

Exploring Association of Household Conditions and Community Behavior in Flood Events in Banjarbaru Using Apriori Method

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ABSTRAK

Banjir di Banjarbaru sebagian besar telah dikaji dari perspektif penyebab alami dan fisik, seperti curah hujan dan topografi wilayah. Sementara itu, hubungan antara kondisi rumah tangga dan perilaku masyarakat saat banjir jarang dieksplorasi secara kuantitatif. Penelitian ini mengisi kesenjangan tersebut dengan menerapkan algoritma Apriori pada data kuesioner dari rumah tangga terdampak banjir untuk menemukan aturan asosiasi. Hasil penelitian menunjukkan bahwa gangguan pada mata pencaharian selama banjir cenderung diikuti dengan penurunan pendapatan, sementara banjir yang berlangsung lebih dari satu hari umumnya memicu evakuasi anggota keluarga dan mendorong pemerintah menyediakan tempat penampungan sementara. Aturan-aturan ini mengimplikasikan bahwa kebijakan mitigasi banjir sebaiknya memprioritaskan sistem peringatan dini, penyediaan tempat penampungan sejak awal, serta bantuan ekonomi yang guna meningkatkan ketahanan rumah tangga terdampak.

Kata kunci: Apriori; Aturan Asosiasi; Banjir; Eksplorasi

ABSTRACT

Floods in Banjarbaru have mostly been studied from the perspective of natural and physical causes, such as rainfall and the region's topography. Meanwhile, the association between household conditions and community behavior during floods is rarely explored quantitatively. This research aims to fill that gap by applying the Apriori algorithm to questionnaire data from flood-affected households to find association rules. The study found that disruptions in livelihoods during floods tend to be followed by a decrease in income, while floods lasting more than one day generally trigger the evacuation of family members and prompt the government to provide temporary shelters. These key rules imply that flood mitigation policies should prioritize early warning systems, pre-positioning of shelter facilities, and targeted economic assistance to enhance the resilience of affected households.

Keywords: Apriori; Association Rules; Flood; Exploration

INTRODUCTION

Banjarbaru City is one of the areas in South Kalimantan Province that is prone to flooding [1], with more than 50% of its area categorized as vulnerable or somewhat vulnerable to floods based on vulnerability zoning [2]. The high intensity of rainfall based on climatological analysis [3], [4], changes in land use, and relatively flat topographical conditions are the main triggers for waterlogging at various points in the city [5]. As a result, floods have a significant impact on various aspects of life, ranging from infrastructure damage to health and socio-economic disruptions [6].

Besides natural factors and the physical structure of the city, the condition of the residential environment and community behavior also increase vulnerability to flooding. Areas such as Cempaka District experience more severe impacts due to the characteristics of slum residential environments and poor drainage systems [7]. Unplanned settlements along riverbanks often lack proper drainage systems, and the community tends to build without considering water conservation and green open spaces [8]. The habit of throwing garbage into drainage channels and covering the ground with cement drastically reduces water absorption, accelerating the occurrence of flooding [9]. In areas like Kemuning, floods are even considered a routine occurrence every rainy season by the residents, indicating low preparedness and effectiveness of early warning systems [10]. As a result, this area has become a top priority for flood management [11].

Most of the previous flood research in Banjarbaru still uses an analytical approach that focuses on the causes of floods. There are rarely any studies that specifically apply an exploratory approach in the context of flood-prone settlements, where this approach has the advantages in identifying hidden relationships, especially those related to the condition of the home environment, the behavior of riverside communities, and the impact of floods. Exploratory concepts like Apriori are effective in uncovering hidden patterns that are not detected by conventional analysis. The choice of association rule mining over conventional methods like logistic regression or correlation matrices is due to its ability to analyze complex, multidimensional categorical data without assumptions of linearity or predictor independence [12].

Apriori works by identifying combinations of items that frequently appear in the dataset through an iterative process, starting from single items to more complex combinations, filtering itemsets based on a specified minimum threshold [13]. Association rules are widely used to analyze transaction data, but this method is also relevant in processing questionnaire data. Several studies have shown that association rules can reveal interesting patterns in respondents' responses that are complex and multidimensional. For example, this method is effective in extracting relationships between questionnaire variables using the Apriori algorithm [14].

