

Predicting If Mental Health Facilities Will Offer Free Treatment to Patients

Who Cannot Afford It

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ABSTRACT

There is a growing recognition that mental health is a vital public health and development issue worldwide. Considerable studies have reported that there are close interactions between poverty and mental illness. The association between mental illness and poverty is cyclic and negative. Impoverished people are generally more prone to mental illness and are less capable to afford treatment. Likewise, people with mental health problems are more likely to be in poverty. The availability of free mental health treatment to people in poverty is critical to break this vicious cycle. Based on this hypothesis, a model was developed based on the responses provided by mental health facilities to a federally supported survey. We examined if we can predict whether the mental health facilities will offer free treatment to the patients who cannot afford treatment costs in the United States. About a third of the 9,076 mental health facilities who responded to the survey stated that they offer free treatment to the patients incapable of paying. Different machine learning algorithms and regression models were assessed to predict correctly which facility would offer treatment at no cost. Using a neural network model in conjunction with a decision tree for input variable selection, we found that the best performing model can predict the mental health facilities with an overall accuracy of 71.49%. Sensitivity and specificity of the selected neural network model was 82.96 and 56.57% respectively. The top five most important covariates that explained the model's predictive power are: ownership of mental health facilities, whether facilities provide a sliding fee scale, the type of facility, whether facilities provide mental health treatment service in Spanish, and whether facilities offer smoking cessation services.

INTRODUCTION

The quality of mental health and income are highly interrelated and interact in a complex negative cycle. Poverty is a multidimensional phenomenon that adversely alienates physical and mental health, and results in deprivation of education and other basic needs¹. The inverse relationship between income level and risk of disease is a ubiquitous and persistent observation in public health². Poverty increases the risk of mental ill-health and mental illness escalates the likelihood of plunging into poverty³. People in poverty have been observed to have two times more mental health disorders than their counterparts⁴. People in poverty are in dearth of financial resources for basic needs that limits their opportunities to education. Without education they have less opportunities of employment. With less opportunities of employment they are more likely to be exposed to adverse living environments and be less access to required healthcare. Evidence shows people in low-income groups have 1.5 to two times more prevalence of depression than general population⁴. Those who live in deprived condition with lowest levels of education and unemployment have highest level of mental disorders¹. The effects of poverty and poor mental health spill over into the society as surge in crime rates, family disruption, frustration, stress, and homicides⁵.

The bitter truth is poor people are more prone to mental illness but they cannot afford the treatment of their mental illness. Mental illness prevents them from having better education and descent employment, which further plunges them into more poverty. To break this vicious cycle, providing free of cost mental health services to poor people is vital. But due to the fragmented healthcare system, poor people in the United States are not receiving free mental health treatment from government. Most of time mental patients who go to mental health facilities to obtain the services are turned away because of their inability

to pay. However, some facilities still accept and treat such patients at free of cost. It will be interesting and important to identify the driving factors that enable those facilities. Determining the factors that enable mental health facilities to provide free treatment services will help policy makers to focus on increasing those factors. As a result, people in poverty will receive better mental health treatment that ultimately can help them to escape from such a vicious cycle.

This study aims to develop a model for evaluating and determining significant covariates that can predict whether the mental health facilities will offer treatment at no cost to the patients incapable of affording the treatment cost in the United States. Along with this aim, this study will examine the spatial variation on the percentage of offering treatment by mental health facilities free of cost to these patients with number of uninsured population at state level.

LITERATURE REVIEW

There is growing recognition that mental health is a crucial public health and development issue worldwide. According to World Health Report 2001, major depression is the leading cause of disability globally and ranks fourth in the ten leading causes of the global burden of disease. It was estimated to rank second in 2020⁷. Mental and behavioral disorders have a large impact on individuals, families and communities. Individuals suffer the distressing symptoms, as well as not being able to work or shoulder their responsibilities towards family and friends. About one in four families has at least one member currently suffering from a mental or behavioral disorder⁷. In addition, addressing depression in women of child-bearing age is important for improving maternal health, and reducing child mortality. Babies of depressed mothers are five times more likely to be underweight or stunted than babies of non-depressed mothers^{8, 9}. Considerable research has been conducted on the relationship between mental health and poverty. For example, researchers have found that people experiencing hunger, facing debts or living in poor and overcrowded housing are more likely to suffer from common mental disorders^{4, 10}, which indicates there are close interactions between factors associated with poverty and mental illness. An analysis of 22 mental health consumers from residential care facility suggested that a failure to recognize poverty as a key mental health policy issue will continue to constrain efforts to facilitate consumer empowerment and social integration¹¹. Therefore, it will be crucial to break the vicious cycle between poverty and mental illness by providing free of cost mental health services to patients with low income.

