The associated factors of suicide attempt in French sexual minority adolescents

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Abstract

BACKGROUND: Sexual minority adolescents have greater risk for suicide attempt than heterosexual youth. However, research on risk and protective factors is lacking in sexual minority youth. In this study, we aimed to identify novel risk and protective factors for suicide attempt using machine learning decision tree method.

METHODS: The French cross-sectional study "Portraits adolescents" included 14 265 school-age adolescents. Decision tree algorithm was used to predict SA and to compare the different risk and protective factors between sexual minority youth and heterosexual peers.

RESULTS: Twenty predictive factors were identified among the 70 survey fields output from the predictive modeling for SA. Substance consumptions were among the top risk factors for SA. Parental support was an important protective factor among all adolescents regardless of sexual orientation. Interestingly, through the decision tree, real-life friend support was found protective in heterosexual youth, online friend support was a protective factor in homosexual adolescents.

CONCLUSIONS: Using the decision tree-based algorithm, we not only verified those important protective factors that were demonstrated in existing studies, but also discovered novel protective and attributive factors, such as real-life and online friend support. We urge that social networks should be optimize to provide safety and support for the sexual minority adolescents.

Introduction

Suicide among adolescents is a worldwide major public health problem [1]. In the United States, it is the second leading cause of death among youth aged 10-24 since year 2011, and cost 6000 lives per year from 2011 to 2019 [2]. In France, suicide is the second leading cause of death for 15-24 years old, with more than 16% of deaths in this age group in 2014 [3]. One of the main risk factors for death by suicide among adolescents and young adults is a history of suicide attempts [4]. In 2014, one in ten young people said they had thought about suicide at least once in the past 12 months, and nearly 3% had already made a suicide attempt in their lifetime that required hospitalization [5].

Suicide attempts (SA) among adolescents have been found multifaceted. Existing studies identified demographic and socioeconomic characteristics could predict high risk of SA, such as non-Caucasian race and Hispanic ethnicity in the North America [6], care by single parents or non-parent guardians [7]. Some also found SA associated with individual mental health experiences, for which having negative ideas [8], experiencing depressive episodes [9], and substance uses may confer higher risks while support from parents may reduce the risk of SA among adolescents [10]. Besides, sexual orientation was found strongly associated with SA in recent years across the globe. Many studies demonstrated higher risks of SA among the sexual minority adolescents compared to the heterosexual counterparts, ranging from 2 to 5 times [11-15]. With the consensus that non-heterosexual adolescents had high risk of suicide, it remains uncertain whether sexual orientation can independently predict SA with or without interacting with other factors like socioeconomic factors and social experiences.

From the perspective of suicide prevention, it is crucial to find the risk and protective factors with the strongest predictability among adolescents of sexual minority. Although many risk factors for SA have been identified in this population as gender female, feel of insecurity at school, consumption of substances [7,15-18], little is known on risk and protective factors in sexual minority youth. Moreover, specific protective factors also need to be identified in sexual minority youths. Existing studies reporting risk and protective factors for SA using conventional approaches like regression modeling are difficult to use, mainly due to methodological limitations, to develop preventive interventions [19]. Therefore, we performed machine learning-based algorithms to predict SA [20]. Such research could help to develop preventive interventions [21,22].

The aim of this study was to identify potential risk and protective factors of SA among the adolescents of sexual minority using decision tree-based algorithm. Through this approach, we expected to find new factors of SA specifically among adolescents of sexual minority based on primarily collected data. Therefore, appropriate interventions can be accurately and timely implemented to those adolescents having higher risks to alert and prevent potential SA.

Materials And Methods

French adolescents aged 13 to 20 years old were included in this study based on a cross-sectional survey database of *Portraits d'adolescents* [23]. This survey was collaborated between the Departments of National Education and Agricultural Education of France, Fondation Vallée Hospital, and INSERM UMR 1178. To summarize, the survey was conducted in 2013 in 3 French contrasted areas (Haute Alpes, Val de Marne, and Poitou-Charentes). 134 institutions were selected from these areas, representing a total of 730 classes. All students from the selected classes were enrolled in the survey [23].

Time frame of survey

The survey was conducted simultaneously in all the sampling area in the week of October 14, 2013. In each area, trained staff was deployed to the participating institutions to disseminate and collect survey responses on site. The responses were anonymous and confidential. The survey and the current study were approved by Commission of National Information and Liberty (CNIL Protocol No. 912523). Because no intervention was involved, no additional approval was required according to French law.