This research is a preliminary study that uses the Apriori algorithm to identify correlation patterns between household environmental conditions and community behavior in flood-prone areas of Banjarbaru City, specifically in the Cempaka and Banjarbaru Selatan sub-districts, based on questionnaire data. This research is based on the question: What association patterns emerge between household environmental conditions and community behavior during flood events in Banjarbaru City? To answer this question, the objective of this study is to discover association rules between variables in the data and to understand how these relationships reflect the environmental conditions and community behavior in flood-prone areas. The results are expected to offer new insights into community flood vulnerability and support more effective, participatory mitigation strategies.

METHOD

Data were obtained from a survey using questionnaires, involving 102 households in flood-affected areas along riverbanks in Banjarbaru City, South Kalimantan Province, conducted in August 2023 across Banjarbaru Selatan and Cempaka sub-districts. The questionnaire includes the house's coordinates and 26 topics of questions covering the condition of the affected houses, preventive measures before the flood, the situation during the flood, and the post-flood condition, with mutually exclusive answer categories for each question. The data were analyzed without respondent removal, outlier identification, or normalization, assuming all data were valid, relevant, and appropriate for the categorical algorithm used. Minor missing data were retained, as in transaction structures some items may not appear in a transaction. Response bias was minimized through interviews and direct household observations. The data is transformed into a transaction format, as illustrated in Figure 1. Each row in the data is represented as a single transaction that reflects the unique characteristics of a house, namely the combination of categories from the 26 questions. The transformation defines answers as items, with each house's category combination forming a transaction. This resulted in 102 transactions and 71 distinct item types.

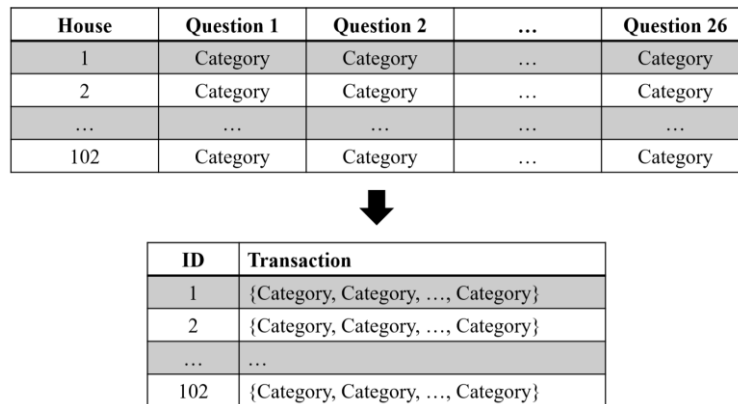


Figure 1. Transformation of Questionnaire Data to Transactions

The analysis was conducted using R version 4.4.2 with the association rule library called arules version 1.7-9 [15]. The process begins with exploring the profile data of houses affected by the flood. The coordinate points are visualized in the form of a map to show the location and distribution of houses, while profile variables such as length of residence, number of family members, and water height are displayed through graphs to illustrate the proportions and relationships of characteristics between variables. Next, association rule mining is applied to mine patterns among these characteristics. Association rules are a data mining technique for finding relationships between items in transaction data. While often used in retail, they can also analyze questionnaire data by transforming responses into transaction form [12]. Association rules describe relationships in if-then form (" \Rightarrow "), meaning if a transaction contains a certain itemset (antecedent), it is likely to contain another itemset (consequent). The mining process has two stages: identifying frequent itemsets and generating rules from them. The classic algorithm for this is Apriori [13], which is described as follows and illustrated in Figure 2.

1. Preparing input of transactions D.

- Setting the support (supp) and confidence (conf) thresholds. Support that is too high results in few rules, whereas support that is too low results in too many rules. High confidence indicates strong rules, while low confidence results in less meaningful rules [16]. The rules generated by this research are divided into two types:

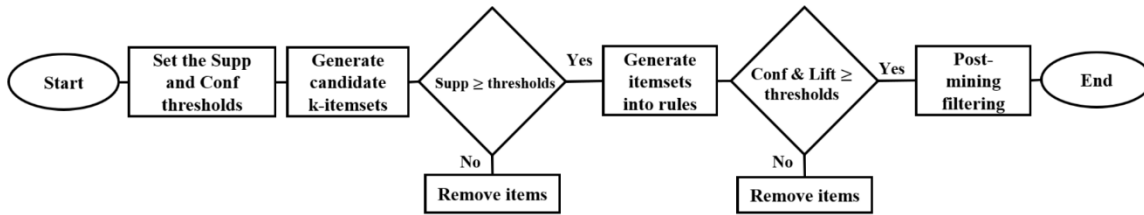


Figure 2. Apriori process

- General rules by setting high support parameters (minsup 60%) and strong confidence (minconf 80%). The 60% minimum support for general rules refers to thresholds commonly used in studies [17], with confidence based on [18].
 - Unique rules by setting low support parameters (minsup 10%) and strong confidence (minimum 90%). The minimum 10% support follows [19], with confidence set at the upper bound of [18] range to ensure stronger reliability for rare associations.
- Finding frequent 1-itemset. Keep the items when $supp \geq minsup$ which is calculated as

$$Supp(A) = \frac{\text{Number of transactions containing } A}{\text{Total number of transactions}} \tag{1}$$

Iteratively generate candidate k-itemsets from frequent (k-1)-itemsets and repeat until no new frequent itemsets remain.

- Form rules from each frequent itemset consisting of ≥ 2 items. Keep the rules when $conf \geq minconf$ which is calculated as

$$Conf(A \Rightarrow B) = \frac{Supp(A \cup B)}{Supp(A)} \tag{2}$$

- Evaluate each rule by also calculating the lift ratio. Keep the rules when $lift \geq 1$, where

$$Lift(A \Rightarrow B) = \frac{Conf(A \Rightarrow B)}{Supp(B)} \tag{3}$$

If $Lift > 1$, then A and B tend to appear together more often than expected if they are independent, indicating a positive relationship.

- The previous steps are applied to each type of rule (general and unique). Then, the remaining rules for each type are filtered by removing those that are redundant, tautological, or do not provide additional meaning, and selecting rules with unique consequents. Leverage as

$$Lev(A \Rightarrow B) = Supp(A \cup B) - Supp(A) \times Supp(B) \tag{4}$$

and conviction as

$$Conv(A \Rightarrow B) = \frac{1 - Supp(B)}{1 - Conf(A \Rightarrow B)} \tag{5}$$

are calculated as evaluations of quality and reliability.

RESULT AND DISCUSSION

A total of 102 houses were affected by the flood, including 53 houses in the Banjarbaru Selatan District and 49 in the Cempaka District. The red dots in Figure 3 indicate the affected houses in both sub-districts. In Banjarbaru Selatan, 49 houses were affected by the overflow of the Kemuning River, while four others were damaged due to flooding in low-lying areas caused by heavy rain, impacting a riverbank area approximately 2 km long. The affected houses in Banjarbaru Selatan are concentrated along the river and near the main road network, as shown in the inset map. In Cempaka, there were 44 incidents due to rain and river overflow along Mistar Cokrokusumo Street, and five others were affected due to poor water absorption in Gunung Kupang Village. The distribution of the affected houses in Cempaka, as seen in the inset map, follows the course of the river and the main roads, particularly in areas with limited drainage capacity.

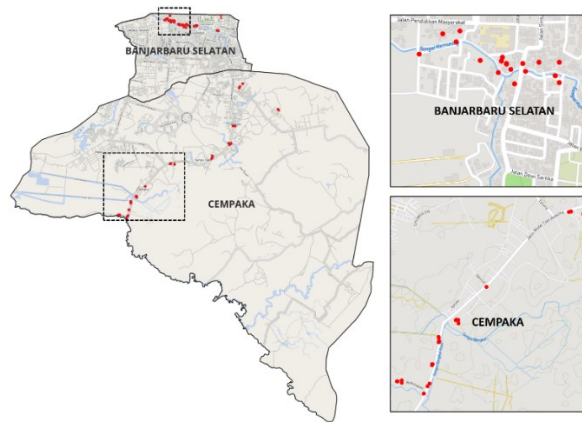


Figure 3. Distribution of flood-affected houses

Figure 4 shows that houses inhabited for more than 25 years are most affected by floods, especially houses with 1-3 and 4-5 family members. A similar pattern is observed in houses aged 15-25 years, dominated by families of 4-5 members. Meanwhile, houses inhabited for less than 15 years tend to be less affected and are generally inhabited by families with a maximum of 5 members. These findings indicate that the flood-affected areas are dominated by older residential neighborhoods with medium family density.

