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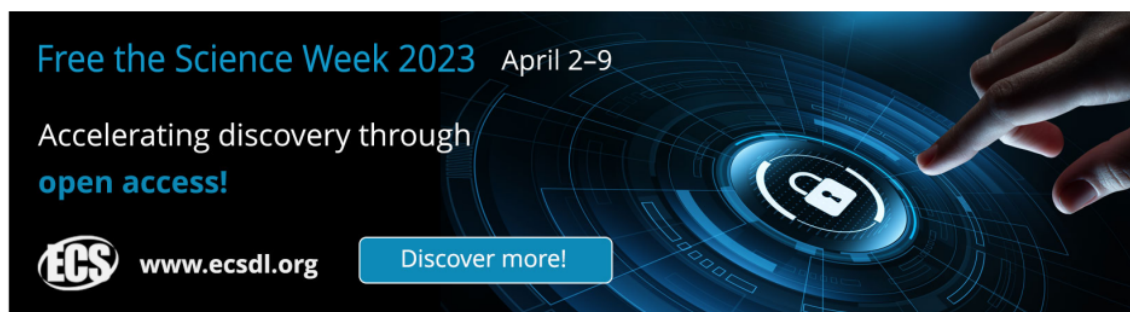
Identification of Adverse Event Patterns in Loperamide Using FP-Growth Algorithm

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Identification of Adverse Event Patterns in Loperamide Using FP-Growth Algorithm

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Abstract. Loperamide is a drug to treat diarrhea, and should not be used for self-medication. There are cases of cardiac disorders due to the use of this drug, this is called an adverse event. Based on this problem, this research will identify the adverse event pattern in Loperamide using the FP-Growth algorithm. The data used is FAERS data from 2015-2017 with the attributes is the age group, sex, drug name, and adverse event. The amount of data after the preprocessing process is 2,840 records. The results is we found the pattern with the highest support values is a combination of adult age groups, male sex, the drug name Loperamide and adverse event cardiac disorders that have a support value of 3.8%, confidence 28.35% and lift ratio 1.483. The implemented using Matlab software and tested using SPMF tools.

1. Introduction

One drug commonly used for the treatment of diarrhea is Loperamide. Loperamide is a drug that is commonly consumed by most households that are sold freely in the market and to get it can be without using a doctor's prescription [1]. Loperamide is used to treat diarrhea symptoms. In addition, Loperamide is a hard drug that should not be a drug that can be recommended to clients who self-medication [2]. The Food and Drug Administration (FDA) Adverse Event Reporting System (FAERS) is a database containing reports of adverse events, medication errors, and product quality complaints that are submitted to the FDA in America. The database is designed to support the FDA's post-marketing safety supervision program for drugs and therapeutic biology products. Adverse events and medication errors are coded using terms in the Medical Dictionary for Regulatory Activities (MedDRA) term [3].

Adverse event means any untoward medical occurrence associated with the use of a drug in humans, whether or not considered drug related. [4]

In the 39 years from when loperamide was first approved in 1976 through 2015, FDA received reports of 48 cases of serious heart problems associated with use of loperamide. This number includes only reports submitted to FDA, so there are likely additional cases about which we are unaware. Thirty-one of these cases resulted in hospitalizations, and 10 patients died. More than half of the 48 cases were reported after 2010 [5]



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Based on this, the research objective is the identification of adverse events to find out what adverse events can occur in the use of this drug so that the public knows the impact of using this drug if consume it freely.

The identification process that will be carried out will apply one method to data mining, namely the association method with the Frequent Pattern Growth (FP-Growth) algorithm. Data Mining is one of the stages of Knowledge Discovery in Database (KDD). KDD is the process of finding knowledge stored in a large database, data warehouse, web, or other large information repository. KDD is often called the same as data mining. Frequent Growth Pattern (FP-Growth) is one of the algorithms in the data mining association for finding frequent itemsets. FP-Growth is built by creating FP-Tree to extract transactions in the database [6]. There are 4 attributes that will be used in this research, namely: drug name, sex, age group, and adverse events.