Inclusion & exclusion criteria of participants

The students aged 13-20 years studying in the participating institutions were enrolled in this study and provided response to the questionnaire on site when the survey staff worked in the institutions. The students older than 18 years old could refuse to participate in this survey after receiving the information letter. Parental consent has been requested for minors (less than 18 years old). Those adolescents who were out-of-school, or hospitalized in psychiatry or other services, or young people supported and educated in the medico-social were excluded.

Measurements

History of SA was the primary outcome, which was defined whether the participant attempted suicide at least once in the past. We asked 70 questions in the following 8 categories, constituting the explanatory and potential confounding variables of analyses.

Sociodemographic: age; gender assigned at birth; sexual orientation; and region (urban, semi-urban and rural area).

Family characteristics: parents' highest education level; parents' professions; parental separation; loss of parent(s); suicide of family members; living with parents; parental support; easily talking about personal problems in family; whether participant thinks mother is very beautiful; whether participant thinks father is very handsome; quarrels/fights between parents.

School experience: grade in which participant was; whether participant has repeated one year; whether participant likes to go to school.

Support from relationships: real-life friend support; online friend support, number of friends; whether participant have met online friends in life; whether participant belief that real-life friend is more important than online friend.

Personal life: whether participant focus on physical appearance; whether participant always looks at self in mirror; how participant thinks when they look at themselves in mirror; which part of body not satisfy participant; whether participant avoids to reveal body to others; whether participant pays attention to what participant eat; whether participant has fallen in love; whether participant has dredged; whether participant has had sex experience; whether participant has used oral contraceptives; condoms or other contraceptive approaches during sex.

Mental health: whether eating is a pleasure; whether participant has suffered from overeating; whether participant has suffered from anorexia; whether participant has some questions to ask to themselves or the person around; participation in dangerous games; considering adolescence as an easy period.

Consumption of substances: smoking (during last 30 days); smoking intensively (at least ten cigarettes per day); drinking (during last 30 days); drinking regularly (at least 10 times during last 30 days); drunk (5 glasses per time during last 30 days); drunk often (at least 10 times during last 30 days); use of cannabis (during last 30 days); use of cannabis regularly (consumption of 10 times during last 30 days); and use of other drugs (amphetamine; inhaler; ecstasy; lysergic acid diethylamide [LSD]; crack; cocaine; heroin; Hallucinogenic mushroom; or methylenedioxymethamphetamine [MDMA]); consume alcohol with cannabis; consume alcohol with drugs

Health condition: BMI (Body Mass Index); whether participant has had a period of overweight; satisfaction of health; easy to tell the health problem with a doctor; easy to tell the health problem with father; easy to tell the health problem with mother; have another close adult person to talk about health problem.

Analytic method

First, we used the one-way chi-square test to compare the demographic characteristics Second, we applied the decision tree-based predictive algorithm, a machine learning-based approach, to identify risk factors for SA based on the value of split rules while avoiding overfit of models or imposing an explanatory structure between predictors and outcomes [24,25]. Third, to estimate the effects of the risk factors identified from the decision tree-based modeling, we conducted single logistic regression models to predict SA based three subgroups (heterosexual, homosexual and bisexual). Estimate of effects from logistic regression models were displayed in odds ratio (OR) and 95% confidence interval (CI). The machine-learning computations and logistic regression were conducted using SAS Studio 9.4 (SAS Institute, Cary, NC, USA). Statistical significance was determined with a two-tail p value less than 0.05 for descriptive statistics and regression models.

Results

Characteristic of participants

Among all the participants, 14,265 aged 13 to 20 have answered the question of sexual orientation. They were classified into 3 groups: homosexuals (209, 1.5%), bisexuals (428, 3%) and heterosexuals (13,628, 95.5%) (Table 1). Most of the students were in ages of 13 to 16 years (71.7%), studying in high school (65.5%) and female (52.2%). As for the geographic origins, 46.4% of the students were from Hautes-Alpes (semi-urban), 26.8% from Val de Marne (urban), and 26.8% from Poitou-Charentes (rural). Several demographic characteristics varied between homosexual, bisexual and heterosexual subjects. The bisexual subjects were more likely to be female (73.6% vs. 67% homosexual vs. 51.3% heterosexual, p<0.0001), and mostly have repeated a school year (39.3% vs. 34% homosexual vs. 31.3% heterosexual, p <0.001) whereas homosexual youth were the most likely in high schools (79.4% vs. 75.9% bisexual vs. 65.0% heterosexual, p<0.001). According to suicide attempts, the bisexual subjects reported the highest rate (36.2% vs. 19.4% homosexual vs. 10.6% heterosexual, p <0.0001).