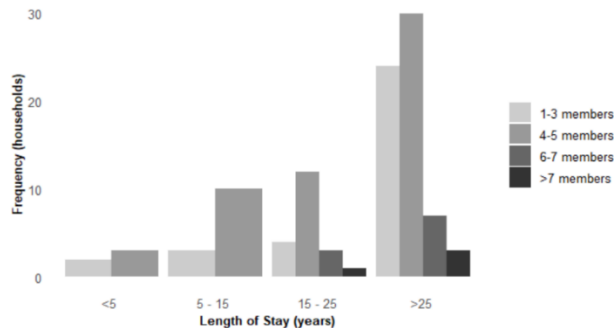


Figure 4. Distribution of household members by length of stay

About 80 events occur within a short duration, specifically less than one day. This is evident in the mosaic plot in Figure 5. In floods lasting less than one day, the most frequently recorded water height falls within the 0–0.5 meter category, with a proportion of 31.4%. Meanwhile, in floods lasting more than one day, the highest proportion is recorded in the water height category of more than 1 meter, at 16.7%. This condition primarily occurs in the Bangkal Village area, Cempaka District, particularly around Jalan Mistar Cokrokusumo, where nearly half of the surveyed houses are located. These findings indicate a relatively high risk of flooding in the area, both during short-duration and long-duration floods, which could potentially inundate houses and disrupt transportation activities in the vicinity. Looking at the frequency variable in the second mosaic plot, floods with a frequency of more than five times tend to occur with higher water levels. In this category, the highest proportion is recorded at water levels of more than 1 meter, which is 28.2%. Areas with water levels of more than 1 meter are spread across various points but are dominated in Bangkal Village, Cempaka District. These findings indicate that areas more frequently affected by floods tend to experience more severe flooding in terms of water height. This suggests a particular vulnerability in the Bangkal Village area to recurring major floods, as well as an increased potential for environmental damage, infrastructure damage, and threats to public safety.

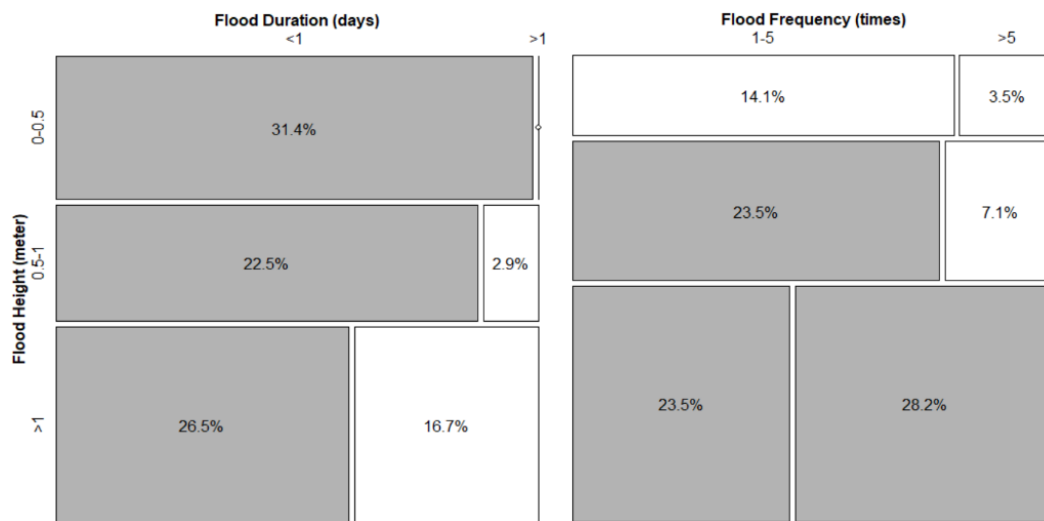


Figure 5. Distribution of proportions of flood height, duration, and frequency

The data dimension is in the form of a matrix with 102 transactions and 71 items. Figure 6 displays the transaction-item matrix, which has a density of 36% (relatively dense). The number of response items per transaction varies between 24 and 26 items, with an average of 25.56 items across all transactions. The range indicates that the majority of households responded to each question, showing their engagement in the survey.