METHOD

DATA COLLECTION

This study is a secondary analysis of data drawn from National Mental Health Services Survey (N-MHSS) by Substance Abuse and Mental Health Services Administration's (SAMSHA) in 2010. The survey was designed to capture all mental health treatment facilities across the United States and its territories. The survey excluded prisons, military or tribal facilities, and private or small group practices that do not have license to operate mental health clinic. The data were collected by mail questionnaire (24.4%), web-based survey (53.4%) and telephone interview (22.2%). The sample consisted of 16,197 mental health treatment facilities including 15,562 treatment facilities in the SAMSHA database⁶ and 635 facilities solicited from the Centers for Medicare and Medicaid Services and other professional agencies. A total 4011 treatment centers were excluded because they were ineligible or already closed at the time of survey that made survey sample down to total of 12,186. The response rate was 91.2% yielding total sample population to 11,118. After additional inspection, 744 treatment centers were found ineligible or duplicates and removed resulting a final sample of 10,374⁶.

This study examines the subset of treatment facilities that had responded to question "Does this facility offer treatment at no charge to clients/patients who cannot afford to pay?"⁶ A total 1,298 (12.5%) facilities were removed from the analysis because their responses were unknown to this question that resulted total number of facilities to 9,076 for further analysis. The data of uninsured population at state level was obtained from Kaiser Foundation⁷.

DATA ANALYSIS

Descriptive statistics was assessed using nodes of Stat Explore, DMDB, and Multiplot in SAS Enterprise Miner Client 12.3 version. The target variable is binary with response of “yes” or “no”. Out of 236 input variables, 129 are interval, 83 are binary, one is unary, and 28 are nominal. The dataset was partitioned into training (70%) and validation (30%). Important variables were selected by variable selection node with default settings where any variables with more than 50% missing values were not selected. Among 22 selected variables, missing values of six interval variables were imputed by mean, and missing values of 12 class variables were imputed by mode. All skewed interval variables were transformed by transformation node using maximum normal option. Since the main goal of this project is to classify treatment facilities as correctly whether they accept low-income patients/clients at free of cost for all nodes, misclassification rate (validation data) was set as a model selection criterion. Various approaches were used to determine the best model with the least misclassification rate. Different models along with ensemble node were built to obtain the best model. We assessed the performance of different models by changing their relevant parameters. For example, neural net performance was boosted when default numbers of hidden units were increased from three to five. Neural network performed better than other methods. Figure 1 shows the nodes and their relation to assess the best model using SAS Enterprise Miner Client 12.3 version. Using SAS Bridge for ESRI, spatial distribution of percentage of treatment facilities which offer treatment at no charge to the patients who cannot afford along with total number of uninsured population at state level was revealed (Figure 2).