Predictive factors selected from decision tree-based algorithms to predict SA

The decision tree was based on the whole sample data comprising of 70 variables including sexual orientation. We tested our model with several sets of parameters and obtained the best goodness of fit when the cost-complexity pruning method was used as subtree evaluation criterion and the number of leaves after pruning was 30. The minimum average misclassification rate is 0.120 (Figure 1.A) and the Area under the receiver operating characteristics curve (AUC-ROC) is 0.87 (Figure 1.B). In the model, 20 predictive factors were identified by the value of relevance and efficacy, in which sexual orientation was output from the variable selection (Table 2).

As demonstrated in the flow of decision tree (Figure 2), the data was split into a series of dichotomous partitions. At each partitioning, non-missing data entered either of the two branches while missing was dropped from the tree. In this way, data input in the tree was processed until a maximal tree was formed. As the formation of tree proceeded along the series of partitions, the cumulative probability of SA rose in the branch indicating SA while the cumulative probability of not-SA rose in the counterpart direction

Quantification of effects of predictors output from the decision tree models

The 20 predictive variables from the predictive modeling for SA were classified into 6 categories, namely, demographics, relations, personal life, mental health, consumption of substances and health condition. We input these variables, except sexual orientation, in single logistic regression models to estimate the effects of each variable on the heterosexual, the homosexual, and the bisexual subsets, respectively (Table 3).

Among the homosexual subjects, 6 protective factors (parental support, have met some online friends in life, online friend support, belief that eating is pleasure, satisfaction of health, belief that talking about health is easier with mother) were found associated with SA while another 7 risk factors (participated in dangerous games, dissatisfaction with some body, consume alcohol with drugs, history of cocaine use, history of ecstasy use, history of amphetamine use, intensive use of tobacco parts) found inversely associated (Table 3).

Among the bisexual subjects, 5 protective factors (parental support, belief that adolescence is an easy period, belief that eating is pleasure, satisfaction of health, belief that talking about health is easier with mother) were found associated with SA while 6 risk factors (participated in dangerous games, consume alcohol with drugs, history of cocaine use, history of ecstasy use, history of amphetamine use, intensive use of tobacco) were identified (Table 3). Interestingly, online friend support did not appear a protective factor among bisexuals.

In heterosexual group, 7 factors (parental support, have met some online friends in life, real-life friend support, belief that adolescence is an easy period, belief that eating is pleasure, satisfaction of health, belief that talking about health is easier with mother) were identified as protective factors of SA while 11 factors (gender, living with parents, first sexual activity, participated in dangerous games, dissatisfaction with some body parts, when you look at yourself in a mirror you are not happy, consume alcohol with drugs, history of cocaine use, history of ecstasy use, history of amphetamine use, intensive use of tobacco) were risk factors (Table 3).

Discussion

In our study, we confirmed the high rates of SA among LGB adolescents, compared to the heterosexual counterparts, and further differentiated the predictiveness for SA by sexual orientation.

In our study, consumptions of alcohol and substances were among the top three risk factors for SA in all sexual orientations. Jiang et al. found that in North America consumption of alcohol was associated with SA especially drinking alcoholic beverages mixed with drugs like marijuana [26]. This point was consistent with our result that the consumption of alcohol with drugs could independently predict SA apart from sexual orientation. Moreover, we implied from our result that consumption of other illicit drugs for entertainment could be additive in terms of odds of SA among both LGB and

heterosexual adolescents. Very few studies gave the comprehensive consideration of and contrast the consumptions of any possible substances among adolescents in France and Western Europe in existing literature. The simultaneous use of alcohol and drugs often leads to high-risk behaviors because it accelerates and enhances the pharmacological effects of substances [27]. In addition to substance consumption, dissatisfaction with some body parts is also identified as an important risk factor. It also could be a more direct way for teenagers to express their self-criticism as pointed out in other studies, which is considered to be a suicide-related factor [28,29].

