




Associated Patterns and Predicting Model of Life Trauma, Depression, and Suicide Using Ensemble Machine Learning

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Abstract

This study aimed to find associated patterns by association rule mining and propose a prediction model using ensemble learning methods of high levels of trauma items affecting depression and suicide among primary school students in Thai rural extended opportunity schools. Our proposed methods were different from others that have analysed the relationship of high life trauma leading to depression and suicide by using statistical analysis. We found strongly associated patterns and effects among primary students' trauma, depression, and suicide. The trauma of psychological abuse and neglect may result in suicide, whereas psychological abuse, neglect, and the experience of self-harm are also likely to result in the increased severity of traumatic events in life. The trauma of physical and sexual abuse, neglect, helplessness, feeling worthless, being weak, and self-harm were associated with depression. Our research discovered new knowledge that the risk of suicide arises from two extreme types of trauma: when children's safety is frequently threatened and the family communicates frequently using rude or abusive words; these traumas may not merely correlate with depression but may ultimately result in suicide. Moreover, this study discovered 7 highly important trauma items and 4 suicide items for predicting depression and suicide using the Random Forest technique. We found that the Random Forest technique performed well in predicting depression and suicide. The predicted depression results show that the overall accuracy was 85.84%, precision was 89.33%, and recall was 75.28%. The predicted suicide results show that the overall accuracy was 91.28%, precision was 89.05%, and recall was 84.72%. From these results, we identified high life trauma affecting depression and suicide, which are very beneficial to practitioners to use in preliminary screening. In addition, those involved need to be aware and attentive in counselling these people with these symptoms in time.

Keywords:

Association Rule Mining;
Trauma;
Depression;
Suicide;
Random Forest;
FP-Growth; Machine Learning.

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1- Introduction

Adverse life-changing traumatic experiences during childhood have been multi-dimensionally associated with adverse psychological outcomes [1]. The prevalence of childhood trauma is increasing worldwide and to date has been identified with contributing to increased risk for depression and suicidal behavior among children, as well as having implications for later-in-life psychological impact of emotional distress, mood disorders, and suicide risk [2]. Previous empirical evidence confirmed that the outcome of a childhood's accumulation of experiences of life trauma can be linked to the development of pain waiting to trigger mental illness and may mostly end up in severe depression or suicide [3-6]. The psychology model explains that all aspects of the problematic mood and behavior are the result of untreated past

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trauma, as well as describing mental breakdowns as a result of the functioning of the conscious, subconscious, and unconscious minds analogous to an iceberg [7, 8]. All the traumatic phenomena that occur are not lost; instead, they will be accumulated in the unconscious and become more intense if triggered by similar events. This results in severe problems, leading to suffering from depression and premature death [9].

Alter et al. (2021) indicated varying patterns of childhood traumatic life events and depression and suicide risk behavior [2]. Experiential life trauma predicts depression and suicide [10]. Higher levels of childhood trauma had a direct effect on traits of impulsivity and hostility and were directly associated with increased suicide risk, irrespective of the severity of depression [2]. Traumatic life events, such as child sexual abuse, are a causal agent in many negative adulthood outcomes, including the risk for life-threatening behaviors such as suicide ideation and suicide attempts [11]. The results of discrete patterns of childhood victimization experiences revealed that anger was significantly associated with suicidal behavior among people who had experienced a lifetime of traumatic events [1, 3]. Adolescent psychiatric in-patients suffer high rates of childhood sexual abuse, trauma-related distress, and suicidality [10].

Depression and self-inflicted injury during childhood and adolescence are of grave concern in Thailand. These problems, initially occurring with life-risk traumas at an early age, lead to psychiatric disorders and suicide attempts in the late teens and adulthood [4, 12]. Of great concern, warning signs are increasing among primary school students in Thai rural extended opportunity schools [13]. Traumatic life experiences are a response to incidents involving violence, physical and sexual violence and neglect. Traumatic life events and depression figures as a main cause for the elevated suicide rate at more advanced ages and is often related to childhood maltreatment [4]. Accumulating life trauma cause children to store negative memories; thus, experiencing similar incidents can cause them to activate feelings of distress, fear, panic, anxiety, insecurity, being overwhelmed, inability to cope, all resulting in negatively reducing the processes of emotions, thought, perception, and behavior and resulting in mal-adaptation, becoming depressed and trying to be left by themselves [10]. Recently, machine learning techniques have become involved in the field of psychiatry and psychology regarding depression and suicide. Since depression and suicide is a multi-faceted phenomenon with complex risks, machine learning algorithms are needed to manage complex model relationships among a large number of factors. According to Passos et al. (2016), the prediction suicide model was implemented with machine learning techniques. Passos et al. (2016) found that previous hospitalization for major depression, PTSD, drug dependence, and psychosis could strongly predict the risk of death by suicide [5]. Kuroki (2015) proposed risk factors for suicide ideation and suicide attempt among Filipino Americans using random forest algorithm. Important factors contributing to suicide ideation were depressive disorder, substance use disorder, and years in the United States [14]. DelPozo-Banos et al. (2015) used artificial neural networks with routinely collected electronic health records to identify high risk of suicide. In their study, prescription of psychotropics, depression and anxiety, and self-harm factors were identified as suicide [15]. Bae (2015) developed a decision tree for predicting attempt suicides with dependent variables and eleven socio-demographic, intrapersonal, and extra personal variables as independent variables. In the depression group variables, the most powerful factor to predict a suicide attempt was delinquency [16].

The challenge for mental health practitioners is to be proactive by filling the gaps in mental illness prevention. Studies suggest that depression and suicide in children is predicted by a combination of a number of factors; working with all factors enables comprehensive case searches [3, 4, 10] while surveillance operations require speedy and accurate searches [5]. Several studies have used life trauma as a quick screening for problems; however, there is still debate over its efficacy [12]. In addition, it needs to be proved, “Is life trauma, depression, and suicide related or a prediction for each other?”, “What type of life trauma predicts depression or suicide?”, “Which one effects the others?”, “What type of trauma acts as a mediator between depression and suicide?”, and “What type of trauma activates the severity of depression and suicide?” [5, 12]. These questions need solutions in order to improve practice. Knowledge of the timeliness of the search, surveillance, and screening is required and is a means for preventing depression and suicide [3, 5].

From the review of literature in this field, the existing studies that used data analytics to predict depression and suicide, used a limited number of inputs or omitted psychologically important inputs, while, as mentioned before, experiencing traumatic events and suicide risk is correlated, hence the following research questions were proposed in this study:

RQ1: What data analytic methods can identify associated patterns of life trauma, depression, and suicide?

RQ2: How do we analyze these associated patterns?

RQ3: Can life trauma items derived from associated patterns be used to predict depression and suicide?

Overall, based on previous research and these research questions, the contributions of this work are: 1) This research identifies associated patterns of high trauma items that affect depression and suicide by association rule mining. The results give a better understanding of the relationship of trauma affecting depression and suicide among primary school students in Thai rural extended opportunity schools. 2) The prediction model in this work was made using ensemble learning techniques to predict depression and suicide based on only important high life trauma items and suicide items.

