BP Neural Network Prediction Model for Suicide Attempt among Chinese Rural Residents

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Abstract

Objective: This study aimed to establish and assess the Back Propagation Neural Network (BPNN) prediction model for suicide attempt, so as to improve the individual prediction accuracy.

Method: Data was collected from a wide range case-control suicide attempt survey. 659 serious suicide attempters (case group) were randomly recruited through the hospital emergency and patient registration system from 13 rural counties in China. Each case was matched the control by the same community, gender, and similar age (±2 ages). Face to face interviews were conducted for each subject with the structured questionnaire. Logistic regression was applied to preliminarily screen the factors and BPNN was used to establish the prediction model of suicide attempt.

Results: Multivariate logistic regression indicated that family history of suicide (OR=4.146), mental problem (OR=3.876) Low education level, poor health, aspiration strain, hopelessness, impulsivity, depression are the risk predictors and social support, coping skills, healthy community are the protect predictors for suicide attempt. Repetitious data simulation process of BPNN indicated that three-layer BPNN with 9 hidden layer neurons is the optimal prediction model. The sensitivity (67.6%), specificity (93.9%), positive predictive value (86.0%), negative predictive value (84.1%), total coincidence rate (84.6%) all manifested that it is excellent to distinguish suicide attempt case.

Conclusions: The BPNN method is applicative, feasible, credible and good discriminative effect for suicide attempt. The BPNN established has significant clinical meaning to distinguish suicide attempt for the clinical psychiatrist and lay theoretical foundation for artificial intelligence expert assisted diagnosis system for suicide attempt in the future.

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Keywords

Background

Suicide attempt is a behavioral result of suicidal individual, who takes suicidal action but survive. The previous literature research shows that the suicide rate of aged 5 and above in China from 2002 to 2015 is 6.75/100,000 people, urban residents declined from 12.79/100,000 to 5. 07/100,000, rural residents declined from 15.32 /100,000 to 8. 39/100,000[1]. The latest literature research shows that the average annual suicide rate in China from 2012 to 2015 is 675/100,000, higher in rural than urban areas, higher in males than females, and higher in elderly people than young people[2].

Although suicide rate has declined recently, it is still the main death cause [1, 3]and the main threat to health and society in China. A large number of literature indicated that attempted suicide is the high-risk population for suicide completed [4–6]. Previous studies have shown that about 30% to 60% suicide has the history of suicide attempt[7] and suicide attempt is the clear features of suicidal behavior[8]. So, it is an urgent and important research area to screen predicting indicators and establish the precise prediction model for suicide attempt and has great theoretical referencere for preventive measures of suicide attempt and suicidal behavior.

So far, there have some previous studies on Chinese suicide attempt. Phillips (2002) etc. have studied the risk factors of suicide attempt in rural Chinese people basing on Shandong province data[9]. Zhang (2006) have researched the characteristics of the Chinese suicide attempt [7], Liu and Jia (2011) have studied the epidemiological characteristics of suicide attempt in China [10]. Zhang (2012) etc. have reviewed the risk factors of suicide attempt and researched the relationship between social factors, psychological factors and suicide attempt in China [11]. Tong, Y (2018) etc. have researched the prevalence of psychiatric diagnoses in individuals who die by suicide or attempt suicide in China [12].

Center for Suicide Prevention Research of Shandong University has developed lot of research on suicide attempt and suicide in recent years, the research involving molecular epidemiological studies, environmental factors[13], genetic factors of suicide attempt[14–17]. The prevalence of various mental disorders among suicide attempters and the relationship between them still has been researched [18]. Sun (2018) has analysed the suicide attempt associate with suicide acceptability in rural China [19].

These previous literature is significant and provide research experience for further suicide attempt research. Most of early literature aimed to discuss and screen the risk factors and established the prediction model from a few major aspects but based on synthesized perspective. Moreover, the suicide attempt population is a special survey population, the distributions of theirs demographic and personality psychological characteristic variables are likely to be skewness distribution and the relationships among variables are likely interactive

and nonlinear. However, most previous literature established the prediction model by traditional prediction methods such as Logistic regression, which always ignored the application condition (linear, independent, normal distribution and equal variance) of the methods. This ignore of the application condition of the traditional prediction methods always result in inaccurate results or larger prediction bias, which maybe the main limitations of the previous literature. Furthermore, suicide attempt is a composed result of the combined of many factors.The intricate relationships between these factors can hardly be accurately represented by a fixed mathematical pattern. However, back propagation (BP) neural network as the simulation of the human brain working mechanism can handle the complex fuzzy mapping relation and identify the complex nonlinear relationship between variables. The BP neural network, maximum simulates human brain intelligently, could deal with arbitrary nonlinear relation between variables. It has many incomparable advantages on complex model fitting and distribution approximation over the traditional statistical methods. Previous little literature has applied the BP neural network model in the suicide or suicide attempt research field [20, 21], but hardly any literature was found in recent years. So it it significant to establish the prediction model basing on BP neural network so as to improve the prediction accuracy and put forward more targeted prevention strategies for suicide attempt.

Methods

Subjects and Data Collection

Data of the current study was collected from a wide range case-control suicide attempt survey. The large survey was carried out from May 2012 to December 2014 in Shandong province, China. Shandong, located on the east of China, is a typical province with economic prosperity in both industry and agriculture. The 659 serious suicide attempters (case roup) between 12 and 55 years old were randomly recruited through the hospital emergency and patient registration system from 13 rural counties in China. Meanwhile, each case was matched the control by the same community, gender, and similar age (±2 ages). In order to reduce the selection bias of the subjects, the rigorous inclusion and exclusion criterias were set before the suicide attempt survey, which have been elaborated in the published literature[22].