Considering protective factors, support from parents is considered as one of the strongest protective factors of SA in all of adolescents in this study, which reveals the importance role of family. A recent study found that the high satisfaction of family relationship and of personal health were both protective for suicidality (Bae et al., 2019), which was consistent with our finding. In addition, we found that online friend support was a protective factor only in homosexuals whereas real-life friend support was a protective factor in heterosexuals. Among the current literature, we only found two studies pertaining to friends support, in which online friendship were found to be used often by LGBT youth in complement to "perceived limitations in offline resources and relationships" [30] and LGB youth were more likely than non-LGBT youth to think "these friends as better than their in-person friends at providing emotional support" [31]. In the past decade, since adolescents have got to spend much more time online, they are more exposed to support and help from Internet. But Dehaan et al. also pointed out that the relations between online friends or even romantic partners among LGB youth was more difficulty to sustain compared to those made through offline contact [30]. These findings suggest that online friends can be an important source of social support, particularly for LGB youth.

Based on the risk and protective factors reported, we propose the following suicide prevention strategies:

1. Family plans for sexual minorities can be the focus of future development, because LGB adolescents face an environment in their family settings that they have no right to choose and little power to change. Sexual orientation related SA was more open about being LGB with their families, had been often called "sissy" or "tomboy" [32], concealing one's homosexual identity may be less harmful than disclosing it [33]. It is important to encourage positive family relationships and parental support, so that these young people know they have the opportunity to disclose their sexual orientation or gender identity in a positive and safe environment. Interventions with parents can take the form of twinning programs that allow them to share their experiences, to benefit from attentive listening and to learn more about sexual diversity.

2. Friends of Lesbians and Gays and Gay-Straight Alliance groups should be built [9,34] to strengthen the relationships between LGB adolescents and their heterosexual peers.   Led by the education system, in line with the policies of the health administrative department, the aim is to increase communication between heterosexual and sexual minority students, to strengthen education of all students, and deepen the knowledge of coming out, sexual orientation and gender identity. For LGB youth who have locate in unsupportive environment, having positive resources and healthy support systems may literally be the effective prevention of SA.

3. The optimal Internet resources for suicide prevention and protection could be created. Sexual minority youths are more accustomed to relying on the online world, we should establish website resources (The Trevor Project [35], a 24/7 hotline for LGBT suicidal youth; the It Gets Better Project [36], a 24/7 hotline for LGBTQ people who are in crisis) to prevent sexual minority youths from committing suicide.

Limitations and strengths

This study has some limitations. First, since decision tree requires a dichotomous split at each branch, we need to convert a few ordinal variables to binary way, indicating possible misclassification. Second, this study used cross-sectional data to explore predictors of SA, which cannot generate causal relations. Third, the retrospective data that used in this study might cause some recall bias from self-reporting of subjects' previous experiences. Last, we were unable to collect data about

race/ethnicity, religious affiliation, bullying/being bullied, physical and sexual abuses on the adolescents due to the French regulations. Yet, we acknowledged race/ethnicity- and religious belief-specific variations in perception of sexual minority and suicidal behaviors.

Our study also has several strengths. First, decision tree-based algorithm can identify predictors without need to address challenges for regression modeling in the high dimensional data, such as multicollinearity, missing data and complex intervariable relations. It may provide high sensitivity and specificity to predict outcomes from real-world clinical data. Thus, this approach has a great potential to be developed to real-time risk monitoring tools in clinical circumstances for adverse outcome prevention. Second, while most existing studies emphasized male subjects, our study slightly oversampled female subjects between 13 and 20 years old. This might better portray the associations for female subjects.

Conclusions

We explored the decision tree-based approach to predict SA from a primarily collected data of SA in France. Using the decision tree-based algorithm, we not only verified those important protective factors that were demonstrated in existing studies, such as parental support, but also discovered novel protective and attributive factors, such as real-life and online friend supports, and their strengths in affecting SA. We urge that social networks should be optimized to provide safety and support for the sexual minority adolescents. Future research will lie in the development of real-time prediction tools and the expansion of modeling from including time-dependent variables.