This study is organized as follows: Section 2 presents the theoretical background of proposed methods; Section 3 describes research methodology; Section 4 presents the experimental setup and results; the discussion is presented in Section 5; lastly, the conclusion is provided in Section 6.

2- The Theoretical Background of Proposed Methods

The theoretical background of this work used to identify associated patterns, predict depression, and suicide, and evaluate the performance of prediction is presented briefly in this section

2-1- FP-Growth Algorithm

Association rule mining is an unsupervised learning-based data mining analysis technique. The correlation rule search is used to measure the accuracy of the associated rule with support and confidence as criteria for selecting a general model of correlation. The form of the correlation rule is $A \rightarrow B$, where A is a condition and B is the result. Support values measure the probability of the number of data items co-occurring against the total number of items. Confidence measures the probability that one event (A) will occur, and another event (B) will occur [17]. There are several algorithms for finding the association rule. The most well-known and widely used algorithm is FP-Growth algorithm [18].

FP-Growth algorithm uses the divide-and-conquer FP-tree principle for establishing common association rules. This technique can quickly establish a relationship rule. The limitation is the data use algorithms that must be in binary form and it takes a lot of memory when the tree is large. In the first step, the root of the tree is created and assigned to null. Then, data is sequenced with each variable's value represented by a node [19, 20]. The principle of the FP-Growth algorithm is shown in *Algorithm 1*.

Algorithm 1. FP-Growth Algorithm

Input: FP-tree

Output: The complete set of frequent patterns.

Method: Call FP-Growth (FP tree, null).

Procedure FP-Growth ($Tree, \alpha$)

```
{
  (1) if  $Tree$  contains a single path  $P$ 
  (2) then for each combination (denoted as  $\beta$ ) of the nodes in the path  $P$  do
  (3) generate pattern  $\beta \cup \alpha$  with  $support =$  minimum support of nodes in  $\beta$ ;
  (4) else for each  $a_i$  in the header of  $Tree$  do {
  (5) generate pattern  $\beta = a_i \cup \alpha$  with  $support = a_i.support$ ;
  (6) construct  $\beta$ 's conditional pattern base and then  $\beta$ 's conditional
      FP tree  $tree_\beta$ 
  (7) if  $tree_\beta \neq \emptyset$ 
  (8) then call FP-Growth ( $Tree, \alpha$ ) }
}
```

2-2- Decision Tree

Decision Tree is most widely used for classification. When there are data in the form of a table, data in each column is called an attribute, and in each row is called an instance. For modeling, the data in the attribute result is called class which is assigned to the root node. After that, it continuously finds the next attribute to form a decision tree. The attribute at the top node is called parent, and the attribute at the bottom node is called child. To create a decision tree, select attributes that follow the top node as branches and leaves by calculating the entropy value of the condition in each attribute as shown in Equation 1:

$$Entropy(s) = -\sum_{i=1}^c p_i \log_2 p_i \quad (1)$$

where s denotes the attribute used to calculate Entropy. p_i is the ratio of the number of members in group i to the total number of members in the sample.

The entropy obtained from each attribute condition is then used to find the Information Gain [21] in Equation 2:

$$IG(S, A) = Entropy(s) - \sum_{veValues(A)} \frac{|s_v|}{|s|} Entropy(s_v). \quad (2)$$

where A denotes attribute A , $|s_v|$ is a member of attribute A with value v , and $|s|$ are members of the sample. The selection of the child node following the parent node is selected from the attributes with the highest information gain. This process continues to run until finding the result at the leaf node.

2-3- Random Forest

Random forest is an algorithm based on the bagging algorithm [22]. The random forest is one of the ensembles learning methods that consist of a set of decision trees that are generated by the recursive sampling of bootstrapped samples of training data [23]. In this algorithm, B separate training sets which are bootstrapped from the training set and then the predictive functions are generated.

$$\{\hat{f}_1^*(x), \hat{f}_2^*(x), \dots, \hat{f}_B^*(x)\}$$

The final predictive function is in Equation 3:

$$\hat{f}_{avg}(x) = \frac{1}{B} \sum_{b=1}^B \hat{f}^{*b}(x) \quad (3)$$

where the asterisk marks a function on a bootstrapped set [17].

2-4- Gradient Boosting Decision Trees

Gradient tree boosting has been widely used in data mining competitions. This algorithm is trained in an additive manner. At each time step t, it grows another tree to minimize the residual of the current model. Formally, the objective function can be described [24] as follows in Equation 4:

$$L^{(t)} = \sum_{i=1}^n l(y_i, \hat{y}_i^{t-1} + f_t(x_i)) + \Omega(f_t) \quad (4)$$

where l denotes a loss function that measures the difference between the label of the i instance y_i and the prediction at the last step plus the current tree output; and $\Omega(f_t)$ is the regularization term that penalizes the complexity of the new tree.

3- Research Methodology

The research methodology in Figure 1 describes the process of the proposed method.

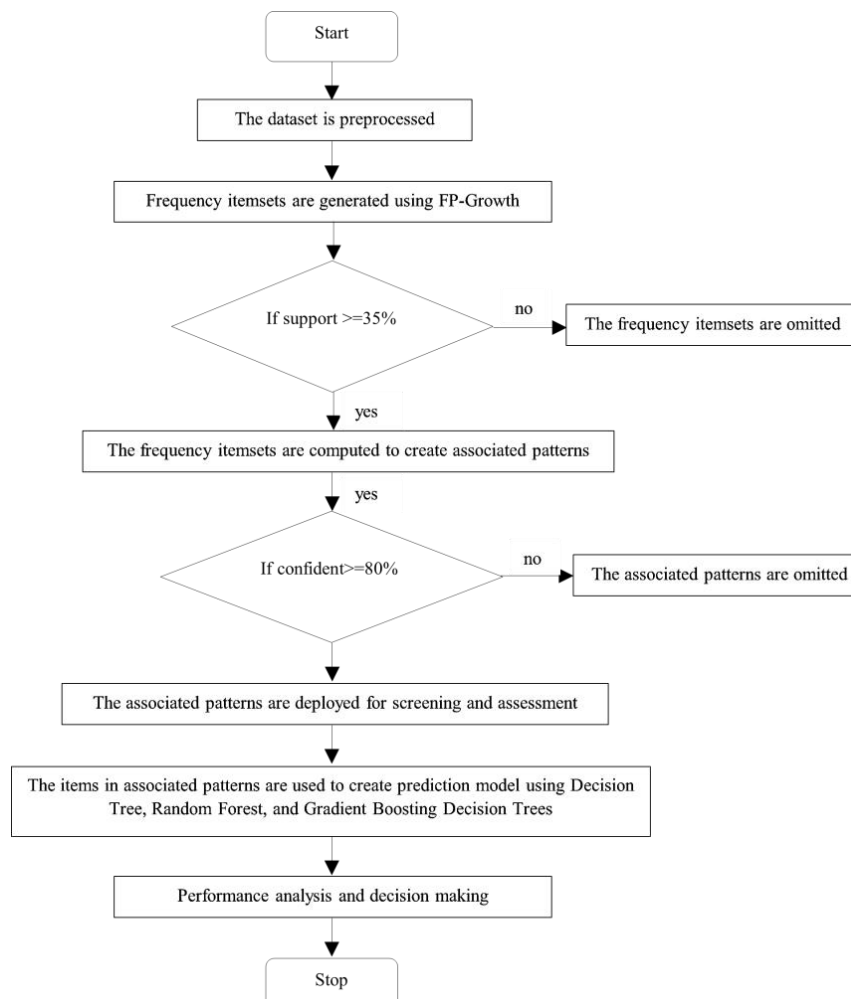


Figure 1. Flowchart of the research methodology

4- Experimental Setup and Results

4-1- Data Description

The data used in this study were self-assessment questionnaires obtained from 1) trauma assessment 2) Children's Depression Inventory 3) DS 10 assessment for suicide with details as follows:

1) The small t trauma assessing instrument developed by Chuatai and Chndarasiri (2017) [25]. Four statements were measured from incidents involving acts of violence and causing negative self-belief, namely, events involving physical violence, mental violence, sexual violence, and incidents related to neglect. This assessing instrument was composed of 59 items on a 5-point Likert scales from 1: 'never' to 5: 'on a regular basis', classified into three groups including high, moderate, and low small t trauma levels. A total score of less than 125 was defined as having low traumatic experience, 126-144 having moderate traumatic experience, and a score above 145 having a high exposure traumatic experience. The total for Cronbach's alpha reliability measure was .936.

2) Children's Depression Inventory (CDI) developed by Kovacs (1992) [26], translated into Thai by Trangkasombat and Liknapichitkul (1996) [9]. The CDI used for screening, assembling the diagnosis, and following up on the treatment of depression in children classified at a high level. There were a total of 27 questions included in different aspects of depressive symptoms seen in children, indicating the severity of depression over the past two weeks. The children read and took the questionnaire on their own. Each item consisted of three options from 0: 'no sadness at all' to 2: 'having symptoms all the time'. A total score of 15 or more during this at screening was considered a clinically significant depression.

3) DS 10 developed by Tangseree et al. (2009) [27], was used to assess the risk of suicide. It was composed of 10 items assessing events, symptoms, or thoughts and feelings that occurred in the past two weeks, each item consisted of two options, 'with' or 'without'. A total of 2 or more items at screening were considered a clinically significant suicide risk.

In this study, the data included 423 samples collected from male and female primary school students in Thai rural extended opportunity schools in the south of Thailand.

4-2- Ethical Consideration

Permission for the study was obtained from the Ethics Committee of Walailak University, Thailand (Protocol Number WUEC-20-168-01).

4-3- Finding Associated Patterns using FP-Growth

Using FP-Growth in RapidMiner Studio version 9.8 (*RapidMiner, Inc.: Boston, MA, USA*) [28], 59 items of the trauma questionnaire, 27 items of the depression questionnaire, and 10 items of the suicide questionnaire were identified for associated patterns. A total of 34, 14, and 35 associated patterns related to high life trauma, depression and suicide were found, respectively. Table 2 and 3, the associated patterns of depression and suicide were the high life trauma items in the trauma questionnaire. The best parameters for the association rule mining which yield minimum support is 35% and minimum confidence of 80%. The associated patterns of high life trauma, depression and suicide are shown in the Table 1 to 3.

Table 1. Associated patterns resulting in high life trauma

No.	Antecedent
1	I've regularly experienced events that make me feel worthless.
2	I used to feel stressed/difficult to bear the burden of taking care of other family members.
3	When I was depressed, and someone made me uncomfortable by telling me saucy stories regularly.
4	When I was depressed, and someone regularly threatened my safety.
5	When I was depressed, and someone regularly threaten to hurt me.
6	When I was depressed, and regularly felt stressed/difficult to bear the burden of taking care of other family members.
7	When I was depressed, and my family communicate in frequent rude or abusive words.
8	When I was depressed, and there have been situations where I regularly feel incapable.
9	I'm not sure things are going well, and I've regularly experienced events that make me feel worthless.
10	When I was at risk of suicide, and someone regularly threatened my safety.
11	When I was at risk of suicide, and someone regularly threaten to hurt me.
12	When I was at risk of suicide, and I used to be terrified when I regularly saw my family members drunk or taking drugs.
13	When I was at risk of suicide, and I used to feel stressed/difficult to bear the burden of taking care of other family members.

No.	Antecedent
14	When I was at risk of suicide, and there have been situations where I regularly feel incapable.
15	When there is a pressure or frustration, and I used to be terrified when I regularly saw my family members drunk or taking drugs.
16	When there is a pressure or frustration, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
17	When there is a pressure or frustration, and there have been situations where I regularly feel incapable.
18	When I was miserable, depressed, sad, crying, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
19	I don't follow instructions often, and I've regularly experienced events that make me feel worthless.
20	I don't follow instructions often, and someone made me uncomfortable by telling me saucy stories regularly.
21	I'm not as good as others, and I've regularly experienced events that make me feel worthless.
22	I've been regularly given bad names or nicknames, and I've regularly experienced events that make me feel worthless.
23	I feel hopeless, worthless to live, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
24	When I was so miserable that I didn't want to live, and I've regularly experienced events that make me feel worthless.
25	There have been situations where I regularly feel stalled, and there have been situations where I regularly find myself weak.
26	I have been repeatedly betrayed by a close person or broken promises, and I've regularly experienced events that make me feel worthless.
27	I regularly lose or take away from the people/pets/things that I loved, and I've regularly experienced events that make me feel worthless.
28	My friends used to bully me regularly, and someone made me uncomfortable by telling me saucy stories regularly.
29	Contemplating suicide, and I've regularly experienced events that make me feel worthless.
30	Someone used to tease me regularly, and someone made me uncomfortable by telling me saucy stories regularly.
31	I've always had people look at me distrustfully, and someone made me uncomfortable by telling me saucy stories regularly.
32	When I was depressed, I don't often follow instructions, and I've regularly experienced events that make me feel worthless.
33	When I was depressed, I've been regularly called bad names or nicknames, and I've regularly experienced events that make me feel worthless.
34	When I was depressed, I was so miserable that I didn't want to live, and I've regularly experienced events that make me feel worthless.

Table 2. Associated patterns resulting in depression

No.	Antecedent
1	Had been hospitalized for suicide or had attempted it before, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
2	Experienced unexpected loss of vital organs, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
3	When there is a pressure or frustration, and there have been situations where I regularly feel incapable.
4	Had been hospitalized for suicide or had attempted it before, and experienced unexpected loss of vital organs, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
5	Had been hospitalized for suicide or had attempted it before, and high trauma, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
6	Had been hospitalized for suicide or had attempted it before, and there is a pressure or frustration, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
7	Had been hospitalized for suicide or had attempted it before, and there is a pressure or frustration, and there have been situations where I regularly feel incapable.
8	Experienced unexpected loss of vital organs, and high trauma, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
9	Experienced unexpected loss of vital organs, and there is a pressure or frustration, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
10	There is a pressure or frustration, and there have been situations where I regularly find myself weak, and there have been situations where I regularly feel incapable.
11	Had been hospitalized for suicide or had attempted it before, and experienced unexpected loss of vital organs, and high trauma, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
12	Had been hospitalized for suicide or had attempted it before, and never had a serious or chronic disease and there is a pressure or frustration, and there have been situations where I regularly feel incapable.
13	Had been hospitalized for suicide or had attempted it before, and there is a pressure or frustration, and there have been situations where I regularly find myself weak, and there have been situations where I regularly feel incapable.
14	Experienced unexpected loss of vital organs, and high trauma, and never had a serious or chronic disease and there is a pressure or frustration, and there have been situations where I regularly feel incapable.