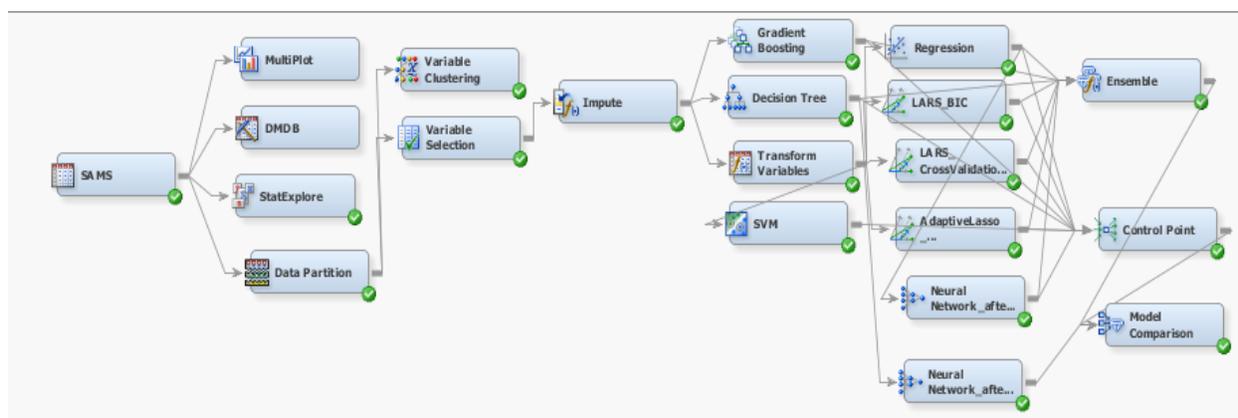


Figure 1. Diagram of SAS Enterprise Miner Project for Developing the Best Model

RESULT

Of total 9,076 facilities, 3,539 (34.11%) facilities were found to offer treatment at no charge to patients who were not able to pay. More than two thirds (66.9%) of facilities in this study samples were run by private non-profit organization. Massachusetts has the lowest prevalence of insured population (3.59%) whereas Texas has the highest (20.28%). The highest percentage of facilities that offer free treatment is in Delaware (85.00%), and lowest percentage is in Vermont (36.51%). Table 1 shows details of the distribution of facilities that offer treatment at no charge to the patients who cannot afford the treatment cost, and prevalence of uninsured population at state level.

Variables	Median (IQR)	Mean (95% CI)	Min/Max
Percentage of Facilities that Offer Free of Cost Treatment	62.12 (46.71, 77.53)	61.72 (58.32, 65.19)	36.51/85.00
Percentage of Insured Population	11.95 (6.39, 17.51)	12.19 (11.15, 13.23)	3.59/20.28

Table 1. Distribution of Facilities that Offer Free of Cost Treatment and Uninsured Population at State Level in the United States in 2010

The spatial distribution result shows that South and Southwest regions have higher percentage of population without insurance and more number of facilities that offer free of cost treatments to low-income patients than Northeast and Midwest regions. Figure 2 reveals the spatial distribution of both variables across the United States.