The structured questionnaires were used to collect the information of each case and control respondent by face to face interview. Each interview expended about half and an hour by the professional trained interviewer in a quiet place. In order to improve the compliance the head of the village and the village doctor were recruited as referrer but not attended the interview in the survey. Information was answered and obtained from the attempts suicide cases and their control subjects personally.

Measurements

In order to explore the main influencing factors and establish an accurate prediction model of the suicide attempt based on synthesized perspective, the questionnaires used in the survey contained various aspects of information. The socio-demographic questionnaire was used to collect the demographic information such as age, gender, education level, marital

status, etc. The recode method of the demographic variables was showed in Table 1. The items of the questionnaires and the international generally recognized mental survey scales were recruited to investgate the risk factors of the suicide attempt. The measurements methods and the recode method of the variables have been detailedly elaborated in the published literature[22]. Here, only the measuring and recode methods of the important variables and statistical significant variables were elaborated in detail.

In the current study, the dichotomous variables, such as family history of suicide, mental problem, aspiration strain, were measured by corresponding item of the questionnaire and dichotomized as "0 =No" and "1 = Yes". Aspiration strain was measured by "Can you feel the aspiration strain in life?" If there is a large discrepancy between expectation and reality, the person would experiences aspiration strain.

Education level and health status variables were still measured by corresponding items. As to the categorical variables, education level was recoded as "1= primary or below", "2 = middle school", "3 = college or above". Health status variable was recoded as "1 = very poor or poor", "2 = middle", "3 = good or excellent".

The Beck Hopelessness Scale (BHS) was applied to investigate the hopelessness level. The Dickman impulse scale was used to to investigate the impulsivity. State-Trait AnxietyInventory (STAI) scale was used to to investigate the anxiety. CES-D depression scale was used to to investigate the depression. GSS suicide attitude scale was used to to investigate the suicide attitude. IRLE life event scale was used to to investigate the negative life events. Landerman social support scale was used to to investigate the social support. CRI Moos coping skills scale was used to to investigate the coping skills. WHO Community Stress and Problem questionnaire was used to to investigate the community environment.The previous research indicated that the scales have well reliability and validity in China [23–26]. As to the numerical variables, such as hopelessness, impulsivity, anxiety, depression, suicide attitude scale score (GSS), negative life event score (NLEs), social support, coping skills, community environment were coded as their scores.

Data Analysis Methods

The $\bar{X} \pm SD$ was used to descript the quantitative data and relative number was used to descript the qualitative data. The t test and χ^2 test was used to compare the difference of quantitative and qualitative data between two groups respectively. Logistic regression was applied to preliminarily screen the factors and BP neural network was used to establish the prediction model of suicide attempt. Statistical analysis software such as SAS9.2, SPSS21.0 and Matlab R2010b were applied in current study.

Ethical approval

This study was approved by the ethics committee of Weifang Medical University and Shandong University and paper version informed consents were obtained from all participants in current study.

Results

Demographic Description of the Sample

The average age of the case group and control group is 31.62±8.09 years, 31.81±8.11 years respectively. There are 249 (37.8%) subjects are male and 410 (62.2%) are female in case group and 250 (37.9%) are male and 409 (62.1%) are female in control group. The statistical result indicate that there is not significant difference on age, gender variables between two groups (P=0.659, P=0.955). It indicates that the main confounding variables are controlled and the design of the current study is religious.

There are 105 (15.9%) subjects are never married and 554 (84.1%) are ever married in case group and 86 (13.1%) are never married and 573 (86.9%) are ever married in control group. there is not significant difference on marital status variable between two groups (P=0.137). There is significant difference between two groups on education level variable (P<0.001). The demographic description of the samples was showed in Table1.

Preliminary Screen Influence Factors Basing on Logistic Regression

Univariate and multivariable Logistic regression method were applied to preliminary screen the influence factors of suicide attempt. Because linear relationship is the main apply condication of the Logistic regression, so it is necessary to determine whether there have the linear relationship between *LogitP* and each variable by scatter plot. The scatter plots indicated that there were approximate linear relations, so the Logistic regression method can be used to preliminary screen the influence factors.

Firstly, univariate Logistic regression was used to identify the influence factors. In the univariate Logistic regression, suicide attempt or not (1= Suicide Attempt, 0= Non-suicide Attempt) is the dependent variable and each variable is the independent variable. There were 34 variables were screened according to $\alpha = 0.10$, the detailed results have been showed and could be referenced in the published literature[22].

Secondly, Likelihood Ratio (LR) stepwise multivariable Logistic regression method was applied to further screen the influence factors after the regression diagnosis by SAS software. Table 2 shows the 12 variables in the optimal multivariable Logistic regression, and the χ^2 value of model test is 635.485 (P<0.001), Nagelkerke R^2 is 0.598.

Multivariate Logistic Regression study found that family history of suicide is the first important predictor (OR=4.146), mental problem (OR=3.876) is the second important risk factor to suicide attempt. Low education level, poor health, aspiration strain, hopelessness, impulsivity, depression are the risk factors for suicide attempt. Social support, coping skills, and healthy community are the protect factors for suicide attempt according to significant level (α=0.05).

In order to test the discriminant effect of the multivariate logistic regression model, different classification cutoff values were set, and the sensitivity (Se) and specificity (Sp) of the different threshold values were indicated by SPSS21.0 softwere. The result indicated that when the threshold values was set to 0.6 (Se=80.2%, Sp=83.8%, Total consistent rate π

=82.2% and Youden index =0.640) the discriminant effect was optimal. The receiver operating characteristic (ROC) curve was showed in Figure 1.