2. Research Metodology

Workflows of this research can be seen in the following picture:

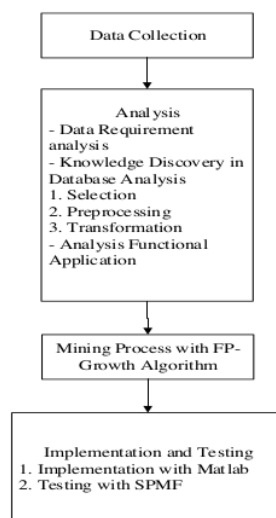


Figure 1. Workflows

2.1 Data Collection

The data used in this study is data from the FAERS (Food and Drug Administration Adverse Event Reporting System) from 2015-2017. Data is taken from the site www.fda.gov. The amount of data after the preprocessing stage is 2,840 records.

2.2 Analysis

2.2.1 Data Requirement Analysis. FAERS data is divided into 7 files. Each file stores different data relating cases of adverse events. This research just will use 3 FAERS files, namely Demo, Drug and Reac files. Demo file contains patient demographic and administrative information. Drug file contains drug/biologic information for as many medications were reported for the event. Reac File contains all "Medical Dictionary for Regulatory Activities" (MedDRA) terms coded for the adverse event (1 or more). The research attributes needed for this can be seen in Table 1.

Table 1. Attributes

No	Attribute	Explanation
1	Primaryid	Unique number to identify FAERS report
2	I_F_Cod	Code for the status report that occurs. Initial (Initial) or follow up (Follow Up)
3	Age	The numerical value of the patient's age
4	Age_cod	Unit stands for age of the patient
5	Sex	Sex
6	Occr_country	The country where the event occurred
7	Drug_seq	Unique number to identify the order of drugs used
8	Role_cod	Codes for reported drug roles - The first suspect (Primary Suspect) - Second Suspect (Secondary Suspect) - Concomitant - Interacting
9	Drugname	Name of medicinal product
10	Prod_ai	Drug Content
11	Pt	Adverse Event

2.2.2 *Knowledge Discovery in Database Analysis*. Selection, this stage will selection of several attribute categories was conducted so that the data used in the research was more focused. The attribute categories to be selected can be seen in Table 2.

Table 2. Attribute Requirement

No	Attribute Requirement	Kategori
1	Primaryid	-
2	I_F_Cod	I
3	Age	-
4	Age_cod	-
5	Sex	-
6	Occr_country	US (<i>United States</i>)
7	Drug_seq	1
8	Role_cod	PS (<i>Primary Suspect</i>)
9	Drugname	-
10	Prod_ai	<i>Loperamide</i> dan <i>Loperamide Hydrochloride</i>
11	Pt	-

The amount of data after the selection process from 2015-2017 was 6,366 records. The selection process is then carried out again to select adverse events in accordance with the issues raised. Adverse events that are used are adverse events related to disorders of the body. The selection process is carried out on the "pt" attribute. The amount of data after the final selection process was 4,079 records.

Preprocessing, Preprocessing stage or also called data cleaning will be performed cleaning data from missing values, inconsistent data, redundant data, and outliers.

- Check The Missing Value
There were 1,239 data records were missing values. The missing value is found in the attributes "age" and "sex". Handling is done by removing data. The total data after the missing value handling stage is 2,840 records.
- Check The Inconsistent Data

There are 30 inconsistent data records on the "age_cod" attribute, the inconsistent data is data with the age code "DEC" or a decade, "DY" or day, and "MON" or month. The data to be used is the unit "YR" or year. The handling process is done by changing all units to "YR".

- Check The Redundant Data
There is no redundant data, so the amount of data remains 2,840 records.
- Check The Outliers data
There is no outlier data, so the amount of data remains 2,840 records.

Transformation, At this stage, the process of transforming data into a form or group is needed according to the research. In this research, there are 2 attributes that will be transformed, namely "age" into the age group and "pt" into the SOC (System Organ Class) group.

- Transformation age to age group
The age group in this research uses age groups based of the Indonesian Department of Health. The age groups to be used can be seen in Table 3.