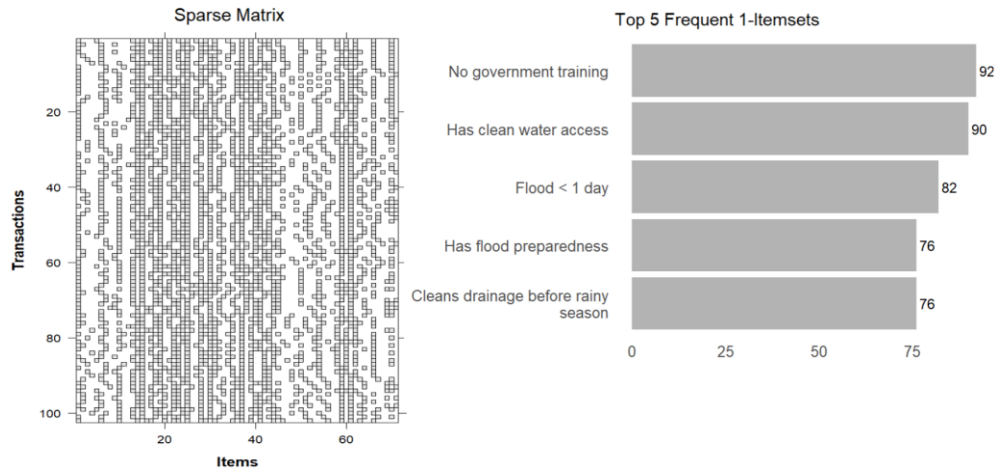


Figure 6. Sparse matrix and Top 5 Frequent 1-itemsets

Frequent itemsets in Figure 6 show an overview of the individual items that appear. Items with the highest frequency found, such as "No emergency response training provided by the government," "Houses facilitated with clean water," and "Flood duration less than a day," have high occurrences in over 80 houses. These items reflect common issues experienced by most households in facing floods. The next frequency search identifies frequent item pairs (2-itemsets) based on the general rule parameters (min support 60%). Unique rule itemsets are not shown due to limited results. Based on Table 1, the three itemsets with the highest frequency are {Houses facilitated with clean water, No government training for emergency response}, {Houses facilitated with clean water; Flood duration less than a day}, and {No government training for emergency response, Flood duration less than a day}. These three pairs of conditions appeared in more than 70 houses and were often found together in the observed houses.

Most houses have access to clean water and are located in areas that only experience short-duration floods, but there is still a lack of disaster preparedness training from the government. The generalization of these findings indicates that although basic infrastructure such as access to clean water is adequate and most affected areas only experience flooding for a short duration, the aspect of community preparedness for disasters remains very weak due to the lack of government intervention in the form of emergency response training. The policy relevance that can be drawn is the need for the government to integrate disaster preparedness training programs into flood mitigation strategies, especially in the focus areas of Kemuning Village, which are physically quite prepared but still socially vulnerable, so that the community's response to floods can be faster, more effective, and minimize further risks for the local community.

Table 1. Top 3 Frequent 2-Itemset

Itemset	Frequency
{House has access to clean water, There is no government-provided training for emergency response}	81
{House has access to clean water; Flood duration is less than one day}	75
{There is no government-provided training for emergency response, Flood duration is less than one day}	74

Association rules were formed from frequent 2-itemsets with a maximum rule length of two in if-then form, divided into general rules that reflect common community behavior patterns and unique rules according to their thresholds. The rules were then filtered by selecting those with a lift value greater than one. Redundant rules, such as reverse rules, subsets, or tautological rules, were removed during the post-mining filtering stage to improve clarity and relevance, with a focus on rules with unique consequents. Leverage and conviction values were calculated and reviewed as additional indicators of rule quality and reliability. The results are presented in Table 2.

The first general rule is supported by a support of 65.6% and a confidence of 98.5%. This indicates that the majority of households in the data experience this condition, and livelihood disruptions are almost always accompanied by a decrease in income. The lift value of 1.34, leverage of 0.16, and conviction of 18.00 indicate a strong and reasonable positive relationship, with a low probability of occurring by chance. The rule is meaningful but may have inflated confidence due to the consequent's dominance. Next, the second general rule shows that when there is drainage channel cleaning activity before the rainy season, the flood duration is generally less than one day. This rule is supported by a support value of 64.7% and a confidence value of 86.8%. This indicates that most households in the data experience shorter flood durations when there is drainage channel cleaning activity. The lift value of 1.08, leverage of 0.04, and conviction of 1.49 indicate a positive relationship, not as strong as the first rule, and it could be coincidental. This means that some instances where flooding lasts less than a day may not be entirely due to drainage cleaning, but rather there are other factors at play. Furthermore, the high confidence may partly result from the high prevalence of short flood duration in the dataset, so the potential inflation of confidence should be considered when interpreting this rule.