BP Neural Network Prediction Model for Suicide Attempt

Artificial Neural Network (ANN) is a newly statistical method, as an Artificial Intelligence Technology (AIT), which imitate the structure and function of biological human brain to establish mathematical or computational model. Artificial Neural Network (ANN) is an adaptive system [27, 28] consist of mess of neuron nodes, which deal with the information according to adjusting the internal relationship of large number of neuron connections. ANN has many unique characteristics over the traditional statistical methods and computer algorithms, such as good fault tolerance, highly non-linear, self-learning, self-organization, self-adaptability etc. These unique characteristics make ANN has a good application effect in associate memory, nonlinear mapping, classified recognition and optimization design [27]. The error Back Propagation Neural Network (BPNN) is the most widely used and relatively mature method of Artificial Neural Network (ANN). Back Propagation neural network was blossomed by Rumelhart and McCelland in 1986, which is a multi-layer feedforward network model trained according to the error reverse propagation algorithm[28]. In the current study, the 12 variables screened by multiple Logistic regression analysis were set as the input variables, and suicide attempt or not (1= Suicide Attempt, 0= Non-suicide Attempt) was set as the output variables. Because the construction of BP neural network is based on matrix operation, the missing values have obvious influence on matrix calculation, so further sorting data was carried out to delete the missing values of the database (N=870). The sample size of new sample database satisfies the requirement of neural network model construction.

Construction of BP Neural Network Structure

Although increase network layers can improve accuracy and reduce error, it leads to more complicated network and increase difficulty of network training. Therefore, the current study selected the typical three-layer BP neural network with one input layer, one hidden layer, and one output layer. In the structure of BP neural network, there were 12 variables in the input layer, 2 output neurons in the output layer, and 5~14 neurons in the hidden layer. The range of neurons number in the hidden layer were determined by $H = \sqrt{M + N} + \alpha$, α is the constant from 1 to 10, N is the number of input neurons, and M is the number of output neurons. Because the aim of the prediction model is distinguish the suicide attempt or not, which belong to pattern recognition, so hidden layer was set to S-type tangent function and output layer was set to S-type logarithmic function. The structure of BP neural network constructed was showed in Figure 2.

Training of BP Neural Network

Entered the "nnstart" command in the Matlab R2010b command window by the Graphical User Interfaces (GUI) of the Matlab R2010b software and started the neural network model toolbox procedure embedded in software. Click the button "Pattern Recognition Tool" to enter the classification pattern recognition interface. In the data selection interface, matrix database of influence factors X.mat file was imported as the input neures and matrix

database of outcome variable Y.mat file was imported as the output neures. The Matlab R2010b software randomizedly divided the database into difference group for difference porpose according to proportion, 70% sample as training sample, 15% as verification sample and 15% as test sample. Next, the core problem is to determine the number of hidden layer, because different hidden layer would result in different sensitivity (Se), specificity (Sp), positive predictive value (PV+), negative predictive value (PV-), total coincidence rate (π), and number of iterations. In the constructing of BP neural network structure process, the number range of hidder layer has been determined from 5 to14. Repetitious data simulation process and neural network model training were carried out through Matlab R2010b software under different number of hidden layers.

Comprehensivly considering data simulation process, results of neural network model training and main model evaluation indexes (such as PV+, PV-, π, number of iterations), which indicated that when the number of hidden layers neurons (N_{hidden}) is 8~10 the model evaluation were well. Model evaluation indexes with different number of hidden layer neurons showed in Table 3.

Because the initial value of weights coefficient (w)and threshold value (b) is a random number between −1 and 1 in the process of training model, different value of w and b would establish different learning process model. Repetitious data simulation processes were carried out by Matlab R2010b software to training model when the hidden layers neurons (N_{hidden}) is from 8–10 and the model predicted evaluation indexes were exhibited in Table 4. Theoretically, if the coincidence rate is higher, the number of iterations is lower and the network is conciser, the network model will be optimal BP neural network model. Comprehensively consider the total coincidence rate of training samples, verified samples, test samples, total samples and the PV+ and PV- of the total samples and number of iterations, Network 4 whose N_{hidden} =9 was the optimal BP neural network model of suicide attempt. The structure of the optimal BP neural network model, parameter settings and operation results parameters of the optimal BP neural network model was showed in Figure 3.

Input w1=net.iw { 1, 1 } command, Matlab R2010b software will output the weight coefficient (W_{ij}) of input layer unit and hidden layer unit. Input b1=net.b command, then the threshold value (b_1) between input layer and their hidden layer could be output. Input w2=net.lw { 2, 1 } command, then the weight coefficient (W_{jk}) of each output layer unit and hidden layer unit could be output. Input b2=net.b command, then the threshold value (b_2) between output layer and their hidden layer could be output [29, 30].

Verification and Evaluation of BP Neural Network

Matlab R2010b software drew the histogram of error (Error = Targets - Outputs). Most errors are concentrated around the Zero Error line, which indicated that most of the errors are small and the discriminant efficiency of BP neural network model was excellent. Meanwhile, the confusion matrixes were exported by the Matlab R2010b software, which were showed in Figure 4. The confusion matrixes showed the coincidence rate of each sample was above 80% and the total coincidence rate for all samples was 84.6%, which

manifested that the discrimination efficiency of the prediction model for suicide attempt was outstanding.

The receiver operating characteristic (ROC) curve of each data sample still was output by Matlab R2010b software, which was showed in Figure 5. The ROC curve demonstrates that the area under the curve of each sample was about 85% and the discrimination efficiency of the prediction model for suicide attempt was excellent.

Discussion

Although suicide rate has declined in China recently, it is still the main death cause to health and society. Literature indicated that attempted suicide is the high-risk population for suicide. So, it is an urgent and signifcant to screen predictin indicators and establish the predicting model for suicide attempt. Most of the previous literature researched based one aspect not based on synthesized perspective and hardly any literature recruited the Artificial Neural Network (ANN) as the statistical method to establish the predicting model for suicide attempt. Because the special characteristics of database for suicide attempt population and the incomparable advantage of BP neural network, the current study was carried out. BP neural network, as the most widely used and relatively mature method of Artificial Neural Network (ANN), can handle all kinds of complex fuzzy mapping relation and identify the complex nonlinear relationship between variables simulating human brain intelligently. Whether the database follow linear and normal distbution or not, the BP neural network have the ablility to maximum limited simulate arbitrary relation between the input and output variables.