Declarations

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Tables

Table 1. - Description of demographic characteristics

Variables	Total		Homosexual		Bisexual		Heterosexual		p
	n=14 265		n= 209		n=428		n= 13 628		
	nb	%	nb	%	nb	%	nb	%	
Sociodemographics									
Gender assigned at birth (N=14265)									<0.0001
Female	7444	52.2	140	67	315	73.6	6989	51.3	
Male	6821	47.8	69	33	113	26.4	6639	48.7	
Age (N=14265)									<0.0001
13-14	4273	29.9	38	18.2	85	19.9	4150	30.4	
15-16	5959	41.8	82	39.2	186	43.5	5691	41.8	
17-18	3670	25.7	78	37.3	145	33.9	3447	25.3	
19-20	363	2.6	11	5.3	12	2.8	340	2.5	
Region (N=14265)									<0.01
urban	3822	26.8	59	28.2	108	25.2	3655	26.8	
semi-urban	6625	46.4	89	42.6	177	41.4	6359	46.7	
rural area	3818	26.8	61	29.2	143	33.4	3614	26.5	
School									
Level of school (N=14265)									<0.001
Middle	4917	34.5	43	20.6	103	24.1	4771	35.0	
High	9348	65.5	166	79.4	325	75.9	8857	65.0	
Repeating a school year (N=14241)									<0.001
Yes	4502	31.6	71	34	168	39.3	4263	31.3	
No	9739	68.4	138	66	259	60.7	9342	68.7	
Parents									
Professional activity of father (N=13789)									<0.01
No	2093	15.0	42	20.1	101	23.6	1950	14.8	
Yes	11722	85.0	167	79.9	327	76.4	11228	85.2	
Professional activity of mother (N=14009)									<0.01

No		2550	18.1	55	26.3	100	23.4	2395	17.9
Yes		11475	81.9	154	73.7	328	76.6	10993	82.1
Mental Health									
Suicide attempts									<0.0001
No		12496	88.5	166	80.6	272	63.8	12058	89.4
Yes		1625	11.5	40	19.4	154	36.2	1431	10.6

Table 2. - Overview of the decreasing ranking of factors for suicide attempts in decision tree
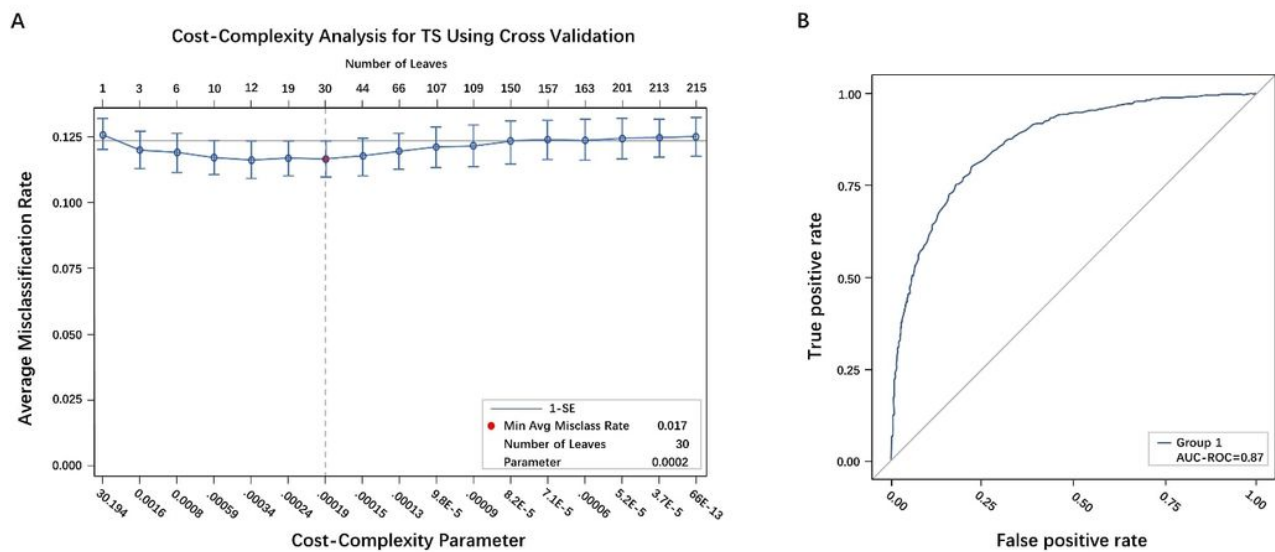
Factor	Decision tree		
	Relative	Efficacy	Rank
Parental support	1.0000	10.7341	1
Consume alcohol with drugs	0.8925	9.5803	2
Sexual experience	0.7495	8.0451	3
Real-life friend support	0.6354	6.8207	4
Belief that adolescence is an easy period	0.5952	6.3885	5
Have met some internet friends in life	0.5521	5.9261	6
Satisfaction of health	0.4605	4.9435	7
History of ecstasy use	0.4141	4.4445	8
Participating in dangerous games	0.4031	4.3274	9
Dissatisfaction with some body parts	0.3533	3.7925	10
Belief that talking about health is easier with mother	0.3512	3.7697	11
Online friend support	0.3303	3.5451	12
Belief that eating is pleasure	0.2976	3.1943	13
When you look at yourself in a mirror you are happy	0.2948	3.1641	14
Living with parents	0.2807	3.0127	15
Sexual orientation	0.2565	2.7528	16
History of cocaine use	0.2150	2.3076	17
Gender assigned at birth	0.1941	2.0836	18
Smoking	0.1791	1.9226	19
History of amphetamine use	0.1505	1.6151	20