Table 3. Associated patterns resulting in suicide

No.	Antecedent
1	I used to feel stressed/difficult to bear the burden of taking care of other family members.
2	Had been hospitalized for suicide or had attempted it before, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
3	Experienced unexpected loss of vital organs, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
4	When I was depressed, and someone regularly threaten to hurt me.
5	When I was depressed, and regularly feel stressed/difficult to bear the burden of taking care of other family members.
6	When I was depressed, and my family communicate in frequent rude or abusive words.
7	When I was depressed, and there have been situations where I regularly feel incapable.
8	I'm not sure things are going well, and I've regularly experienced events that make me feel worthless.
9	When there is a pressure or frustration, and I used to be terrified when I regularly saw my family members drunk or taking drugs.
10	When there is a pressure or frustration, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
11	When there is a pressure or frustration, and there have been situations where I regularly feel incapable.
12	When I was miserable, depressed, sad, crying, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
13	I don't follow instructions often, and I've regularly experienced events that make me feel worthless.
14	I'm not as good as others, and I've regularly experienced events that make me feel worthless.
15	I feel hopeless, worthless to live, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
16	When I was so miserable that I didn't want to live, and I've regularly experienced events that make me feel worthless.
17	I have been repeatedly betrayed by close person or broken promises, and I've regularly experienced events that make me feel worthless.
18	I regularly lose or take away from the people/pets/things that I loved, and I've regularly experienced events that make me feel worthless.
19	Contemplating suicide, and I've regularly experienced events that make me feel worthless.
20	Had been hospitalized for suicide or had attempted it before, and depression, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
21	Had been hospitalized for suicide or had attempted it before, and depression, and my family communicate in frequent rude or abusive words.
22	Had been hospitalized for suicide or had attempted it before, and depression, and there have been situations where I regularly feel incapable.
23	Had been hospitalized for suicide or had attempted it before, and I've regularly experienced events that make me feel worthless.
24	Had been hospitalized for suicide or had attempted it before, and there is a pressure or frustration, and I used to feel stressed/difficult to bear the burden of taking care of other family members.
25	Had been hospitalized for suicide or had attempted it before, and there is a pressure or frustration, and there have been situations where I regularly feel incapable.
26	Had been hospitalized for suicide or had attempted it before, and I don't follow instructions often, and I've regularly experienced events that make me feel worthless.
27	Had been hospitalized for suicide or had attempted it before, and I'm not as good as others, and I've regularly experienced events that make me feel worthless.
28	Had been hospitalized for suicide or had attempted it before, and I was so miserable that I didn't want to live, and I've regularly experienced events that make me feel worthless.
29	Had been hospitalized for suicide or had attempted it before, and I've regularly experienced events that make me feel worthless.
30	Had been hospitalized for suicide or had attempted it before, and have contemplated suicide, and I've regularly experienced events that make me feel worthless.
31	Experienced unexpected loss of vital organs, and I've regularly experienced events that make me feel worthless.
32	Experienced unexpected loss of vital organs, and I'm not sure things are going well, and I've regularly experienced events that make me feel worthless.
33	Experienced unexpected loss of vital organs, and contemplating suicide, and I've regularly experienced events that make me feel worthless.
34	Never had a serious or chronic disease, and there is a pressure or frustration, and there have been situations where I regularly feel incapable.
35	Never had a serious or chronic disease, and I was so miserable that I didn't want to live, and I've regularly experienced events that make me feel worthless.

5- Discussion

RQ1: What data analytic methods can identify associated patterns of life trauma, depression, and suicide?

The associated patterns in this study were found by the FP-Growth technique that are shown in Tables 1, 2 and 3. The study found 34, 14, and 35 associated patterns related to high life trauma, depression, and suicide with 100% confidence. This proposed method is a new way to discover associated patterns of high trauma items that affect depression and suicide. The results give a better understanding of the relationship of trauma affecting depression and

suicide among primary school students in Thai rural extended opportunity schools. Most previous researches were only identified which factors were related to each other using a statistical analysis method. Recently, Park et al. (2021) found associations between various types of childhood trauma and suicidal behavior using chi-squared and t tests. The results showed that all types of childhood trauma were associated significantly with suicidal ideation and attempted suicides [29]. Alter et al. (2021) found that amongst major depressive disorder veterans, childhood trauma was directly associated with increased suicide risk, irrespective of their severity of depression, or the degree of hostility and impulsivity [2]. It can be seen that previous studies did not address the correlation patterns of items leading to depression or suicide. Our study found associated patterns that reveal patterns of trauma, depression, and suicide, and which item patterns of trauma can lead to depression and suicide. Also, associated patterns identify the relationship that occurs with psychological abuse, emotional abuse, physical and sexual abuse which can be used for screening in a timely manner.

RQ2: How do we analyze these associated patterns?

The research results reflect the associated patterns between life trauma, depression, and suicide of children. These three phenomena are related and affect each other. These findings confirmed previous empirical evidence that had found a profound association between trauma, depression, and suicide in children [3, 10]. These correlations become vulnerable leading to emotional suffering and self-harm [5]. High life traumatic traumas were commonly associated with psychological abuse: "I've regularly experienced events that make me feel worthless.", "there have been situations where I regularly feel incapable.", "I've been regularly called bad names or nicknames.". Psychological mechanisms prove that if the accumulation of life traumatic trauma at all levels of childhood severity is not healed, it is oppressed to an unconscious level and develops into depression [7], especially psychological abuse that makes one feel worthless, incompetent, humiliated [8]. Long-term exposure to such actions leads to losses in the form of emotional disorders, inability to continue and ended up contemplating suicide [7, 10]. These results confirmed that trauma related to psychological abuse increased emotional reactivity and aroused suicide ideation, as well as strengthening the association with depression symptoms [10]. Neglect also increased high trauma among children: "I used to feel stressed/difficult to bear the burden of taking care of other family members.", "I used to be terrified when I regularly saw my family members drunk or taking drugs.", "my family communicate in frequent rude or abusive words.". Childhood psychological abuse and neglect predict suicide risk and depression [4]. These confirmed previous study which shown that neglect is the worst and most destructive form of violence for children [6, 30]. When not given importance and value, these children are unable to develop self-love, or self-esteem, traits that are key symptoms of depression and a life of little value [25, 27]. In particular, students in Thai extended opportunity schools are limited in family nurturing and support in all ways and are often required to take care of their families along with their studies; limitations leading to surrender, hopelessness, and despair [13]. Because of these conditions, research finding show that extended opportunity school students are far more likely to report having stressful life events associated with depression and suicide [31, 32]. In addition, these traumas are often related to suicide: "Had been hospitalized for suicide or had attempted it before.", "Experienced unexpected loss of vital organs.", "There is a pressure or frustration.", "Contemplating suicide.", "I was so miserable that I didn't want to live.", and "I feel hopeless, there is no value in living.". Previous studies have found that children who experienced severe pressure and feelings of worthlessness and hopelessness from life traumas to the point of dealing with suicide attempts or have been hospitalized or loss of vital organs, have a higher chance to commit suicide than others [12, 25]. Thus, depression and suicidal ideation were more strongly correlated with emotional abuse and neglect than other types of maltreatment [3].