Multivariate Logistic Regression study has got the risk and protective indicators of suicide attempt, the conclusion is consistent with the previous literature. The previous literature indicated that family history of suicide[31], mental problem[5, 32, 33], low education level[34], poor health, aspiration strain[35], hopelessness[36, 37], impulsivity[38–40], depression[41] are the risk factors for suicide attempt, the current study drew the similar conclution with previous literature. Corresponding previous measures such as carrying out the screening of high risk population of family history of suicide and mental disorders, improving education level and healthy, reducing the aspiration strain should be taken to prevent suicide attempts. When it comes to the protect indicators, the previous studies still have validated that social support [42–44], coping skills[25, 45, 46], and healthy community[47] are the protect factors. Reinforcing the social support and coping skills and cumunity surrounding are benefit to prevent suicide. Although the negative life events is not statistical significant in the model according to α=0.05, but previous study[48] has indicated that it still have the significant meaning for prevention of suicide attempt. Family history of suicide and the mental problem is the top two risk factors, which should pay more attention by the researchers. The previous measures are conform to the suicide prevention strategies of the previopus literature [4].

In the current study, the 12 variables screened by multiple Logistic regression analysis were set as the input variables and suicide attempt or not was set as the output variables. The

database was randomly divided into three parts, used to train, verificate and test model respectively.

Repetitious data simulation of model construction, model training, model verification and evaluation for BP neural network indicated that the Network 4 established in the current study, which with three-layer BP neural network and 9 neurons in hidden layer is the optimal BP neural network prediction model for suicide attempt. BP neural network verification and evaluation process indicated that the sensitivity, specificity, positive predictive value, negative predictive value, total coincidence rate of the optimal BP neural network prediction model is pretty well. The ROC curve and the confusion matrixes both demonstrated that the distinguish coincidence rate (π) for each samples was about 85% and the distinguish efficiency of the prediction model for suicide attempt was excellent. Compared with the traditional statistical methods such as multivariate Logistic regression carried out, whose sensitivity (Se =80.2%), specificity (Sp=83.8%), total coincidence rate (π =82.2%), Naglkerke R^2=0.598, the optimal BP neural network prediction model is superior in current study. The reason maybe the special advantages of Artificial Neural Network (ANN), which can simulate the working mechanism of cerebral neuron to identify the complex interactional, nonlinear relationship and specific distribution of the data is not required. Theoretically, the prdcication model with both high sensitivity and high specificity is the perfect model, but because the misdiagnosis of suicide attempt will result in the severe mental burden, so the selection strategy in the current study sacrificed sensitivity to increase specificity. Generally speaking, the BP neural network model established in carrent study with total coincidence rate (π =84.6%) has significance clinical meaning to screen the high-risk population of suicide attempt, which is an auxiliary clinical diagnostic tool for the clinical psychiatrist. The more meaningful application of current study is the website platform construction of consultation and prediction for suicide attempt by combining the predicting distinguish BP neural network with computer technology. Furthermore, the artificial intelligence expert assisted diagnosis system for suicide attempt can be designed basing on the current study, which is of great practical significance for the rapid screening of high-risk suicide population and the prevention of suicide.

The practical application of statistical method used in current study still indicated that Logistic regression and BP neural network has its own merit on establishing prediction model for suicide attempt. Logistic regression method has the advantages to filter the mess influencing factors quickly and the standardized regression coefficients of each factor and odd ratio value (OR) were obtained and easily to be compared directly and easy to be given the professional interpretation. Despite the BP neural network is inferior to Logistic regression on preliminary screening the mess factors, which is superior to Logistic regression on classification discrimination and data fitting accurately with high sensitivity and specificity. The combined use of BP neural network and Logistic regression can exploit their respective advantages fully and show good applicability on establishing prediction model. The Logistic regression method aims to reflect the correlation between diseases and causes, which is not suitable to predict diagnosis for single patient accurately. But BP neural network is established based on individual case database, which is more suitable for make high accurate prediction diagnosis for individual patient[49].

However, there are still several problems in the application process of BP neural network need to be solved furtherly. For example, there is no fixed model for the design of network only base on the professional knowledge and repetitive simulation. Althought the weight coefficient (W) and the threshold value (b1) were given by Matlab R2010b software; it is difficult to make epidemiological interpretation. How to deal with the mess input layer variables and the missing value in the application of BP neural network still need to be solved urgently.

Conclusions

Attempted suicide is a comprehensive result of many factors. In order to increase the predicting accuracy, the current study eatablished the prediction model base on multivariate Logistic regression and BP neural network and compared them.

Multivariate logistic regression study have filtrated the risk and protective indicators of suicide attempt. The screening of high risk population of family history of suicide and mental disorders, improving education level and healthy, reducing the aspiration strain, reinforcing social support and coping skills, optimizing cumunity surrounding are all benefit to prevent suicide attempt. The previous literature published recently still have elaborated the effective prevention measures[22] for suicide attempt.

The Logistic regression and BP neural network both show its own merit on establishing prediction model for suicide attempt in differente stage. Logistic regression method has the advantages to filter the mess influencing factors quickly in the preliminary stage, but BP neural network is superior on classification discrimination and data fitting accurately because the its incomparable characteristics, such as strong adaptability, high intelligence, good fault tolerance, flexible application and loose requirements on variables, etc and which is more suitable to make diagnosis for individual patient. The BP neural network established in current study with total coincidence rate (π =84.6%). From the current study the conclution can be draw that the BP neural network method is applicative, feasible, credible and good discriminative effect for suicide attempt. The BPNN model established in current study has significance clinical meaning to distinguish suicide attempt for the clinical psychiatrist and lay the theoretical foundation for the artificial intelligence expert assisted diagnosis system for suicide attempt in the future.

