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DESTINATION AFTER ENTERING FOSTER CARE:

ROAD TOWARD STABILITY

by

DONG YANG

Under the Direction of Gengsheng (Jeff) Qin

ABSTRACT

The duration of children stay in a temporary foster care system needs to be minimal in order to ensure a stable and successful life. However, a time-consuming procedure of investigations is usually taken to decide whether they can reunite with their birth parents. Moreover, if the child fails to reunite with their family, another discharge decision needs to be assessed, leading to even longer time without a normal life. Based on the data from Adoption and Foster Care Analysis and Reporting System (AFCARS), this thesis derives a prediction model to discriminate the children with a tendency of unsuccessful reunification from the rest. An alternative discharge option can therefore be prepared concurrently for the foster youth with high non-reunification probability. The model is obtained by logistic regression and evaluated with receiver operating characteristic (ROC) curve.

INDEX WORDS: Adoption, Discharge, Foster care, Logistic regression, Permanence placement, Reunification, ROC, Youden index

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ROAD TOWARD STABILITY

by

DONG YANG

A Thesis Submitted in Partial Fulfillment of the Requirements for the Degree of

Master of Science

in the College of Arts and Sciences

Georgia State University

2012

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2012

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ROAD TOWARD STABILITY

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1 INTRODUCTION

1.1 Background

Foster care system in the United States dates back to 1853, when the Children's Aid Society started the Orphan Train Movement aiming to help orphaned, abused or neglected children [1]. Modern foster care provides short-term care and supportive service to the children who are unable to stay at home. When placed in foster care system, children will receive appropriate care until a "permanency goal" is defined for them. This decision of long-term placement is referred to discharge.

In 2010, over 400, 000 children in the United States resided in some form of foster care, while more than 250, 000 children entered foster care system [2]. In Georgia, more than 6, 000 were removed from home and placed in foster care [3]. Eight major reasons that can cause a child to be removed by child welfare supervisors and placed in foster care are listed below (the detailed definition of each reason can be found in Adoption and Foster Care Analysis and Reporting System (AFCARS) file).

1 Parental neglect

2 Substance abuse

3 Inability to cope

4 Inadequate housing

5 Incarceration

6 Abandonment

7 Physical or sexual abuse

8 Child's behavior problem

After Children are removed from their original home, there are seven possible temporary placement options for the foster children as shown below:

1 Trial home visit

2 Pre-adoptive home

3 Foster family home, relative

4 Foster family home, non-relative

5 Group home or Institution

6 Supervised independent living

7 Runaway

All above except 'runaway' can be assigned by the state Division of Child and Family Services (DFCS). But not all of the placements are available to the children when they enter the foster care. 'Pre-adoptive home' and 'Trial home visit' are reserved for children already in care preparing to discharge. 'Supervised independent living' is only for the youth above age 18 (or should be) and 'runaway' is not a deliberate placement.

Figure 1.1.1 shows the proportion for each placement setting of Georgia in year 2011. 69 percent of the total children are placed in 'Foster family home, relative' and 'Foster family home, non-relative'. 19.35 percent of the children have already been reserved to discharge when entering foster care, so their placement settings are 'Pre-adoptive home' and 'Trial home visit'. It can also be seen that only a very small portion of them are placed In 'Supervised independent living'.

