

Clarifying major risk factors in suicide attempts by subjects with drug overdose using machine learning: A retrospective study

Naomichi Okamoto

University of Occupational and Environmental Health

Atsuko Ikenouchi (✉ atsuko-i@med.uoeh-u.ac.jp)

University of Occupational and Environmental Health

Ryohei Igata

University of Occupational and Environmental Health

Keita Watanabe

Kyoto University

Reiji Yoshimura

University of Occupational and Environmental Health

Research Article

Keywords: Suicides, Depressive state, Social support lacking, No spouse, SAD PERSONS scale, Machine learning, Association rules analysis

Posted Date: May 16th, 2022

DOI: <https://doi.org/10.21203/rs.3.rs-1631385/v1>

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Abstract

Background: Suicidal attempts by psychotic drug overdose are a common reason for the emergency ward consultation. The epidemiology of suicide and the psychiatric perspective has been well studied; however, the investigation of the frequency and direction of the patients' background factors and their associations was not studied adequately. The present study aims to examine the concurrent occurrence of one event with another in background factors of patients with suicide attempts because of drug overdose by the machine learning method.

Methods: This is a retrospective observational study using electronic medical record information. Patients who attempted suicide from January 2015 to April 2018 were enrolled in the study. Extracted from disease names, out of 143 suicide cases, patients, who attempted suicide through other means, such as wrist cutting, hanging, and jumping, were excluded, and 101 patients who overdosed on psychotic drugs were included in the study. We assessed participants' demographic and clinical characteristics by the SAD PERSONS scale and used association rules analysis.

Results: The results showed that a depressive state, social support lacking, and no spouse were frequently associated with the other factors.

Conclusions: These results suggest that core factors, including depressive state, social support lacking, and no spouse, are essential risk factors, but combined with several other influencing factors, could contribute to the suicidal attempt by drug overdose.

Background

Previous reports showed more than 15% of patients in the emergency ward have psychiatric disorders [1]. Especially in emergency medicine, suicides and attempted suicides represent a major challenge for emergency physicians and paramedics, both in terms of psychiatric and somatic treatment [2]. Among them, suicidal attempts by psychotic drug overdose are a common reason for emergency consultations [3].

The SAD PERSONS scale, one of the most famous assessment tools to assess suicide risk [4], comprises factors like sex, age, depressive state, previous attempt, ethanol and substance use, rational thinking loss, social support lacking, organized plan, no spouse, and sickness. This measure has also been criticized for its simplicity and could not be applied to individual cases [5]. More valid measures are necessary for assessing the individual's current suicide risk because of the diversity of each suicidal background [6].

The epidemiology regarding suicide risk and the psychiatric perspective has been well studied [7, 8]. In contrast, to the best of our knowledge, few studies investigated the frequency and direction of the patients' background factors and their associations. From these findings, a criticism arises for using simple assessment tools, including the SAD PERSONS scale, to evaluate suicide risk.

Therefore, to address this limitation, we examined the concurrent occurrence of one event with another in patients' background factors with suicide attempts because of drug overdose using the machine learning method. Data mining through machine learning has been developed in recent years. Association rules analysis is a rule-based machine learning method for discovering interesting relations between variables in databases. It is intended to identify strong rules discovered in databases using some measures of interestingness [9]. In other words, it is a way of considering the events that may simultaneously occur during an event. The machine learning method, especially association rule analysis, can appropriate associations and patterns from voluminous data and complicated factors, leading to more precise associations among background factors with suicide attempts because of drug overdose than conventional statistical analysis.

Method

Ethics Statement

This study was conducted in accordance with the principles of the Declaration of Helsinki and the Japanese Ethical Guidelines for Medical and Health Research Involving Human Subjects. Before the initiation of the study, the study protocol was reviewed and approved by the University of Occupational and Environmental Health, Japan (approval number: H30-093). These ethics committees also exempted us from obtaining informed consent because this study is a retrospective medical record survey. Instead, we published information about this study to give patients the freedom to opt-out. To protect patients' personal information, we assigned each patient an arbitrary identification number for this study.