Table 3. Age Group

No	Age Number	Age Group
1	0 – 5	Toddler
2	6 – 11	Child
3	12 – 25	Teenager
4	26 – 45	Adult
5	46 – 65	Elderly
6	>66	Older Person

- Transformation attribute "pt" to "SOC"

The attribute "pt" will be transformed into group Organ System Class (SOC) using the Medical Dictionary for Regulatory Activities (MedDRA) conducted online through the site <https://bioportal.bioontology.org/ontologies/MEDDRA>. The SOC groups are in the 27 classes listed in Table 4.

Table 4. System Organ Class

No	System Organ Class
1	Blood and lymphatic system disorders
2	Cardiac Disorders
3	Congenital, familial and genetic disorders
4	Ear and labyrinth disorders
5	Endocrine disorders
6	Eye disorders
7	Gastrointestinal Disorders
8	General disorders and administration site conditions
9	Hepatobiliary disorders
10	Immune system disorders
11	Infections and infestations
12	Injury, poisoning and procedural complications
13	Investigations
14	Metabolism and nutrition disorders
15	Musculoskeletal and connective tissue disorders
16	Neoplasms benign, malignant and unspecified (incl cysts and polyps)
17	Nervous System Disorders
18	Pregnancy, puerperium and perinatal conditions

- 19 Product issues
- 20 Psychiatric Disorders
- 21 Renal and urinary disorders
- 22 Reproductive system and breast disorders
- 23 Respiratory, thoracic and mediastinal disorders
- 24 Skin and subcutaneous tissue disorders
- 25 Social circumstances
- 26 Surgical and medical prosedures
- 27 Vascular disorders

Total data that will be used for the next stage amounted to 2,840 records and 4 attributes namely age, sex, drug name, and adverse events that have been transformed into System Organ Class levels (SOC).

2.3 Mining process with FP-Growth Algorithm

The FP-Growth algorithm work process will be explained. This table is 10 sample data used in this research. The minimum support to be used is 20%.

Table 5. Sample Data

No	Age_group	Sex	Drugname	Adverse Event
1	Adult	M	<i>Loperamide</i>	Cardiac Disorders
2	Adult	M	<i>Loperamide</i>	Cardiac Disorders
3	Adult	M	<i>Hydrochloride</i>	Cardiac Disorders
4	Elderly	F	<i>Loperamide</i>	Psychiatric Disorders
5	Elderly	F	<i>Imodium A-D</i>	Gastrointestinal Disorders
6	Adult	F	<i>Loperamide</i>	Psychiatric Disorders
7	Manula	F	<i>Hydrochloride</i>	Psychiatric Disorders
8	Adult	M	<i>Loperamide</i>	Cardiac Disorders
9	Elderly	F	<i>Loperamide</i>	Gastrointestinal Disorders
10	Adult	M	<i>Hydrochloride</i>	Cardiac Disorders
10	Elderly	F	<i>Imodium A-D</i>	Gastrointestinal Disorders

The stages to be carried out are:

2.3.1 Count the support item. Count the support of each item. The formula of support is

$$\text{Support (A} \rightarrow \text{B)} = \frac{\text{Jumlah anggota (A} \cup \text{B)}}{\text{Total Transaksi}} \times 100\% \quad (1)$$

The value of support can be seen in Table 6.

Table 6. Support item

No	Item	Support	Support (%)
1	Adult	6/10 = 0.6	60
2	M	5/10 = 0.5	50
3	F	5/10 = 0.5	50
4	<i>Loperamide</i>	5/10 = 0.5	50

5	<i>Cardiac Disorders</i>	4/10 = 0.4	40
6	<i>Elderly</i>	3/10 = 0.3	30
7	<i>Loperamide Hydrochloride</i>	3/10 = 0.3	30
8	<i>Psychiatric Disorders</i>	3/10 = 0.3	30
9	<i>Gastrointestinal Disorders</i>	3/10 = 0.3	30
10	<i>Imodium A-D</i>	2/10 = 0.2	20
11	<i>Older Person</i>	1/10 = 0.1	10

Items that have value below the minimum support of 20% will be eliminated. In the table above the item 'Older Person' item has 10% support, then the 'Older Person' item will be eliminated.