Limitations:

One limitation of the study is the narrow range of sampling. Future studies may be conducted in more diverse samples. Only the macroscopical influence factors were considered in current study, the microcosmic aspects such as gene, molecular aspects did not be considered in this study. The aim is to establish the common and general suicide attempt prediction model, so the situational conditions of suicide attempt did not be included in current study. Simplify deletion of missing data and the imperfect sensitivity may be the other limitation of the current study.

Appendix:

The computer programs of the optimal BPNN model with 9 hidden layers neurons.

```
% Solve a Pattern Recognition Problem with a Neural Network
% Script gexnerated by NPRTOOL
% Created Sun Feb 02 03:01:21 CST 2014
%
% This script assumes these variables are defined:
%
% X - input data.
% Y - target data.


inputs = X;
targets = Y;



% Create a Pattern Recognition Network
hiddenLayerSize = 9;
net = patternnet(hiddenLayerSize);

% Setup Division of Data for Training, Validation, Testing
net.divideParam.trainRatio = 70/100;
net.divideParam.valRatio = 15/100;
net.divideParam.testRatio = 15/100;



% Train the Network
[net,tr] = train(net,inputs,targets);



% Test the Network
outputs = net(inputs);
```

```
errors = gsubtract(targets,outputs);
performance = perform(net,targets,outputs)



% View the Network
view(net)



% Plots
% Uncomment these lines to enable various plots.
%figure, plotperform(tr)
%figure, plottrainstate(tr)
%figure, plotconfusion(targets,outputs)
%figure, ploterrhist(errors)
```

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Highlights

- The current study based spacious visual angle and provides a fire-new theoretical reference for searching the predictor of the attempted suicide. The current study handpicked 12 variables eventually, which greatly simplify the predictor system of the attempted suicide.

- This study established the suicide attempt prediction model basing on BP neural network. Most previous literature established the prediction model by traditional prediction methods such as Logistic regression, which always ignored the application condition of the methods and always resulted in inaccurate results or larger prediction bias. The BP neural network, maximum simulates human brain intelligently, could deal with arbitrary nonlinear relation between variables. It has many incomparable advantages on complex model fitting and distribution approximation over the traditional statistical methods. The current study indicated that BP neural network improve the prediction accuracy compare with the traditional prediction.

