecture in this research can be seen in Figure 5.

3.5. The new model of medicine distribution framework

In this research, the design of a new framework system model for simplification of medicine distribution will combine supply chain and expert systems in the rule-based reasoning method. The development of the rule-based reasoning method, hereinafter referred to as the rule based expert system by involving experts in pharmacy to create a system that can be used by the planning, budgeting and medicine procurement committee team as an indicator of consideration in supporting a decision is very possible. As shown by Figure 6.

The process starts from the Public Health Center, when there is a shortage of medicines, you can directly request medicines to other Public Health Centers provided that the type of medicine requested must be available in excess of a certain amount and the minimum amount that determines is the health office as the person in charge of medicine distribution. If at the Public Health Center there is a direct medicine request transaction, the health office will receive a notification via smartphone to evaluate the request for approval or rejection. This can be done because the system has been designed with a mobile hybrid system model so that transactions can be carried out online and in real time (the readiness of the mobile hybrid system technology will be discussed in further research). All transaction activities carried out can be monitored by authorized officers and will then be evaluated for management assessment. The planning process will use the data stored in the system database through a mapping and clustering process (the use of the inference engine in this process will be carried out further research) using an inference engine so that the medicine needs that will be needed can be known. The budgeting and medicine procurement team will also go through the same process in this framework, namely through a mapping and clustering process to support decisions as a consideration to be taken in addition to the information obtained from the planning team. After the medicine procurement process runs as planned, then the data and information from the procurement team will be submitted to the reception team to be matched with the existing data in the system then the medicine data will be file and entered into the database. Furthermore, the data and goods, in this case the medicine, will be attacked by the health office as the person in charge of distributing the medicine to the Public Health Center.

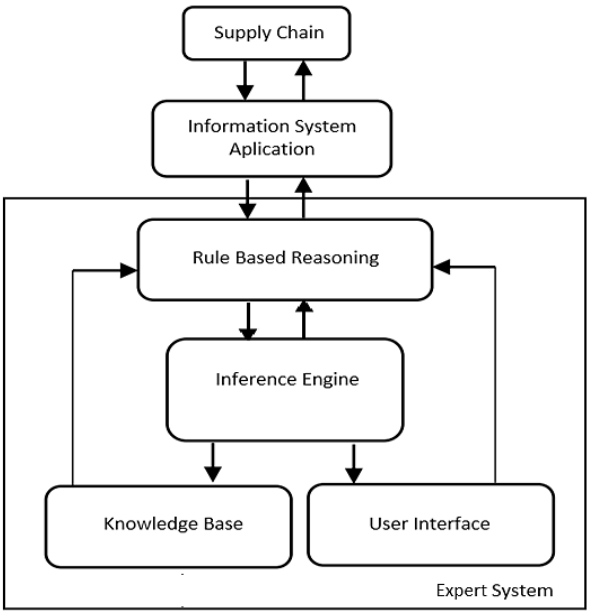


Figure 5. Supply chain expert system architecture

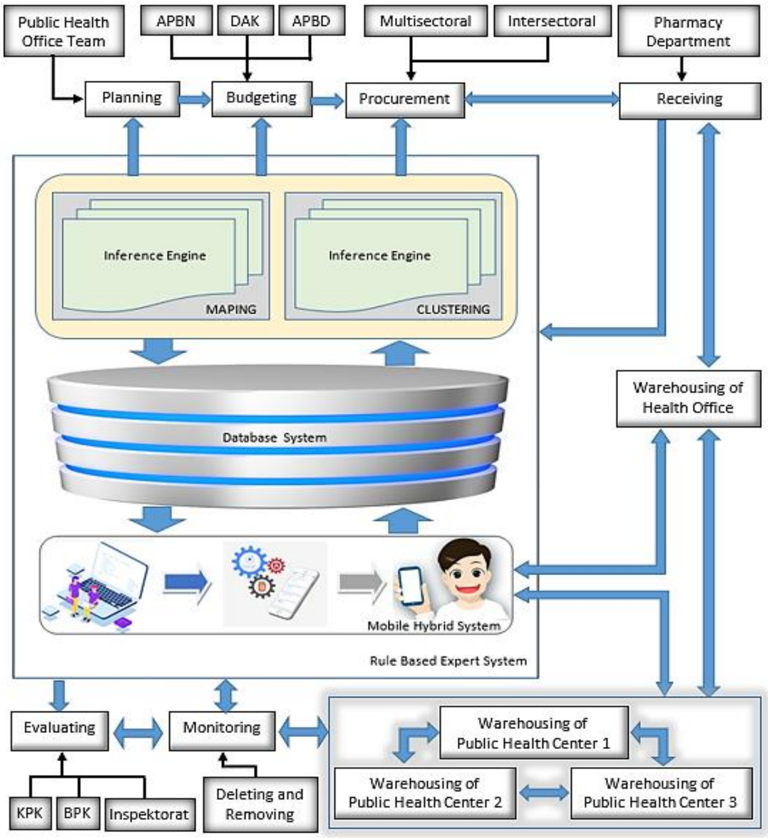


Figure 6. The new model medicine distribution

4. CONCLUSION

The rule-based reasoning method is very suitable to be used because it can adopt the regulations and knowledge of pharmacists into a system in the form of an algorithm, even allowing pharmacists to be directly involved in the research process. The combination of supply chain and expert systems using the rule-based research method in this research resulted in a new framework model based on a mobile hybrid system that can simplify medicine distribution effectively and efficiently. By using this new framework model, there will be no shortage of medicines in a public health center because it can make requests to other public health centers by online and real time. This transaction activity can still be controlled and supervised by the team in charge of medicine at the health office. This system can also be used by the planning, budgeting and medicine procurement team for consideration in making decisions.

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