Study Design and Participants

This study is a retrospective observational study using electronic medical record information. Patients who attempted suicide and visited the emergency department of our hospital from January 2015 to April 2018 were enrolled in the study. Extracted from disease names, out of 143 suicide cases, patients, who attempted suicide through other means, such as wrist cutting, hanging, and jumping, were excluded, and 101 patients who overdosed on psychotic drugs were included in the study. The participants in the present study overlapped with those in our past published study [10]; however, no study has analyzed association rule analysis.

Demographic and Clinical Assessment

Participants' demographic and clinical characteristics were assessed by the SAD PERSONS scale [4], and the assessment score was evaluated immediately after the visit. If the SAD PERSONS score was not assessed on the day of the visit, it was assessed at a later date if it could be inferred retrospectively from the medical record.

Statistical Analysis

All statistical analyses were performed by Python ver. 3.0 [11], and we used association rules analysis. In analysis, we used the apriori-algorithm and excluded the set of a priori unnecessary items from the calculation. The apriori-algorithm method is efficient in finding frequent itemsets from extensive data [12].

We first used the apriori-algorithm to select single products or combinations with a support value of at least 0.1. Second, we set the lift value to be at least 1.0. Lift value is a performance measure of a targeting model (association rule) at predicting or classifying cases as having an enhanced response (concerning the population as a whole), measured against a random choice targeting model. Briefly, it is a measure of the degree to which items X and Y appear simultaneously after accounting for their occurrence frequency. The lift value is based on 1.0. If it is higher than 1.0, item X and item Y are more likely to occur simultaneously, and vice versa if lower than 1.0.

The network association graph was drawn using networkx, a Python library. The size of the nodes was adjusted to be proportional to the number of degrees. Vector orientation was drawn in both directions. Data were expressed as mean \pm standard deviation.

Results

Demographic and Clinical Data

The demographic and clinical data are shown in **Table 1**. The mean age was 40 ± 16 years, and 83% were female, which was according to a previous epidemiological study of patients with suicide attempts because of drug overdose in Japan [13].

Table 1

Demographic and Clinical Data

Patients who overdosed on psychotic drugs (n=101)

Age, year	40 ± 16
SAD PERSONS total score, points	3.6 ± 1.5
SAD PERSONS scale subcategory	
Sex male, %	17 (17%)
Age <20year or 45year<, %	52 (51%)
Depressive state, %	65 (64%)
Previous attempt, %	72 (71%)
Ethanol abuse or substance use, %	22 (22%)
Rational thinking loss, %	11 (11%)
Social supports lacking, %	51 (50%)
Organized plan, %	8 (7.9%)
No spouse, %	57 (56%)
Sickness, %	13 (13%)

The mean age was 40 ± 16 years, and 83% were female, which was according to a previous epidemiological study of patients with suicide attempts because of drug overdose in Japan. Data are expressed as mean ± standard deviation.

Association Rules Analysis

We showed the top 20 lift values, which are over 1.0, in **Table 2**, and drew an association network graph in **Figure 1**. Depressive state, social support lacking, and no spouse were the main three nodes and had various strengths associations with the rest of the nodes.

Table 2

Top 20 Lift Value

	Antecedents	Consequents	Lift Value	Support Value	Confidence Value
1	Previous attempt, Ethanol abuse or substance use	Social supports lacking	1.7163	0.1287	0.8666
2	Social supports lacking	Previous attempt, Ethanol abuse or substance use	1.7163	0.1287	0.2549
3	Social supports lacking, No spouse	Ethanol abuse or substance use	1.6694	0.1188	0.3636
4	Ethanol abuse	Social supports lacking, No spouse	1.6694	0.1188	0.5454
5	Previous attempt, No spouse	Social supports lacking, Depressive state	1.5947	0.2079	0.5526
6	Social supports lacking, Depressive state	Previous attempt, No spouse	1.5947	0.2079	0.6000
7	Ethanol abuse or substance use, Depressive state	Social supports lacking	1.5843	0.1188	0.8000
8	Social supports lacking	Ethanol abuse or substance use, Depressive state	1.5843	0.1188	0.2352
9	Ethanol abuse or substance use, No spouse	Social supports lacking	1.5843	0.1188	0.8000
10	Social supports lacking	Ethanol abuse or substance use, No spouse	1.5843	0.1188	0.2352
11	Social supports lacking, Depressive state	Ethanol abuse or substance use	1.5740	0.1188	0.3428
12	Ethanol abuse or substance use	Social supports lacking, Depressive state	1.5740	0.1188	0.5454
13	Ethanol abuse	Social supports lacking	1.5303	0.1683	0.7727
14	Social supports lacking	Ethanol abuse or substance	1.5303	0.1683	0.3333