Table 3. - Single logistic regression models for suicide attempts

Variable		Heterosexual (n= 13628)			Homosexual (n= 209)			Bisexual (n= 428)		
		OR	95% CI	p	OR	95% CI	p	OR	95% CI	p
Demographics	Gender female	2.57	2.28-2.90	<0.0001	1.00	0.49-2.15	0.997	1.16	0.74-1.84	0.515
	Living with parents	1.74	1.50-2.01	<0.0001	1.25	0.51-2.95	0.61	0.81	0.48-1.35	0.414
Relations	Parental support	0.30	0.27-0.34	<0.0001	0.22	0.08-0.51	<0.001	0.53	0.34-0.80	<0.01
	Have met some online friends in life	0.55	0.49-0.62	<0.0001	0.38	0.18-0.77	<0.01	0.70	0.47-1.05	0.084
	Real-life friend support	0.36	0.23-0.56	<0.0001	0.84	0.04-5.42	0.877	0.78	0.29-1.87	0.591
	Online friend support	1.05	0.93-1.18	0.424	0.45	0.20-0.98	<0.05	1.22	0.80-1.86	0.363
Personal life	First sexual activity	2.98	2.54-3.51	<0.0001	0.81	0.35-1.87	0.622	1.40	0.79-2.53	0.253
	Participated in dangerous games	2.66	2.28-3.08	<0.0001	6.57	2.51-17.71	<0.0001	4.19	2.50-7.14	<0.0001
Mental health	Dissatisfaction with some body parts	3.40	2.89-4.02	<0.0001	9.17	1.87-165.97	<0.05	1.22	0.62-2.51	0.577
	Belief that adolescence is an easy period	0.76	0.71-0.81	<0.0001	0.73	0.50-1.06	0.098	0.70	0.57-0.87	<0.001
	Belief that eating is pleasure	0.44	0.39-0.49	<0.0001	0.40	0.19-0.86	<0.05	0.48	0.30-0.76	<0.01
	when you look at yourself in a mirror you are not happy	1.07	1.03-1.13	<0.01	0.93	0.67-1.29	0.673	1.12	0.92-1.36	0.271
Consumption of substances	Consume alcohol with drugs	7.93	6.29-9.98	<0.0001	21.21	6.18-98.24	<0.0001	7.63	3.89-16.17	<0.0001
	History of cocaine use	4.29	3.29-5.24	<0.0001	6.84	2.23-22.11	<0.001	4.60	2.64-8.26	<0.0001
	History of ecstasy use	4.55	3.55-5.80	<0.0001	5.92	1.49-25.02	<0.05	4.25	2.16-8.78	<0.0001
	History of amphetamine use	4.25	3.17-5.63	<0.0001	4.94	1,59-15.38	<0.01	6.71	3.08-16.24	<0.0001
	Intensive use of tobacco	3.26	2.68-3.96	<0.0001	6.26	2.51-15.88	<0.0001	3.76	2.08-6.98	<0.0001
Health condition	Satisfaction of health	0.28	0.24-0.32	<0.0001	0.32	0.14-0.77	<0.01	0.37	0.23-0.60	<0.0001