2.3.2 Sort items based on the highest support value. The sorted data can be seen in Table 7.

Tabel 7. Sorted Data

No	Data
1	Adult, M, <i>Loperamide, Cardiac Disorders</i>
2	Adult, M, <i>Cardiac Disorders, Loperamide Hydrochloride</i>
3	Adult, M, <i>Loperamide, Psychiatric Disorders</i>
4	F, Elderly, <i>Gastrointestinal Disorders, Imodium A-D</i>
5	Adult, F, <i>Loperamide Hydrochloride, Psychiatric Disorders</i>
6	F, <i>Loperamide, Psychiatric Disorders</i>
7	Adult, M, <i>Loperamide, Cardiac Disorders</i>
8	F, <i>Loperamide, Elderly, Gastrointestinal Disorders</i>
9	Adult, M, <i>Cardiac Disorders, Loperamide Hydrochloride</i>
10	F, Elderly, <i>Gastrointestinal Disorders, Imodium A-D</i>

2.3.3 *FP-Tree*. Based on Table 7 that has been formed, then made *FP-Tree*. *FP-Tree* that has been formed can be seen in Figure 2.

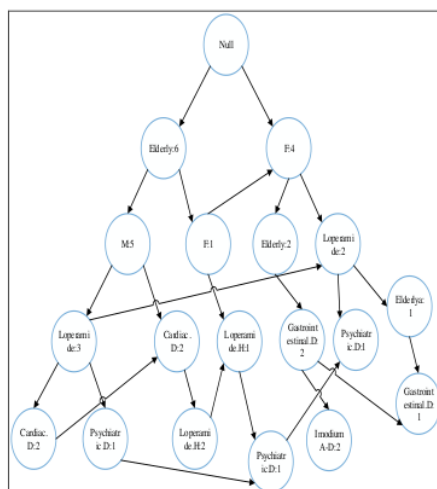


Figure 2. FP-Tree Sample Data

FP-Tree formed for research data totaling 2,840 records can be seen in Figure 3.

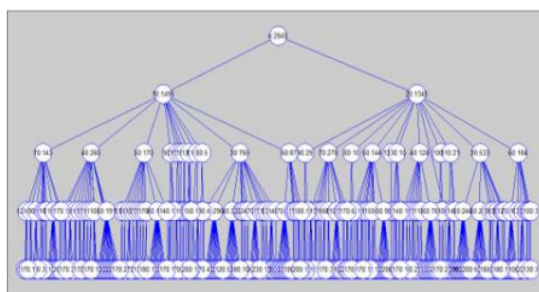


Figure 3. FP-Tree Research Data

2.3.4 Conditional Pattern Base. Conditional pattern base is done by determining the tree branch with a path that ends with the smallest support value. based on the minimum support value, the item that has smallest support value starts from the Imodium A-D, Gastrointestinal Disorders, Psychiatric Disorders, Loperamide Hydrochloride, Elderly, Cardiac Disorders, Loperamide, F, M, and Adults. This is the conditional pattern base of the Imodium A-D pattern.

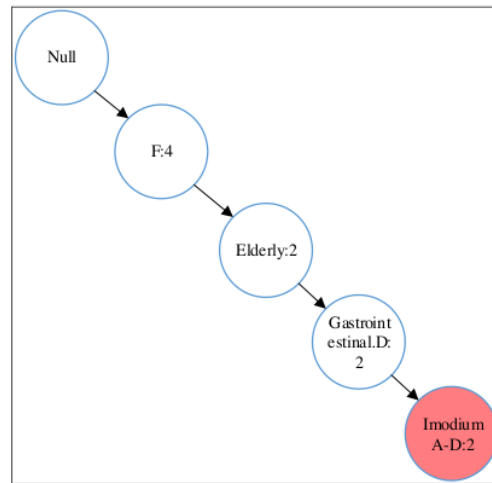


Figure 4. Conditional Pattern Base Imodium A-D

This table is the formation of the Conditional Pattern Base Imodium A-D.