- The BP neural network established in current study has significance clinical meaning to distinguish suicide attempt for the clinical psychiatrist and lay theoretical foundation for artificial intelligence expert assisted diagnosis system for suicide attempt in the future.
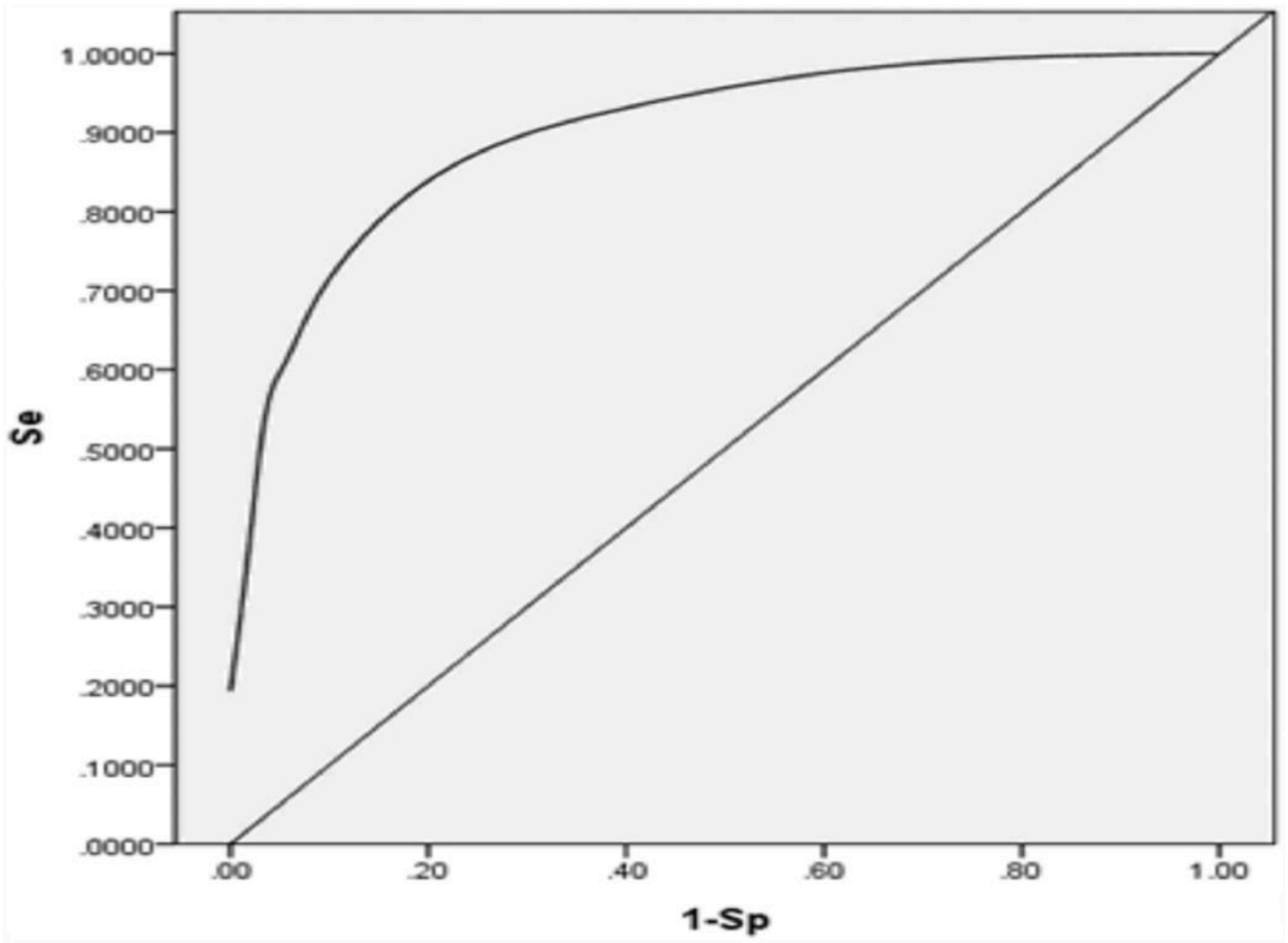
Figure 1.
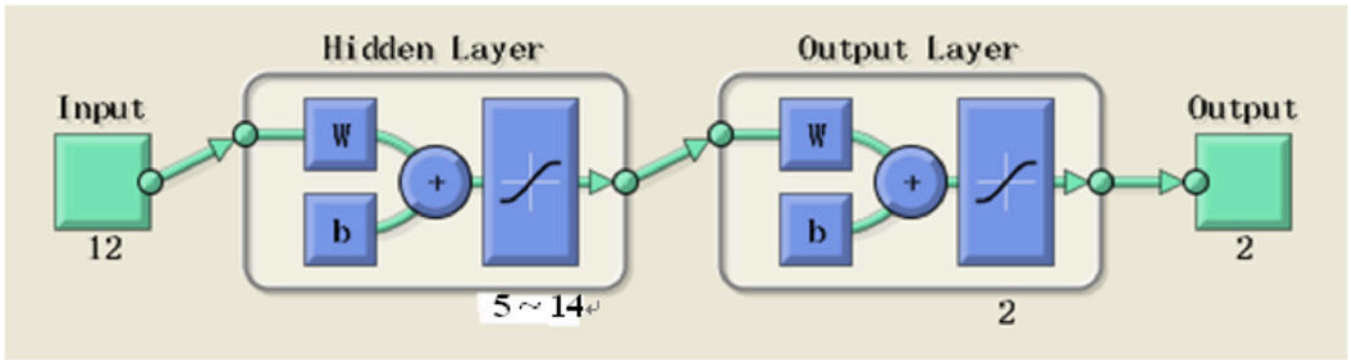ROC Curve of Multivariate Logistic Regression Model
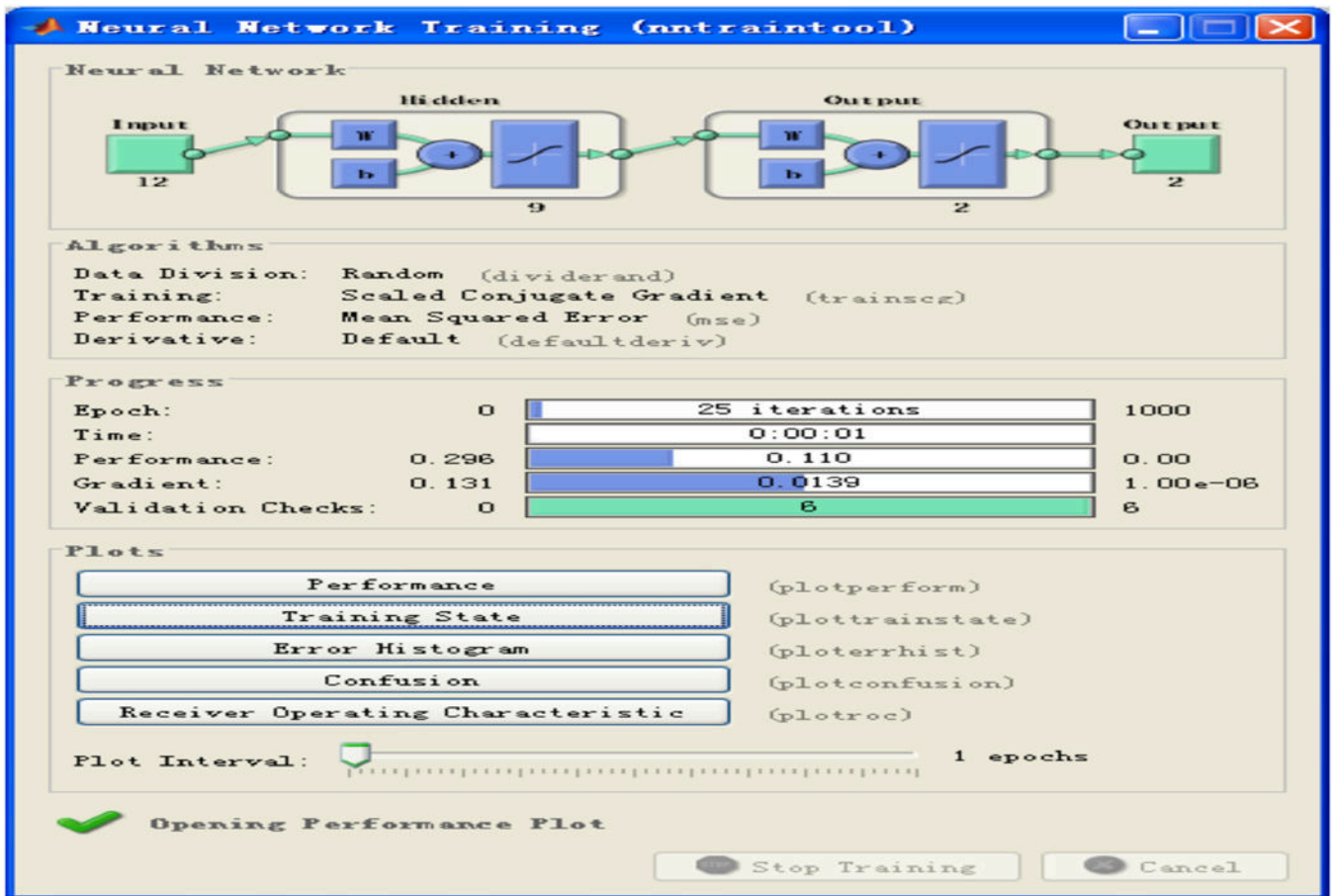
Figure 2.
Structure of BP Neural Network