Belief that talking about health is easier with mother	0.36	0.32-0.41	<0.0001	0.40	0.19-0.85	<0.05	0.46	0.29-0.70	<0.0001

Figures

Figure 1

Cost-complexity analysis. Misclassification rate and AUC-ROC curve
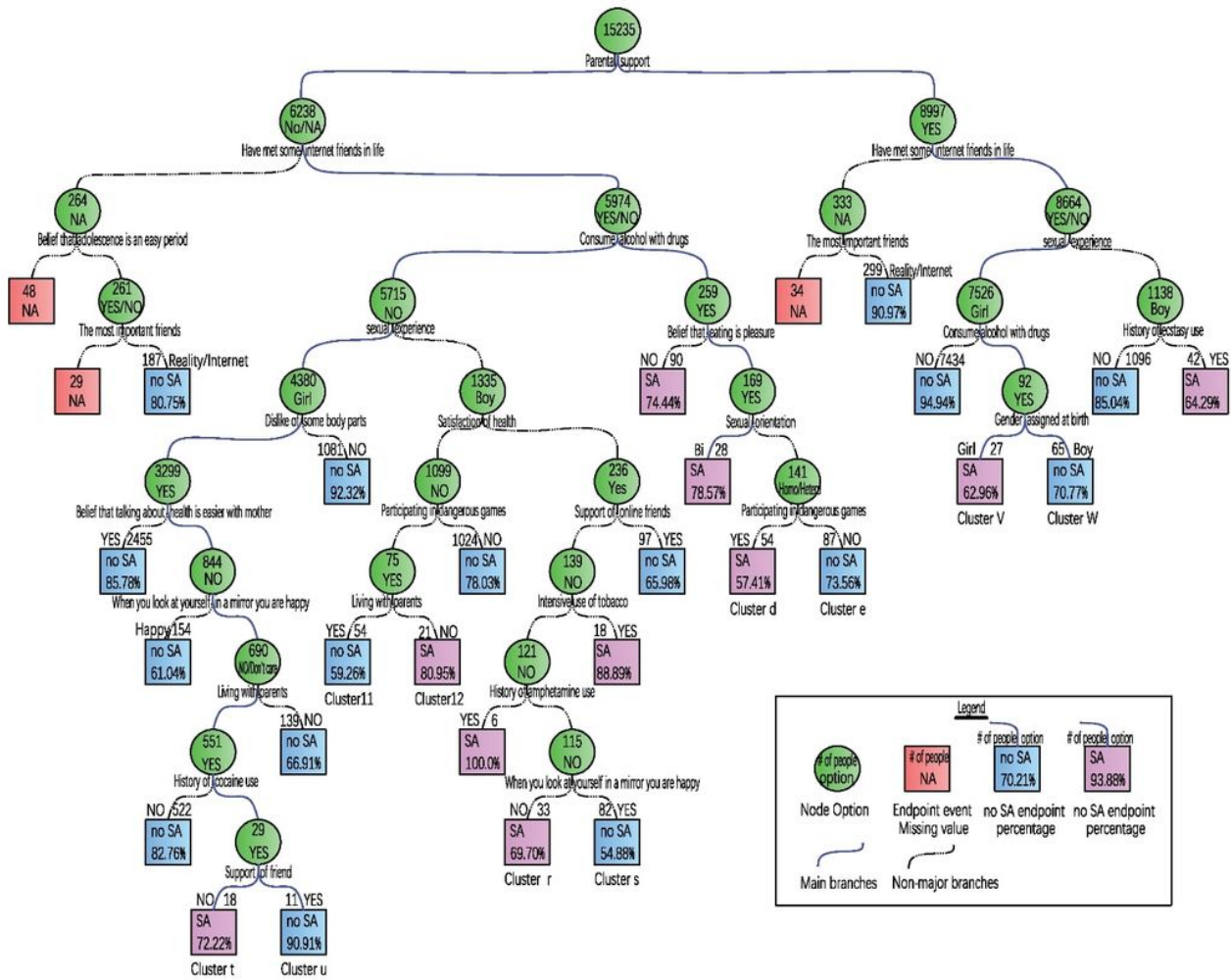
Figure 2

Decision tree model