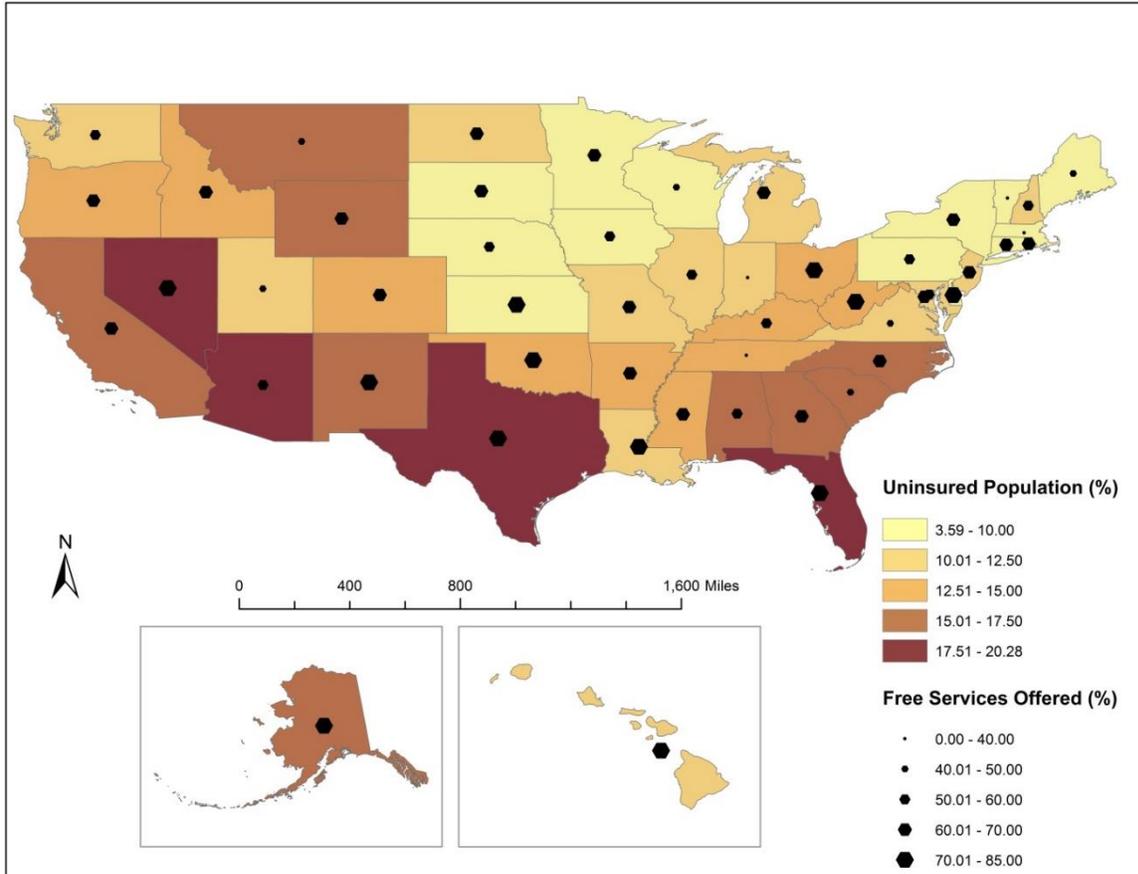


Figure 2. Percentage of Uninsured Population and Percentage of Facilities that Offer Free of Cost Treatment to Patients Who Cannot Afford at State Level of the United States in 2010

For descriptive analysis, we studied the percentage of no-charge service offers at 3 different aspects including facility ownership, facility major funding type, and facility operation type. The top 3 facilities that have the highest rate of offering no-charge services are the U.S. Department of Veterans Affairs, other state government, and State mental health agency (SMHA) as shown in Figure 3. Consistently, the top 3 major funding types that support facilities with the highest rate of offering no-charge services are the U.S. Department of Veterans Affairs funds, state mental health agency funds, and other public funds (Figure 4).

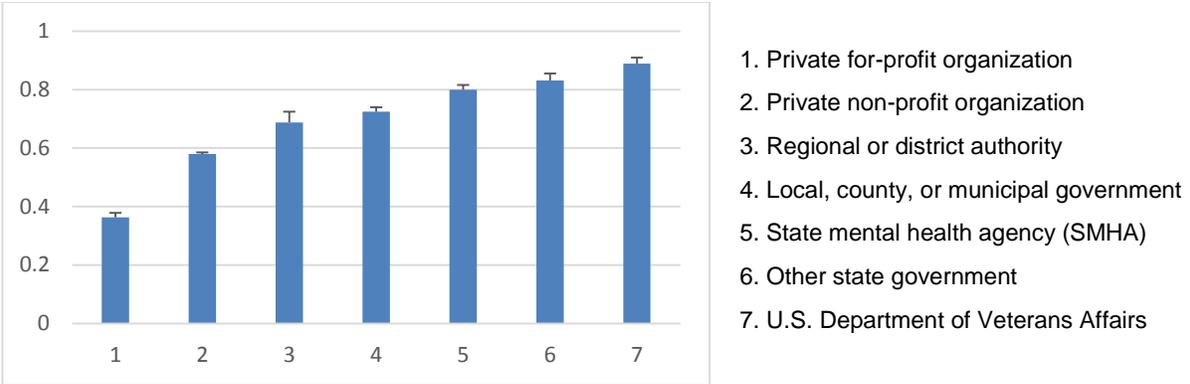


Figure 3. Percentage of Facilities Providing No-charge Service for Each Type of Ownership