Table 2. General and Unique Rules

General Rules	Supp	Conf	Lift	Lev	Conv
Livelihood is disrupted during floods ⇒ Income decreases during floods*	65.6%	98.5%	1.34	0.16	18.00
There are drainage cleaning activities before the rainy season ⇒ Flood duration is less than one day*	64.7%	86.8%	1.08	0.04	1.49
Unique Rules					
Flood duration is more than one day ⇒ Family members evacuate during the disaster*	19.6%	100%	2.21	0.10	Inf
Flood duration is more than one day ⇒ Local government provides temporary shelter for residents*	18.6%	95%	2.15	0.09	11.17

*Significant association between questions ($p < 0.01$, Fisher's exact test)

The decline in community income during floods is the result of various interconnected conditions. When floods occur, the main economic activities especially trade along the banks of the Kemuning River or Jalan Mistar Cokrokusumo are disrupted, often leading to loss of income. In areas such as Cempaka District, the risk of income loss sharply increases when floods occur amidst the high density of low-income residents [1], consistent with previous findings on the vulnerability of low-income urban communities during floods. This risk is exacerbated by the lack of emergency savings in many households, as revealed in the survey. The policy implications of

these findings emphasize the importance of supporting the economic sustainability of communities, such as emergency cash assistance, access to capital during disasters, and strengthening micro-enterprises. Next, the second general rule shows a positive relationship, although not strong. Field facts in the Cempaka area indicate that poor drainage is one of the causes of flooding, as also noted in earlier studies. The condition is worsened by blockages, river narrowing, and sedimentation due to infrequent drainage maintenance [9]. Routine channel cleaning is carried out as a preventive measure before the rainy season, but this is not enough to reduce the duration of flooding. The construction of supporting infrastructure, such as spillways, river normalization, and channel capacity enhancement, is necessary to accommodate extreme rainfall [9]. Moreover, measures like socializing flood-prone warning areas are needed to improve community flood preparedness. [11].

The first unique rule is supported by a confidence value of 100% and a lift of 2.21, indicating a very strong positive relationship between the duration of the flood and the family's decision to evacuate. A leverage value of 0.10 and infinite conviction further strengthen the evidence that there are no cases in the data where flooding for more than one day is not followed by family evacuation, making this relationship very strong and not coincidental. Meanwhile, the second unique rule is supported by a support value of 18.6% and a confidence of 95%, which means that in most cases, the government does provide temporary housing assistance when prolonged flooding occurs. The lift and conviction indicate a significant positive, although not as strong as the first unique rule.

The first unique rule is supported by the fact that floods often recur every year in certain areas, particularly on Jalan Mistar Cokrokusumo, which is prone to inundation due to heavy rainfall [9]. As a result, the floods last a long time and fill the entire house, forcing residents to evacuate themselves to avoid health risks, property damage, and difficulties in accessing basic needs [10], as documented in local disaster reports. The chosen evacuation sites are usually family homes or mosques. Residents transport their belongings to evacuation sites until the flood recedes, then return to clean their homes. Subsequently, the second rule highlights the active role of the government in providing temporary shelters so that residents can take refuge until the flood recedes, reflecting standard disaster response practices. Flood socialization conducted by the government also urges residents to remain on alert, as evidence of their readiness to evacuate if the flood persists for an extended period [10]. Collaboration between the community and the government in disaster mitigation is crucial to ensure the availability of emergency facilities that safeguard the safety and health of residents during the disaster.

CONCLUSION

This study found association patterns, such as livelihood disruptions followed by decreased income, and floods lasting more than one day that triggered family evacuations and the provision of temporary shelters by the government. These findings highlight the need to strengthen early warning systems, emergency response training, and economic support for affected communities. Nevertheless, this study has limitations, particularly in the association rules produced, where the dominance of certain categories could obscure the true relationships. Future analyses should apply or algorithms methods to minimize this effect to produce more accurate and policy-relevant results.

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