Figure 3.
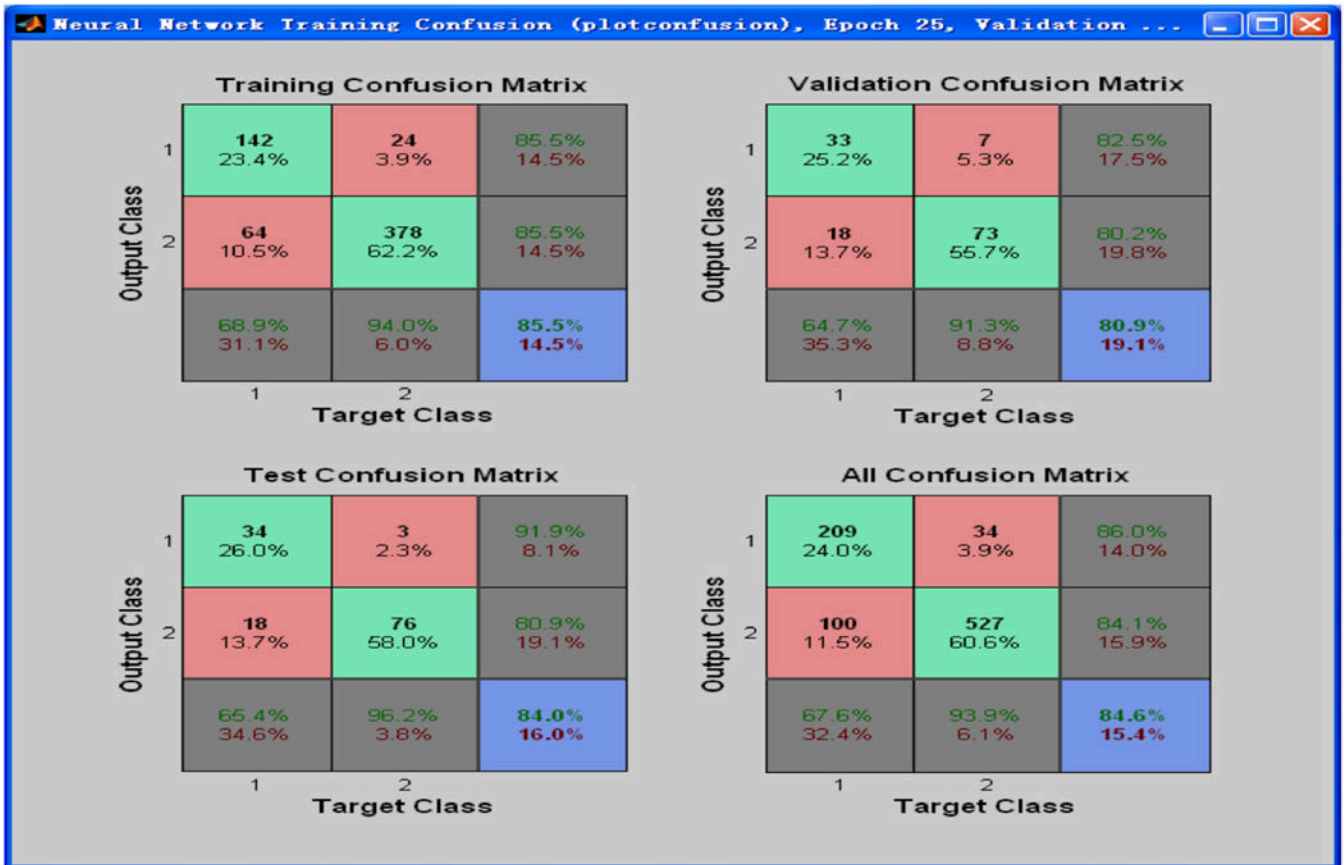Structure and the Parameter Settings of the Optimal BP Neural Network Model