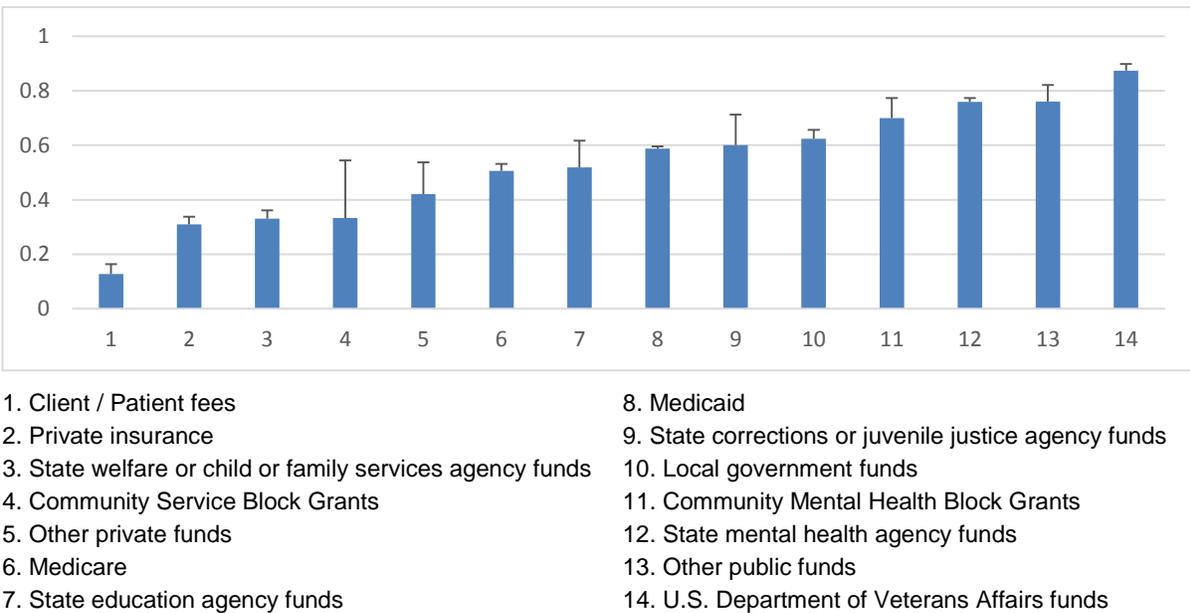
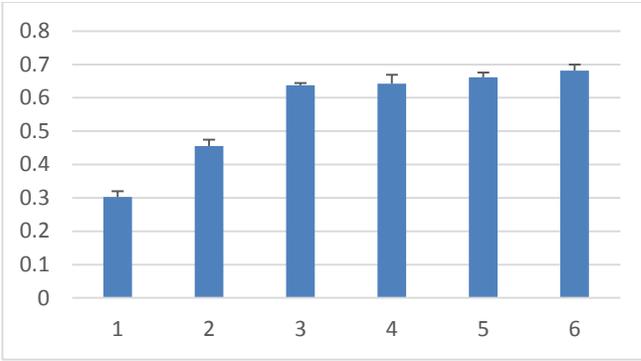


Figure 4. Percentage of Facilities Providing No-charge Service for Each Major Funding Type

The top 4 major funding types of facilities with the highest rate of offering no-charge services are: psychiatric hospital, separate inpatient psychiatric unit of a general hospital, multi-setting (non-hospital) mental health facility, and outpatient, day treatment or partial hospitalization mental health facility (Figure 5).



1. Residential treatment center for children
2. Residential treatment center for adults
3. Outpatient, day treatment or partial hospitalization mental health facility
4. Multi-setting (non-hospital) mental health facility
5. Separate inpatient psychiatric unit of a general hospital
6. Psychiatric Hospital

Figure 5. Percentage of Facilities Providing No-charge Service in Each Facility Type

We also have several other descriptive analysis findings: 1) among all facilities using sliding fee scale, 68.42% of facilities offer no-charge service. For facilities that do not use sliding fee scale, 47.92% offer no-charge service; 2) of the facilities providing smoking cessation services, 70.32% offer no-charge service. For facilities that do not provide smoking cessation services, 57.35% offer no-charge service; 3) All facilities that provide mental health treatment service in Spanish are able to offer no-charge service; 4) For facilities that accept state mental health agency funds (SMHA), 64.37% offer no-charge service. For facilities that do not accept SMHA, 50.26% offer no-charge service (figures not shown).

To reduce variable redundancy and irrelevancy, SAS Enterprise Miner Client 12.3 version was used for variable selection and model development. Among all 236 variables, 7 interval, 10 binary and 8 nominal variables have been selected by variable selection node (Figure 6).

Variable Name	Role ▲	Measurement Level	Type
CHILDADOL	Input	Binary	Numeric
COMPATIENTSCHED	Input	Binary	Numeric
CRISISTEAM	Input	Nominal	Numeric
FACILITYTYPE	Input	Nominal	Numeric
FEESCALE	Input	Binary	Numeric
FOSTERCARE	Input	Binary	Numeric
FUNDLOCALGOV	Input	Binary	Numeric
LANGSPANISH	Input	Binary	Numeric
LICENSEMEDICAID	Input	Binary	Numeric
LICENSEMEDICARE	Input	Binary	Numeric
MAJORFUNDTYPE	Input	Nominal	Numeric
MHEMGCCY	Input	Nominal	Numeric
MHHOUSING	Input	Nominal	Numeric
MODE	Input	Nominal	Numeric
OPACEPER017	Input	Interval	Numeric
OPETHERHISP	Input	Interval	Numeric
OPLEGALTOTVOL	Input	Interval	Numeric
OPRACEPERASIAN	Input	Interval	Numeric
OWNERSHIP	Input	Nominal	Numeric
PERCENTCP	Input	Interval	Numeric
PERCENTVA	Input	Interval	Numeric
SMOKINGCESSATION	Input	Binary	Numeric
SMOKINGPOLICY	Input	Nominal	Numeric
TREATFAMTHRPHY	Input	Interval	Numeric
TREATPSYCHOTHRPY	Input	Binary	Numeric