High traumatic traumas also are associated with depression, especially physical and sexual abuse: "Someone made me uncomfortable by telling me saucy stories regularly.", "Someone regularly threatened to hurt me.", "Someone regularly threatened my safety". Previous studies revealed that embarrassment, sexual harassment, threats of harm including threats to security induced in children feelings of nervousness in socializing, avoidance, loneliness, loss of self-worth and happiness due to depression [3, 11]. Depression was associated with suicide: "Had been hospitalized for suicide or had attempted it before.", "There is a pressure or frustration.", "Experienced unexpected loss of vital organs". Numerous studies have confirmed this knowledge, especially those children who had been hospitalized because of suicide attempts, or pressured from conflict or frustration [10, 11]. Depression caused by loss or grief often caused by dismemberment, a bad reputation, or poor self-identity could lead children to various forms of self-harm [3]. Suicide planning and suicide attempts more strongly correlated with physical abuse; children who experienced greater intensity of trauma were more susceptible to developing depression and suicidal behaviors [3]. Children who were physically abused and injured at an early age developed a feelings of being unloved, worthless, helpless, hopeless, depressed, and prone to self-harm [12, 25]. Neglect and psychological abuse often caused high trauma which induced depression, "I used to feel stressed/difficult to bear the burden of taking care of other family members." and psychological abuse: "There have been situations where I regularly feel incapable." and "There have been situations where I regularly find myself weak.". Increasing emotional neglect among those experiencing childhood trauma are traits related to patients with depression and are suicidal [30]. Previous evidence revealed that being ignored reinforced greater pain [5, 12]. Moreover, carrying a burden beyond the capacity of small children can create feelings of being too weak to live, inadequacy, helplessness all of which predicts depression and suicide [13].

In summary, children's trauma, depression, and suicide patterns are correlated to each other. The life trauma of psychological abuse and neglect may result in suicide whereas psychological abuse, neglect, and the experience of self-harm often results in the increased severity of life trauma. In addition, the trauma of physical and sexual abuse, neglect, hopelessness, feeling worthless, weak, and self-harm were associated with depression. These results confirmed that childhood abuse and neglect were significantly associated with depression and suicide risk [4]. Furthermore, sexual and emotional abuse related to guilt, shame, depression, and suicidal ideation [6]. Childhood trauma was associated with adverse psychological outcomes. Various aspects of childhood trauma, as well as psychopathologies must be routinely assessed [3]. There is a critical need for trauma informed policy and procedures in mental health and psychiatric nursing [10].

RQ3: Can life trauma items derived from associated patterns be used to predict depression and suicide?

1) Finding important features for predicting depression and suicide by machine learning techniques.

From this study, 4 high trauma items were identified as follows: 1) There have been situations where I regularly feel incapable, 2) Someone regularly threatened my safety, 3) I used to feel stressed/difficult to bear the burden of taking care of other family members, and 4) My family communicate in frequent rude or abusive words. These items are related to depression that affects suicide. In conclusion, each high trauma item occurs with the presence of depression; this also affects inclination towards suicide without considering the depression items. Previous studies have found that life is full of obstacles, which the responsibility for carrying heavy burdens, reinforcing feeling of inability, feeling insecure about life's problems including feelings of being worthless and helplessness which may lead to depression [3, 11]. Facing these obstacles lead to reluctance to live and to committing suicide [1, 12].

Moreover, our study discovered 3 high trauma items that affect depression: 1) There have been situations where I regularly feel incapable, 2) There have been situations where I regularly find myself weak, and 3) I used to feel stressed/difficult to bear the burden of taking care of other family members. Psychological theory explains that depression occurs when a person feels lethargic, weak, unable to taking responsibility to function normally [5].

In addition, high trauma 4 items: 1) I've regularly experienced events that make me feel worthless, 2) There have been situations where I regularly feel incapable, 3) I used to be terrified when I regularly saw my family members drunk or taking drugs, and 4) I used to feel stressed/difficult to bear the burden of taking care of other family members. These statements were related to 4 suicide items as follows: 1) Had been hospitalized for suicide or had attempted it before, 2) There is a pressure or frustration, 3) I was so miserable that I didn't want to live, and 4) Contemplating suicide. These co-occurring items influence suicide. Feelings of worthlessness, hopelessness, fear, oppression, inability to cope with responsibility makes it easier for a person to contemplate committing suicide [5]. This is especially true if the suffering continues to cause the person to feel horrible, overwhelmed, suicidal, and had attempted suicide previously [12].

Therefore, important items in prediction depression are as follows: 1) There have been situations where I regularly feel incapable, 2) There have been situations where I regularly find myself weak, and 3) I used to feel stressed/difficult to bear the burden of taking care of other family members. Important items in prediction suicide are: 1) I've regularly experienced events that make me feel worthless, 2) There have been situations where I regularly feel incapable, 3) Someone regularly threatened my safety, 4) I used to be terrified when I regularly saw my family members drunk or taking drugs, 5) I used to feel stressed/difficult to bear the burden of taking care of other family members, 6) My family communicate in frequent rude or abusive words, 7) Had been hospitalized for suicide or had attempted it before, 8) There is a pressure or frustration, 9) I was so miserable that I didn't want to live, and 10) Contemplating suicide. This result is consistent with past studies that indicated that perceived awkwardness, weakness, and difficulty exceeding our ability to live indicates depression [10]. Meanwhile worthlessness, hopelessness, insecurity, fearfulness, wanting to bear the burden, being insulted, extreme sadness, suicidal thoughts, and suicide attempts predict child suicide [5].

From the relationship above, we discovered new knowledge and must be aware of the risk of suicide when two items of high trauma arise. There are 1) Someone regularly threatened my safety, and 2) My family communicate in frequent rude or abusive words where these questions do not correlate with depression items but will result in suicide immediately. From item: "Someone regularly threatened my safety." is related to physical abuse. This item indicating physical abuse strongly correlates with suicide planning and suicide attempt [3]. From item: "My family communicate in frequent rude or abusive words." is related to psychological abuse. This item indicates that psychological abuse may affect to suicide risk [4]. Both items are consistent with past studies showing that a life of fear, insecurity, violence and lack of family support is a key contributor to suicide decisions [5, 10].