Figure 4.
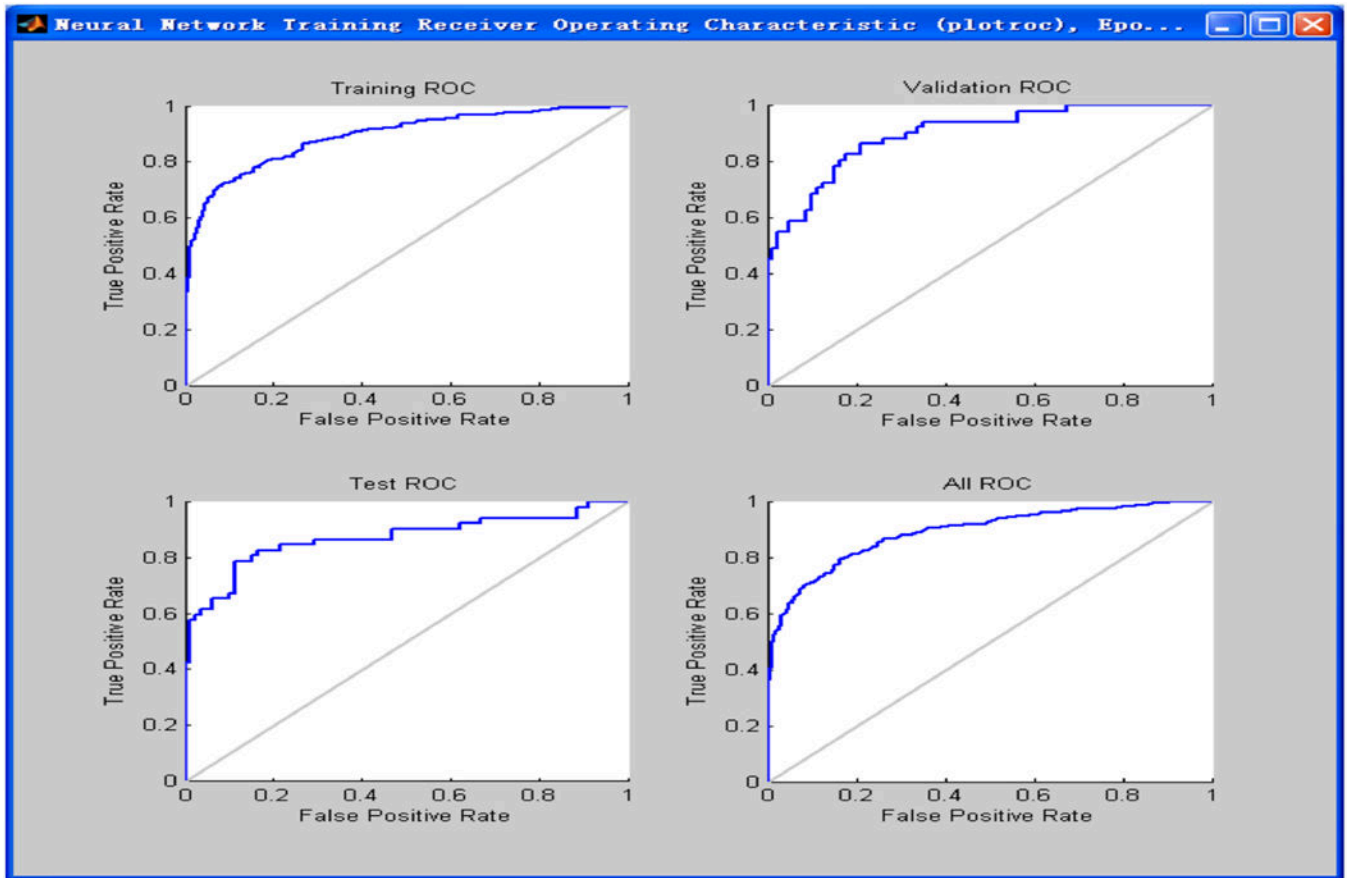Confusion matrixes of the BP neural network model

Figure 5.
ROC Curve of Each Sample for Optimal BP Neural Network Model

Table 1

Demographic Description of the Samples

| Variables | N (%) / $\overline{X} \pm SD$ | | Statistic | P value |
	Case group (N=659)	Control group (N=659)	χ^2 / t	
Age	31.62±8.09	31.81±8.11	−0.442	0.659
Gender			0.003	0.955
Female (0)	410 (62.2%)	409 (62.1%)		
Male (1)	249 (37.8%)	250 (37.9%)		
Education Level			70.691	**<0.001**
Primary or below (1)	342 (51.9%)	206 (31.3%)		
Middle school (2)	309 (46.9%)	412 (62.5%)		
College or above (3)	8 (1.2%)	41 (6.2%)		
Marital Status			2.210	0.137
Never married (0)	105 (15.9%)	86 (13.1%)		
Ever married (1)	554 (84.1%)	573 (86.9%)		

Table2

Multivariate Logistic Regression for the Suicide Attempt (Sle =0.05, Sls=0.10)

Variables	Standard B	95% CI	OR	P
Education Level	−0.582	0.408–0.766	0.559	**<0.001**
Family History of Suicide	1.422	1.693–10.152	4.146	**0.002**
Health Status	−0.417	0.477–0.911	0.659	**0.012**
Mental Problem	1.355	1.198–12.540	3.876	**0.024**
Aspiration Strain	0.025	1.021–1.031	1.026	**<0.001**
Hopelessness	0.044	1.028–1.062	1.045	**<0.001**
Impulsivity	0.087	1.047–1.136	1.091	**<0.001**
Depression	0.094	1.070–1.127	1.098	**<0.001**
NLEs[#]	0.009	0.999–1.019	1.009	0.075
Social Support	−0.055	0.918–0.976	0.947	**<0.001**
Coping Skills	−0.020	0.970–0.991	0.980	**<0.001**
Community Environment	−0.051	0.923–0.978	0.950	**<0.001**
Nagelkerke R^2	0.598			

[#]Notes: indicates Negative Life Event Score.

Table 3

Predicted Evaluation Indexes with Different Hidden Layers Neurons

N_{Hidden}	Se	Sp	1- Sp	PV+	PV−	π	Number of iterations
8	68.6%	92.5%	0.075	83.5%	83.3%	84.0%	45
9	67.0%	93.4%	0.066	84.8%	83.7%	84.0%	22
10	68.9%	91.3%	0.087	81.3%	84.2%	83.3%	32

Table 4

Model predicted evaluation indexes with different initial value of weights ^{w} and b

| Network | N_{hidden} | π | | | Total sample | | | | | Number of iterations |
		Training samples	Verified samples	Test samples	Se	Sp	PV+	PV-	π	
Network 1	8	84.0%	84.0%	84. 0%	68.6%	92.5%	83.5%	84.7%	84.0%	45
Network 2	8	84.4%	87.0%	81.7%	67.6%	93.6%	85.3%	84.0%	84.4%	35
Network 3	9	85.2%	84.7%	77.9%	67.0%	93.4%	84.8%	83.7%	84.0%	22
Network 4	9	**85.5%**	**80.9%**	**84.0%**	**67.6%**	**93.9%**	**86.0%**	**84.1%**	**84.6%**	**25**
Network 5	10	83.9%	86.3%	83.2%	66.7%	93.8%	85.5%	83.6%	84.1%	34
Network 6	10	85.4%	84.0%	79.4%	66.7%	93.9%	85.8%	83.7%	84.3%	44