Figure 6. Variable selection

To determine the best model that can predict which treatment facility will offer treatment at no cost to patients, among all ten models, neural network after decision tree was found the best performing model based on the least misclassification rate of 28.51%. Details of the honest assessment of models are shown in Table 2. Neural model with five hidden layers and radial basis function based on the misclassification rate was selected.

Selected Model	Predecessor Node	Model Description	Target Variable	Selection Criterion: Valid: Misclassification Rate	Valid: Average Squared Error	Valid: Root Average Squared Error
Y	Neural2	Neural Network_after_DT	NOCHARGE	0.275064	0.191141	0.437196
	Ensmbl	Ensemble	NOCHARGE	0.279838	0.191675	0.437807
	Neural	Neural Network_after_Reg	NOCHARGE	0.287918	0.197656	0.444585
	LARS2	LARS_CrossValidation_5	NOCHARGE	0.295263	0.19675	0.443565
	LARS	LARS_BIC	NOCHARGE	0.296364	0.19683	0.443656
	Tree	Decision Tree	NOCHARGE	0.297466	0.200815	0.448124
	Reg	Regression	NOCHARGE	0.297833	0.197658	0.444587
	Boost	Gradient Boosting	NOCHARGE	0.298568	0.204103	0.451778
	SVM	SVM	NOCHARGE	0.334925	0.21926	0.468252
	LARS3	AdaptiveLasso_CrossValidation_5	NOCHARGE	0.396621	0.239313	0.489196

Table 2. Fit Statistics of All Models Predicting Whether a Facility will Offer Free Treatment to the Patients Who Cannot Afford

The Receivers Operating Curves (ROCs) of all ten models are illustrated in Figure 7. Neural network model has the best ROC index of 0.764 suggesting a strong model.

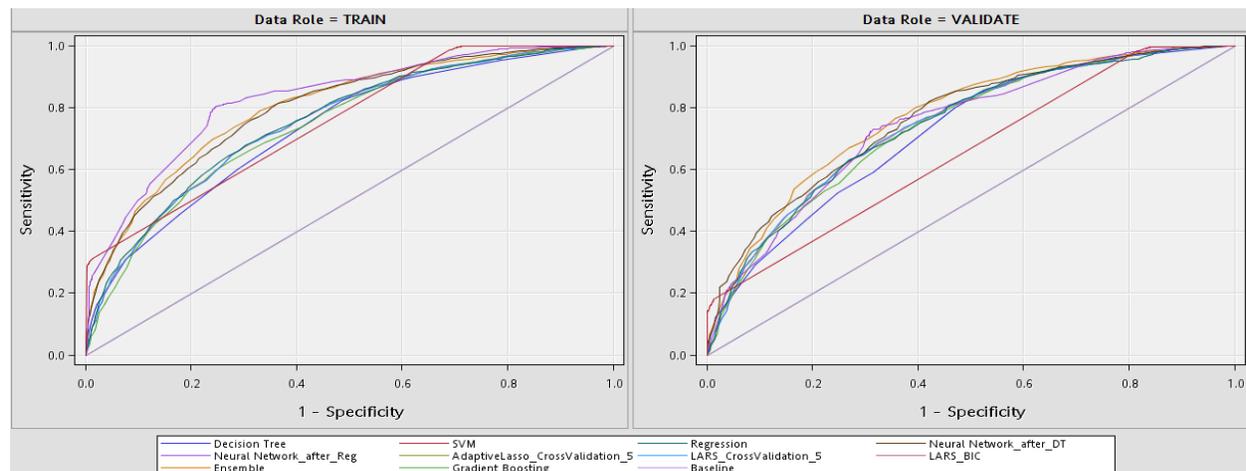


Figure 7. ROC Curves of All Ten Models Predicting Whether a Facility will Offer Free Treatment to the Patients Who Cannot Afford

The total accuracy of the elected logistic regression model is 72.49%, indicating the selected model can predict the treatment facility that offer treatment at no cost to patients about 72.49% correctly. Sensitivity of selected neural network model is 82.96%. Specificity of selected neural network model is 56.57%. It seems that model can predict true positives more correctly than true negatives. Moreover, positive predictive value of neural network model is 74.42%. It indicates when model predicts a treatment facility that offers free of cost service to patients who are unable to pay, about 75% of time the prediction will be correct.