		use			
15	Previous attempt, No spouse, Depressive state	Social supports lacking	1.4340	0.2079	0.7241
16	Social supports lacking	Previous attempt, No spouse, Depressive state	1.4340	0.2079	0.4117
17	Ethanol abuse or substance use, Depressive state	No spouse	1.4175	0.1188	0.8000
18	No spouse	Ethanol abuse or substance use, Depressive state	1.4175	0.1188	0.2105
19	Previous attempt, Depressive state	Social supports lacking, No spouse	1.3970	0.2079	0.4565
20	Social supports lacking, No spouse	Previous attempt, Depressive state	1.3970	0.2079	0.6363

Lift value is a performance measure of a targeting model (association rule) at predicting or classifying cases as having an enhanced response (concerning the population as a whole), measured against a random choice targeting model. Briefly, it is a measure of the degree to which items X and Y appear simultaneously after accounting for the frequency of their occurrence.

Discussion

The novelty of the study lies in the fact that depressive state, social support lacking, and no spouse factors were extracted as three main nodes. Furthermore, these were associated with other nodes in subjects who performed suicide attempts by drug overdose, using the association rule analysis by machine learning.

Previous reports showed more than 15% of patients in the emergency room have psychiatric disorders [1]. Especially in emergency medicine, suicides and attempted suicides represent a crucial challenge for emergency physicians and paramedics regarding psychiatric and somatic treatment [2]. Suicidal attempts by psychotic drug overdose are a common reason for emergency consultations [3]. The epidemiology of suicide and the psychiatric perspective has been relatively well studied [7, 8]; however, the frequency and direction of the association remain well elucidated to date. Association rule analysis, a

rule-based machine learning method for discovering interesting relations between variables in databases, is a robust tool for this investigation [9].

Depressive state, hopelessness, subsequent suicidal thoughts and behaviors, and being unmarried are reported as higher risk factors for suicide [14, 15]. Both quantity and quality social relationships also affect mental and physical health and mortality risk [16]. Also, social isolation is one of the most significant risk factors for suicide and suicide attempt [17, 18], and social support plays a key role in suicide prevention [18]. The three main nodes, depressive state, social support lacking, and no spouse, were quite well matched with previous findings in suicide and suicide attempt risk extracted using conventional statistical analysis.

The study has several limitations, i.e., small sample size, lack of psychiatric diagnosis, educational background, or economic status. Further study must be performed to overcome the same.

Conclusion

In conclusion, the machine learning method in association rules analysis detected the three main nodes, including depressive state, social support lacking, and no spouse. Furthermore, these nodes could be engaged in various strengths associations with the rest of the nodes. This study reveals that core factors, including depressive state, social support lacking, and no spouse, are essential risk factors, but combined with several other influencing factors, could contribute to the suicidal attempt by drug overdose.

Declarations

Ethics approval and consent to participate

This study was conducted in accordance with the Declaration of Helsinki, and the protocol was approved by the Ethics Committee of the University of Occupational and Environmental Health, Japan, Kitakyushu, Japan (approval number: H30-093). The requirement for informed consent was waived by the Ethics Committee of the University of Occupational and Environmental Health, Japan, Kitakyushu, Japan because of the retrospective nature of the study.

Consent for publication

Not applicable.

Availability of data and materials

The data that support the findings of this study are available from the corresponding author, upon reasonable request.

Competing interests

None of the authors have potential conflicts of interest to be disclosed.

Funding

There was no funding for this study.

Author's contributions

NO, RI, AI: conceptualization. NO: methodology, software, and visualization. NO, KW, AI, and YR: validation and writing of original draft preparation. NO: data curation. RI, AI, KW, and RY: writing review, editing, and supervision. All authors read and agreed to the published version of the manuscript.

Acknowledgments

None.

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Figures