2) Prediction model for depression and suicide and Performance Evaluation

In this research work, prediction of depression and suicide uses three classification techniques: 1) decision tree, 2) random forest, and 3) gradient boosting decision trees in RapidMiner Studio version 9.8 (RapidMiner, Inc.: Boston, MA, USA) [25]. The prediction performs parameter optimization to determine which techniques are most effective for predicting depression and suicide. In addition, to prevent over-fitting of the prediction models, 10-fold cross-validations

were applied. By comparing the performance, all trauma items are used against important items. The performance of depression and suicide prediction was evaluated as accuracy, precision, and recall. The confusion matrix in Table 4 represents the performance comparison between predicted and actual values in tabular form. Actual Positive is real positive class, Actual Negative is real negative class, Predicted Positive is positive prediction result given by classifier, and Predicted Negative is negative prediction result given by classifier [33, 34].

Table 4. Confusion Matrix

	Actual Positive	Actual Negative
Predicted Positive	TP (True Positives)	FP (False Positives)
Predicted Negative	FN (False Negatives)	TN (True Negatives)

Based on Table 4, the TP is the number of correct predictions of positive class, TN is the number of correct predictions of negative class, FP is the number of incorrect predictions that an example is positive, and FN is the number of incorrect predictions that an example is negative. The evaluation metrics used to assess depression and suicide prediction from the data sets are defined as follows in Equations 5 to 8:

$$\text{Accuracy: } \frac{TP+TN}{TP+FP+FN+TN} \quad (5)$$

$$\text{Precision: } \frac{TP}{TP+FP} \quad (6)$$

$$\text{Recall (Sensitivity): } \frac{TP}{TP+FN} \quad (7)$$

$$\text{Specificity: } \frac{TN}{TN+FP} \quad (8)$$

Depression prediction results were obtained using all trauma items (59 items) as shown in Figure 2 and Table 5 considering the ROCs curve. The blue line on the graph is the prediction performance of the decision tree, the green line on the graph is the prediction performance of the gradient boosting trees, and the red line is the prediction performance of the random forest. The random forest method has the best performance for prediction using the optimal parameter number of trees = 20, and using information gain criterion with an accuracy of 84.89%, a precision of depression is 87.01%, and a recall of depression is 75.25%.

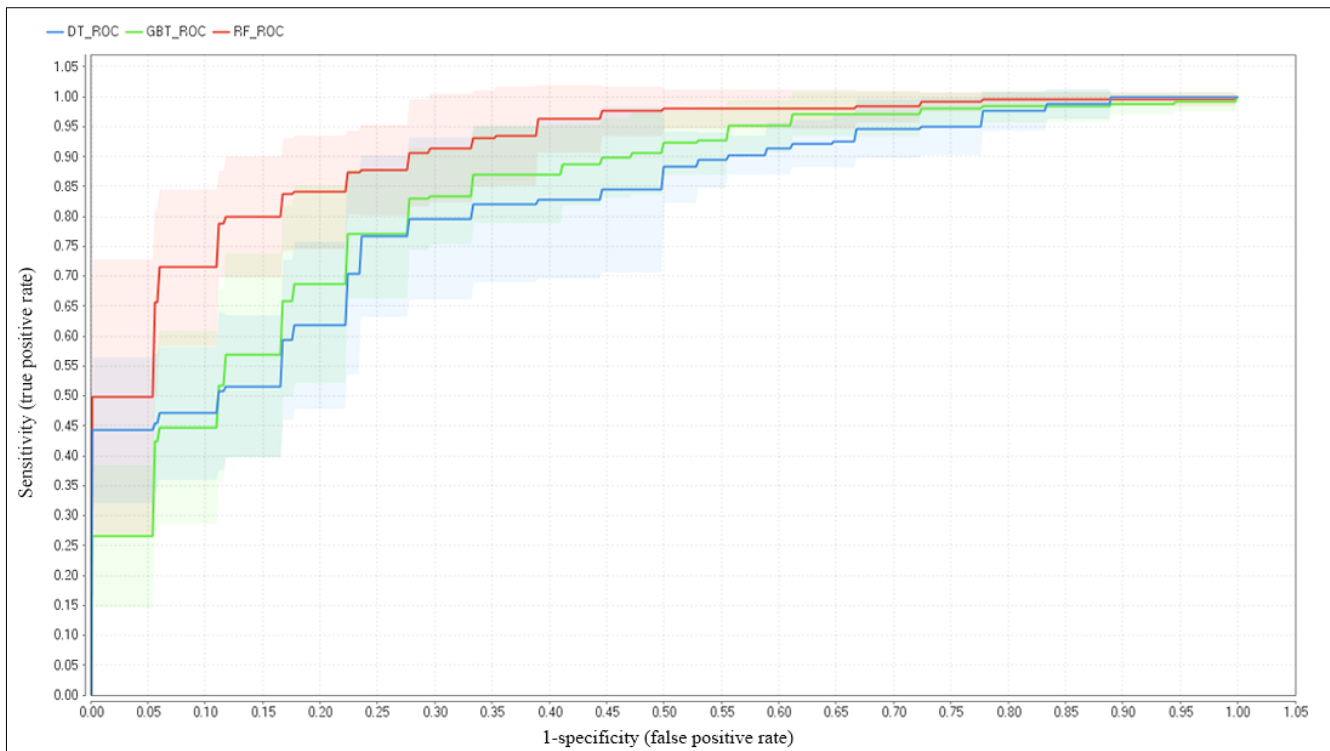


Figure 2. Depression ROCs curves of decision tree (blue line), gradient boosting trees (green line), and random forest (red line) using all trauma items

Table 5. The accuracy, precision, and recall of depression prediction model using all trauma items with random forest classifier

	True Depression	True not-Depression	Class precision
Pred. Depression	134	20	87.01%
Pred. not-Depression	44	225	83.64%
Class recall	75.28%	91.84%	
<i>Average accuracy 84.89% (from 10-fold cross validation)</i>			

Using only three important trauma items for predicting depression, the results are shown in Figure 3 and Table 6 considering the ROCs curve. The blue line on graph is the prediction performance of the decision tree, the green line is the prediction performance of the gradient boosting trees, and the red line is the prediction performance of the random forest. The random forest method performs best performance using an optimal parameter number of trees = 723, and using Gini index criterion with an accuracy of 85.84%, a precision of depression is 89.33%, and a recall of depression is 75.28%.