The decision tree model ranks the top 3 most important variables are ownership, feescale and facility type (Figure 8).

Variable Name	Label	Number of Splitting Rules	Importance
OWNERSHIP	OWNERSHIP	3	1.0000
IMP_FEESCALE	Imputed: FEESCALE	1	0.8628
FACILITYTYPE	FACILITYTYPE	1	0.5661
IMP_LANGSPANISH	Imputed: LANGSPANISH	1	0.5264
IMP_SMOKINGCESSATION	Imputed: SMOKINGCESSATION	2	0.4800
IMP_OPLEGALTOTVOL	Imputed: OPLEGALTOTVOL	2	0.4634
IMP_MAJORFUNDTYPE	Imputed: MAJORFUNDTYPE	2	0.4298
IMP_TREATFAMTHRPY	Imputed: TREATFAMTHRPY	1	0.4262
IMP_LICENSEMEDICAID	Imputed: LICENSEMEDICAID	1	0.4108
IMP_MHHOUSING	Imputed: MHHOUSING	2	0.4041
IMP_FUNDLOCALGOV	Imputed: FUNDLOCALGOV	1	0.3301
IMP_SMOKINGPOLICY	Imputed: SMOKINGPOLICY	1	0.2338

Figure 9. Rank of Variable Importance

DISCUSSION/CONCLUSION

There is growing recognition that mental health is a vital public health and development issue worldwide. Depression is the leading cause of disability globally and ranks fourth in the ten leading causes of the global burden of disease⁷. Considerable studies have reported that there are close interactions between poverty and mental illness^{4, 10}. Providing no-charge treatment for mental illness patients who cannot afford the costs becomes a crucial step to break the vicious cycle between poverty and mental illness.

Only about one third of facilities in this survey sample offers free of cost treatment to patients who cannot afford that indicates large populations of people with mental health problems who cannot pay their treatment cost are not obtaining from majority of the treatment facilities. Similarly, the study of Patel and colleagues found that people in poverty lacking financial resources are less able to access essential health care and treatment⁴. To increase the access to free treatment for people in poverty, more non-profit organization should be financially sustainable to offer treatment at no cost since most of the free services are provided by private non-profit organizations. Supportive community cooperation and effective networks of public private partnership can assist to protect against the severe consequences of poverty and mental ill health². Spatial distribution analysis indicates that states mainly in the southern half of the United States have people without enough insurance coverage. Consistently, the negative relationship between socioeconomic status and optimum health is shown, as most population of the southern region of the U.S have less financial resources. Interestingly, among these states with less insurance coverage, the number of mental health facilities that offer free treatment to needy patients is higher. It suggests non-profit organizations might be focusing more to provide free services in the deprived population. However, it requires more research in smaller geographical units to avoid ecological fallacy since the study by Wolfgang Bielefeld found the opposite association indicating areas with high poverty had less supporting components with fewer financial resources¹³.

Our results from decision tree model shows that the top five most important variables that explained the model's predictive power are: ownership of facility, whether facility provides sliding fee scale, type of facility, whether facility provides mental health treatment service in Spanish, and whether facility offers smoking cession services. It provides more insight where to give more focus so that more facilities can offer free treatment to people who are not able to afford it. Several algorithms including regression, neural network, decision tree, and so on have been tried to develop a parsimonious and effective model. Based on the selection criterion of misclassification rate for validation data, the best model is neural network after decision tree. Its Roc index is 0.764, which suggests it is a strong model. The model also achieves reasonable overall accuracy and sensitivity is 71.49% and 82.96% respectively. However, the accuracy of the model is still not perfect, especially specificity of the model can be improved. Therefore, obtaining

more variables on policy, socio-economic indicators and location of mental health facilities in smaller geographic units can help to describe more about the model, as well as increasing prediction accuracy.

LIMITATIONS

The main limitation of this study is all data are recorded at point prevalence level since it is a cross-sectional study. Any causal inference cannot be made from the findings. All study is about facility not about patients. It is a voluntary survey and no adjustment for non-response rate of 8.8% has been made. Therefore, there is possibility of non-response bias.

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