Table 8. Conditional Pattern Base Imodium A-D

Item	Conditional Pattern Base
Imodium A-D	{F, Elderly, Gastrointestinal Disorders:2}

2.3.5 Conditional FP-Tree. FP-Tree Conditional is formed by counting the number of Support Count for each item that comes from the Conditional pattern base. Items that have a value greater than or equal to the minimum support will be raised while those that are not eliminated. Furthermore, any items that do not have a path that ends in Imodium A-D are discarded. Figure 5 is the form of the FP-Tree Conditional on Imodium A-D items

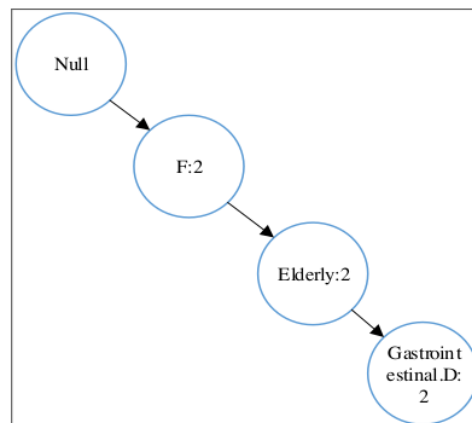


Figure 5. Conditional FP-Tree Imodium A-D

This table is the formation of the Conditional FP-Tree Imodium A-D

Table 9. Conditional FP-Tree Imodium A-D

Item	Conditional FP-Tree
Imodium A-D	{F:2, Elderly:2, Gastrointestinal Disorders:2}

2.3.6 *Frequent Itemset*. Next, find the frequent items set from forming a Conditional FP-Tree by combining items. This table is the result of frequent itemset of Imodium A-D that were formed:

Table 10. Frequent Itemset Imodium A-D

Item	Frequent Itemset
Imodium A-D	{F, Imodium A-D:2}, {Elderly, Imodium A-D:2}, {Gastrointestinal Disorders, Imodium A-D:2}, {F, Elderly, Imodium A-D:2}, {F, Gastrointestinal Disorders, Imodium A-D:2}, {Elderly, Gastrointestinal Disorders, Imodium A-D:2}, {F, Elderly, Gastrointestinal Disorders, Imodium A-D:2}

2.3.7 *Combination of patterns*. The next stage is the formation patterns of frequent itemset that have been discovered. Based on the researcher's goal, which is to find adverse event patterns based on age group, sex, and drug name, the frequent itemset that will be used is 4 items. In Table 10 the frequent itemset that has 4 items are {F, Elderly, Gastrointestinal Disorders, Imodium A-D} then the combination of patterns formed is as follows:

Table 11. Pattern Combination

Frequent Itemset	Pattern Combination
F, Elderly, Gastrointestinal Disorders, Imodium A-D	F, Elderly, Gastrointestinal Disorders → Imodium A-D Imodium A-D, Elderly, Gastrointestinal Disorders → F Imodium A-D, F, Gastrointestinal Disorders → Elderly Imodium A-D, F, Elderly → Gastrointestinal Disorders

The combination of patterns used is only a combination of patterns with consequent adverse events. Then the support, confidence, and lift ratio values are calculated from the pattern obtained. The formula of confidence is

$$\text{Confidence (A} \rightarrow \text{B)} = \frac{\text{Jumlah anggota (A} \cup \text{B)}}{\text{Jumlah anggota (A)}} \times 100\% \quad (2)$$

Lift Ratio is a measure to evaluate whether or not an association rule is strong. Lift Ratio compares the confidence of a rule with the value of benchmark confidence. Benchmark Confidence is a comparison between the number of all. If the value of the lift ratio is greater than 1, it indicates that the rule or rules have benefits and can be used. The higher the lift ratio, the greater the association strength [5]. Formula of lift ratio is

$$\text{Lift Ratio} = \frac{\text{Confidence (A,B)}}{\text{Benchmark Confidence (A,B)}} \quad (3)$$

$$\text{Benchmark Confidence} = \frac{N_c}{N} \quad (4)$$

Note:

N_c = Number of transactions with items that are consequent

N = Number of database transactions

Table 12. Values of Support, Confidence dan Lift Ratio

Rule	Confidence	Support	N_c	B_c	Lift Ratio
<i>Imodium A-D, F, Elderly</i> → <i>Gastrointestinal Disorders</i>	$\frac{2}{2} \times 100\% = 100\% (1)$	$\frac{2}{10} \times 100\% = 20\%$	3	$3/10 = 0.3$	$1/0.3 = 3.33$