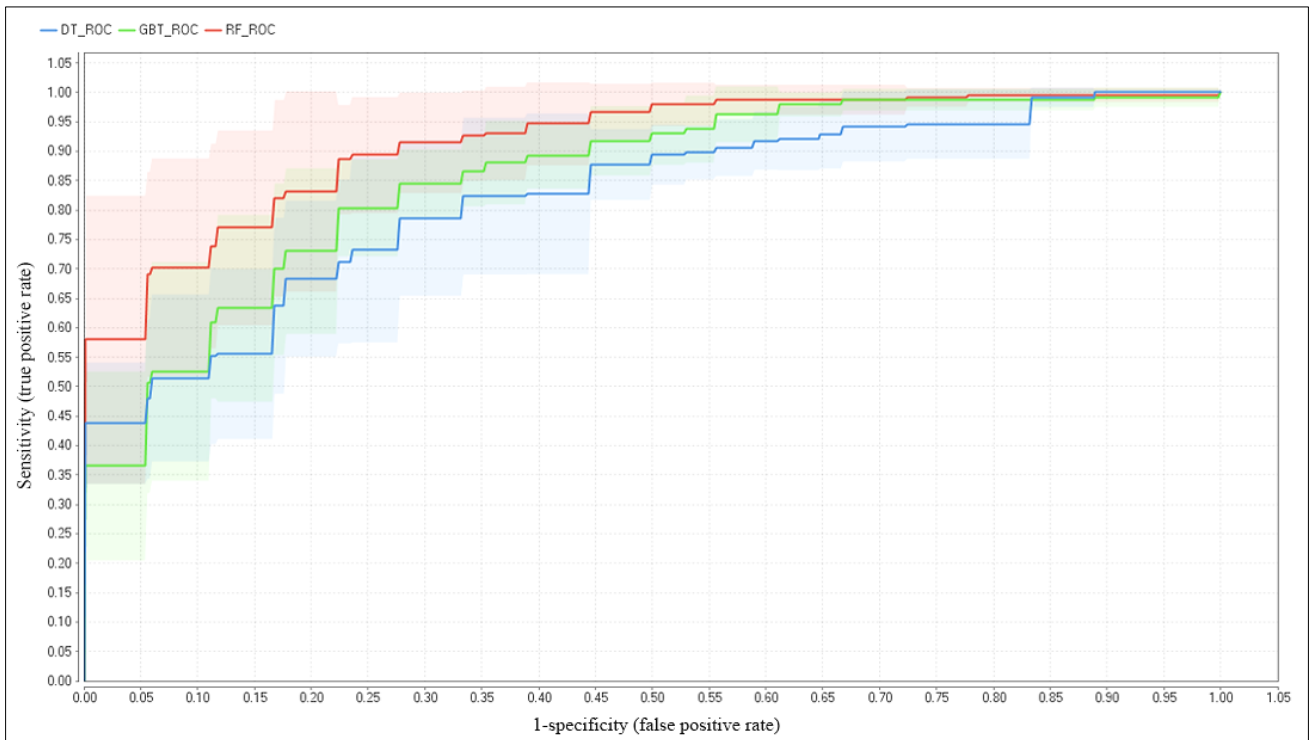


Figure 3. Depression ROCs curves of decision tree (blue line), gradient boosting trees (green line), and random forest (red line) using only three trauma items

Table 6. The accuracy, precision, and recall of depression prediction model using only three trauma items with random forest classifier

	True Depression	True not-Depression	Class precision
Pred. Depression	134	16	89.33%
Pred. not-Depression	44	229	83.88%
Class recall	75.28%	93.47%	
<i>Average accuracy 85.84% (from 10-fold cross validation)</i>			

Therefore, our proposed model using only three important trauma items is the most effective to predict depression, and the precision of the depression is higher than the precision of the use of all trauma items.

Suicide prediction results were obtained using all trauma items (59 items) as shown in Figure 4 and Table 7 considering the ROCs curve. The blue line on the graph is the prediction performance of the decision tree, the green line is the prediction performance of the gradient boosting trees, and the red line is the prediction performance of the random forest. The random forest method has the best performance for prediction using the optimal parameter number of trees = 594, and using information gain criterion with an accuracy of 87.02%, a precision of depression is 90.09%, and a recall of depression is 69.44%.

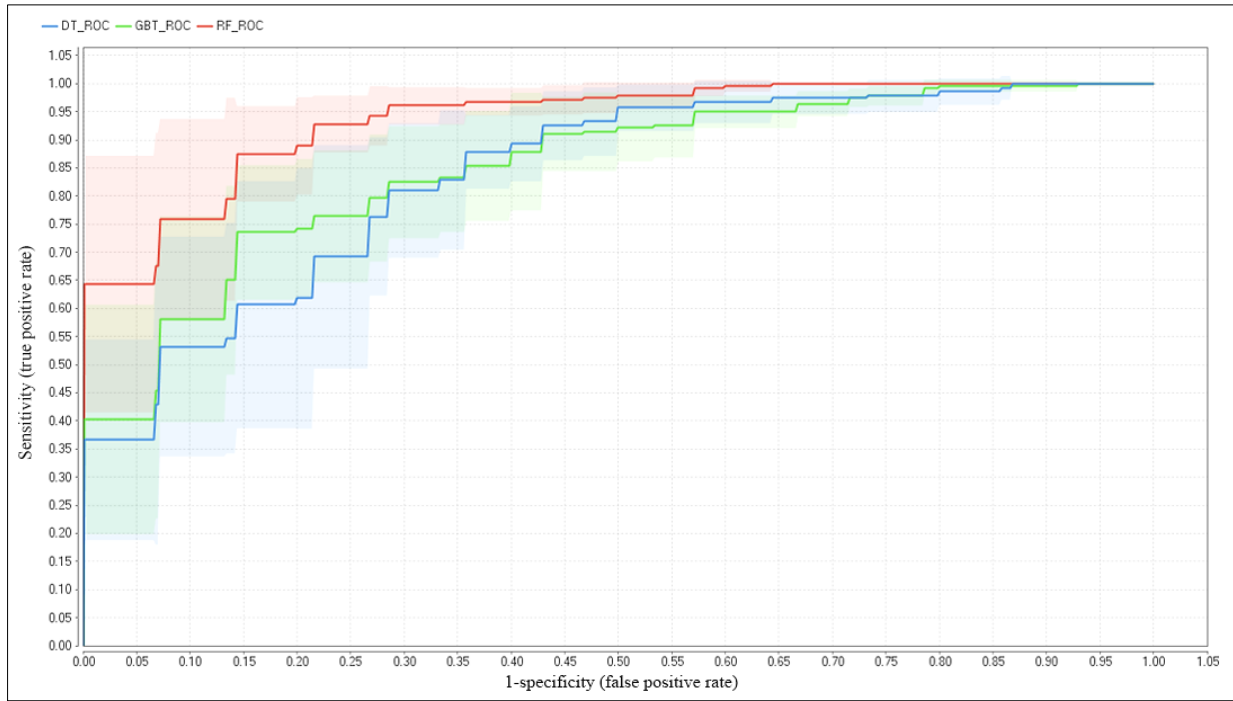


Figure 4. Suicide ROCs curves of decision tree (blue line), gradient boosting trees (green line), and random forest (red line) using all trauma items

Table 7. The accuracy, precision, and recall of suicide prediction model using all trauma items with random forest classifier

	True Depression	True not-Depression	Class precision
Pred. Depression	100	11	90.09%
Pred. not-Depression	44	268	85.90%
Class recall	69.44%	96.06%	
<i>Average accuracy 87.02% (from 10-fold cross validation)</i>			

Using six important trauma items and four important suicide items for predicting suicide, the results are shown in Figure 5 and Table 8 considering the ROCs curve.