2.4 Implementation and Testing

2.4.1 Implementation with Matlab. The process of finding adverse event patterns in Loperamide using the Frequent Pattern Growth (FP-Growth) algorithm is implemented using matlab software. There are 5 fields to be filled in, namely adverse event data in .xls format, minimum support value, minimum confidence value, and selecting a pattern to be generated and file names that will be stored in the .xls format. The application will display the pattern information and the support, confidence, and lift ratio values for each pattern. Using 2,840 adverse event data with a minimum support value of 1% and minimum confidence of 10%, found 791 overall patterns and 23 patterns in accordance with the research objectives, namely 4 itemset patterns with consequent adverse events. This figure is from the Application view implemented.

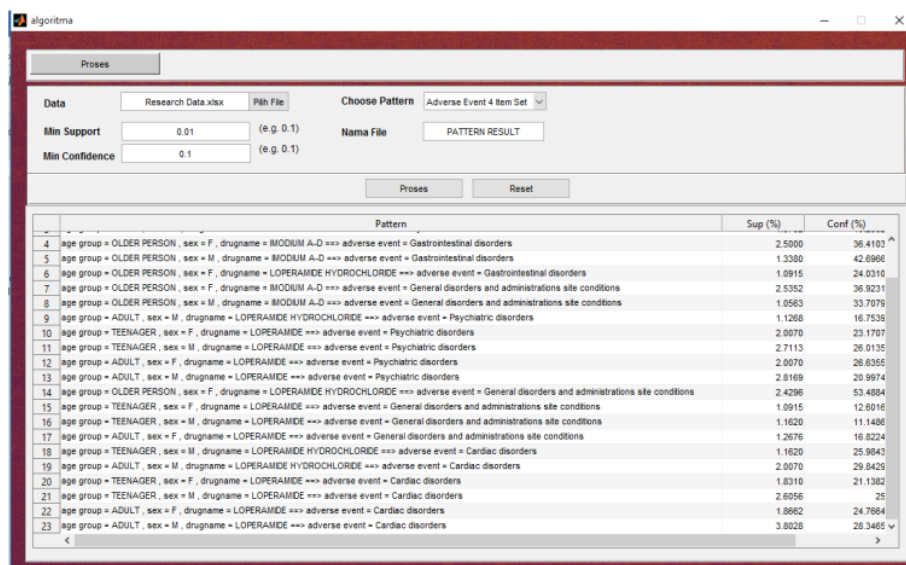


Figure 6. Implementation with Matlab

2.4.2 Testing with SPMF. This test is carried out to determine the accuracy of the number of patterns generated, the value of support, confidence, and lift ratio between applications built with SPMF tools. Based on the testing that has been done, it is known that the number of association patterns result between applications built with SPMF tools is equal to 791 for all patterns and 23 for 4 itemset patterns with consequent adverse events, and the results of the value of support, confidence, and lift ratio also has the same between the application and SPMF. Based on this, it can be concluded that the results of the application built with the results of the tools have the same value. This figure is a test with SPMF that has been done