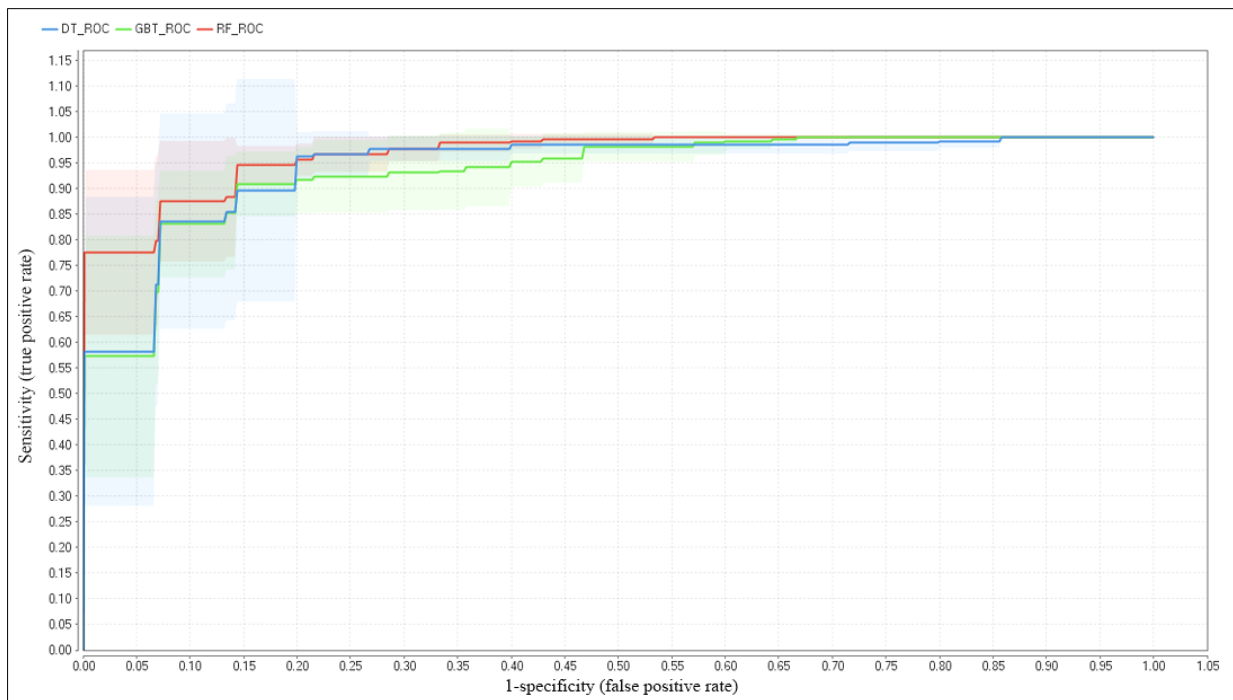


Figure 5. Suicide ROCs curves of decision tree (blue line), gradient boosting trees (green line), and random forest (red line) using six important trauma items and four important suicide items

Table 8. The accuracy, precision, and recall of suicide prediction model using six important trauma items and four important suicide items with random forest classifier

	True Depression	True not-Depression	Class precision
Pred. Depression	122	15	89.05%
Pred. not-Depression	22	264	92.31%
Class recall	84.72%	94.62%	
<i>Average accuracy 91.28% (from 10-fold cross validation)</i>			

The blue line on the graph is the prediction performance of the decision tree, the green line on the graph is the prediction performance of the gradient boosting trees, and the red line on the graph is the prediction performance of the random forest. The random forest method performs best performance using an optimal parameter number of trees = 327, and using gain ratio criterion with an accuracy of 91.28%, a precision of suicide is 89.05%, and a recall of suicide is 84.72%. Therefore, our proposed model using only six trauma items and four suicide items are the most effective to predict suicide, and the accuracy and recall of suicide is higher than the accuracy and recall of the use of all trauma items.

6- Conclusions

This research identified the associated patterns of high-life trauma items affecting depression and suicide among primary school students in Thai rural extended opportunity schools by FP-Growth association rule mining. Results showed that 34 associated patterns were high trauma, 14 associated patterns were depression, and 35 associated patterns were suicide. Moreover, it was found that the important high-trauma 7 items and suicide 4 items led to the prediction of depression and suicide using random forest ensemble learning. The predictive depression and suicide performance of the proposed method were evaluated in terms of accuracy, precision, and recall. The experimental results showed that our important feature items outperformed all other items that had been used previously to predict depression and suicide. In addition, our proposed method can be used as a primary step for screening depression and suicide.

This study have the following implications:

1) Academic research implications: 1.1) Researchers should select high-traumatic traits that contribute to depression and suicide predictions from this study in a further study to develop a quick and efficient short-term screening and assessment that facilitates the screening and assessing of depression and suicide among children in rural extended opportunity schools and risk groups., 1.2) Action research should be carried out or undertaken for early intervention to reduce the severity and for the prevention of depression and suicide., and 1.3) An in-depth research of the relationship between trauma, depression, suicide, other mental health problems and psychiatric disorders is needed.

2) Practical implications for practitioners: 2.1) These associated patterns and prediction models can help practitioners realize the importance of evaluating traumatic experiences. In case of experiencing life trauma, surveillance must be accompanied by an assessment of depression and suicide., and 2.2) Practitioners should increase their awareness of prediction patterns among the three phenomena, focusing on and engaging stakeholders such as parents, guardians, school teachers, and child care participation, especially reducing psychological abuse and neglect while promoting safe and positive relationships and positive inter-communication.

This study had the following limitations: This work is related to the associated patterns and prediction model of life trauma effecting depression and suicide using the 1) Trauma assessment 2) Children's Depression Inventory 3) DS 10 assessment for suicide. Another dataset, e.g., involving patients with social and cultural differences or the elderly, may use different prediction models. Therefore, this model is primarily suitable for students in Thai rural extended opportunity schools.

Future studies will be able to use other additional assessment instruments such as the Post-Traumatic Stress Disorder Checklist (PCL-5), Post-Traumatic Growth (PTG), and Patient Health Questionnaire (PHQ) to improve the performance of the prediction model.

7- Declarations

7-1- Author Contributions

Conceptualization, S.A. and P.T.; methodology, P.T.; software, P.T.; validation, S.A. and P.T.; formal analysis, P.T.; investigation, S.A.; resources, S.A.; data curation, S.A. and P.T.; writing—original draft preparation, P.T.; writing—review and editing, S.A. and P.T.; visualization, S.A. and P.T.; supervision, S.A. and P.T.; project administration, P.T. All authors have read and agreed to the published version of the manuscript.

7-2- Data Availability Statement

Data sharing is not applicable to this article.

7-3- Funding

The authors received no financial support for the research, authorship, and/or publication of this article.

7-4- Ethical Approval

Permission for the study was obtained from the Ethics Committee of Walailak University, Thailand (Protocol Number WUEC-20-168-01).

7-5- Conflicts of Interest

The authors declare that there is no conflict of interests regarding the publication of this manuscript. In addition, the ethical issues, including plagiarism, informed consent, misconduct, data fabrication and/or falsification, double publication and/or submission, and redundancies have been completely observed by the authors.

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