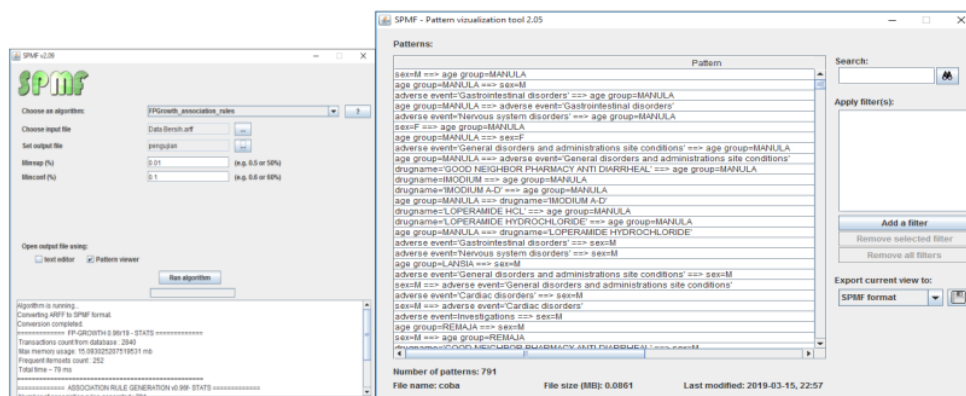


Figure 7. SPMF Testing

3. Result and Discussion

The pattern used in accordance with the research objectives is a 4 itemset pattern with consequent adverse events. There are 23 matching patterns. The pattern that can be used as useful information is a pattern that has a lift ratio value ≥ 1 . The patterns that meet the lift ratio are 20 patterns. The pattern can be seen in Table 13.

Table 13. Pattern Result

No	Pattern		Support (%)	Confidence (%)	Lift Ratio
	If	Then			
1	Adult , M , Loperamide	Cardiac Disorders	3.803	28.346	1.483
2	Adult , M , Loperamide	Psychiatric Disorders	2.817	20.997	1.302
3	Remaja , M , Loperamide	Psychiatric Disorders	2.711	26.014	1.613
4	Remaja , M , Loperamide	Cardiac Disorders	2.606	25	1.308
		General Disorders And			
5	Manula , F , Imodium A-D	Administrations Site	2.535	36.923	1.945
		Conditions			
6	Manula , F , Imodium A-D	Gastrointestinal Disorders	2.5	36.41	2.929
		General Disorders And			
7	Manula , F , Loperamide Hydrochloride	Administrations Site	2.43	53.488	2.818
		Conditions			
8	Adult , M , Loperamide Hydrochloride	Cardiac Disorders	2.007	29.843	1.561
9	Adult , F , Loperamide	Psychiatric Disorders	2.007	26.636	1.652
10	Remaja , F , Loperamide	Psychiatric Disorders	2.007	23.171	1.437
11	Adult , F , Loperamide	Cardiac Disorders	1.866	24.766	1.295
12	Remaja , F , Loperamide	Cardiac Disorders	1.831	21.138	1.106
13	Adult , M , Loperamide	Investigations	1.444	10.761	1.634
14	Adult , M , Loperamide	Nervous System Disorders	1.373	10.236	1.14
		Gastrointestinal Disorders			
15	Manula , M , Imodium A-D	Cardiac Disorders	1.338	42.697	3.435
16	Remaja , M , Loperamide Hydrochloride	Cardiac Disorders	1.162	25.984	1.359
17	Adult , M , Loperamide Hydrochloride	Psychiatric Disorders	1.127	16.754	1.039
18	Manula , F , Loperamide Hydrochloride	Gastrointestinal Disorders	1.092	24.031	1.933
19	Remaja , M , Loperamide	Nervous System Disorders	1.092	10.473	1.166
		General Disorders And			
20	Manula , M , Imodium A-D	Administrations Site	1.056	33.708	1.776
		Conditions			

Based on the table, the research objective to find the adverse event patterns in Loperamide was successfully, and also in the pattern results table above it is known that the pattern with the highest support value is a combination of adult age groups, male sex, drug name Loperamide and adverse event cardiac disorders has a support value of 3.8%, confidence 28.35% and lift ratio 1.483. From this

pattern, it is also known that based on FDA data from 2015-2017 related to adverse event of cardiac disorders, it turns out that many occur in the adult age group of men who consume Loperamide with the name of the drug Loperamide. This can be used as information for the public about adverse events that will occur so it is recommended because this drug is a hard drug, people are more careful in consuming it, tried according to a doctor's prescription or coming to a health clinic.

4. Conclusion

Based on the results of the research, the following conclusions are obtained: 1. Successfully built an application to identify adverse event patterns in Loperamide using the Frequent Pattern Growth (FP-Growth) algorithm. 2. Using 2,840 adverse event data with a minimum support value of 1% and minimum confidence of 10%, found 791 overall patterns and 23 patterns in accordance with the research objectives, namely 4 itemset patterns with consequent adverse events. 3. Patterns with the highest support values are a combination of adult age groups, male sex, drug names Loperamide and adverse event cardiac disorders which have a support value of 3.8%, confidence 28.35% and lift ratio 1.483.

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