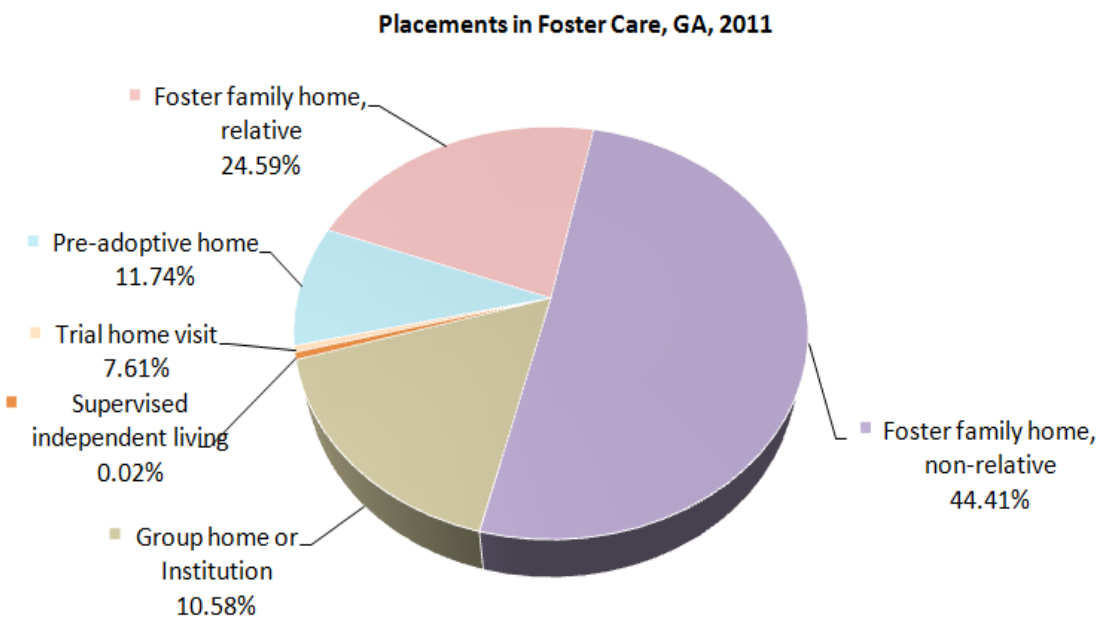


Figure 1.1.1 Pie Chart: Placements in Foster Care, GA, 2011

When the children are in foster care system, decisions will be made on their future for a long-term, stable family life. There are eight possible options for this permanency planning (discharge):

1 Reunification with parent or primary caretaker

2 Adoption by other relatives

3 Adoption by non-relatives

4 Guardianship

5 Emancipation

6 Transfer to another agency

7 Runaway

8 Death of child

Among these options, 'Emancipation', 'Transfer to another agency', 'Runaway' and 'Death of child' are undesired, which cannot be accepted by the children welfare administrations. For the rest of the discharges, the most ideal one is the 'Reunification', as it is widely believed that this is the best in-

terest of the foster youths to stay with their birth parents if possible. Also, children who fail to unite with a permanent family of some kind are less likely to enjoy success in life, as measured by high school and college degrees, homelessness, and other indicators [4]. Therefore, 'Reunification' after foster care is receiving increasing attention in the field of child and family welfare [5]. Most states encourage efforts to provide the birth parents with support and needed services (e.g. mental health or drug/alcohol treatment, parent skills, training and assistance with child care and/or adequate housing) so that their children can be safely returned to them.

However, there are still many cases where the children are not assigned to return home. If a child is not assigned to return to his/her birth parents, the parental rights will be terminated. When the parental rights are terminated by the court, most states will try to place children with their relatives (kinship foster care or relative placement) which may lead to an adoption by the relatives. And if adoption by the relatives is not available for them, adoption procedure will be taken for non-relatives.

In the year of 2011, approximately 5,000 children were discharged from the foster care in Georgia. 46.11 percent of them rejoined with their family (Figure 1.1.2), while 35.65 percentage was adopted by relative and non-relative family. 6.17 percent of foster children's discharge is 'Guardianship'.

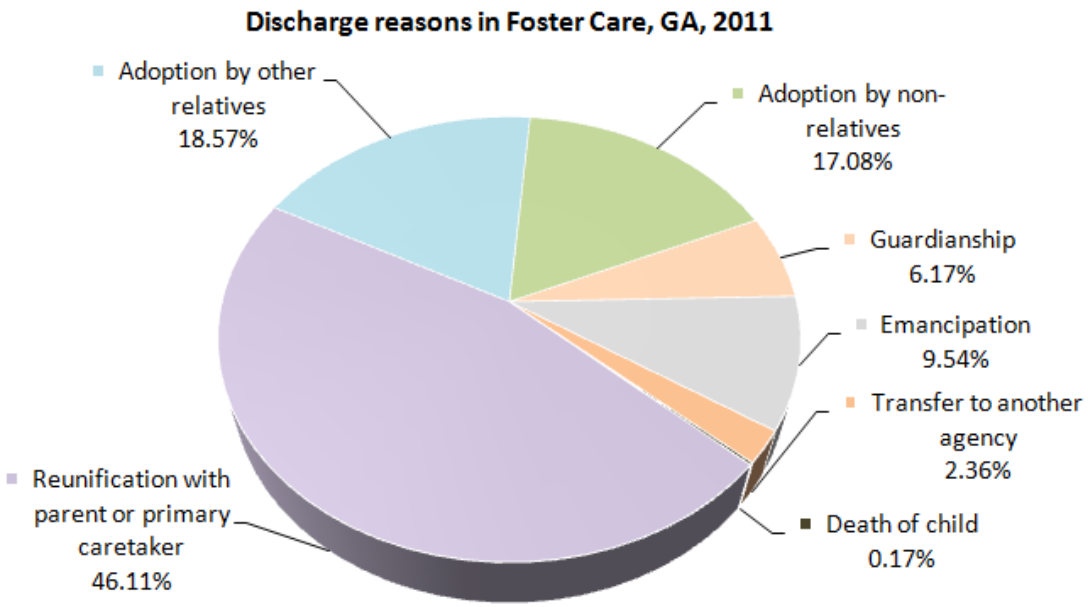
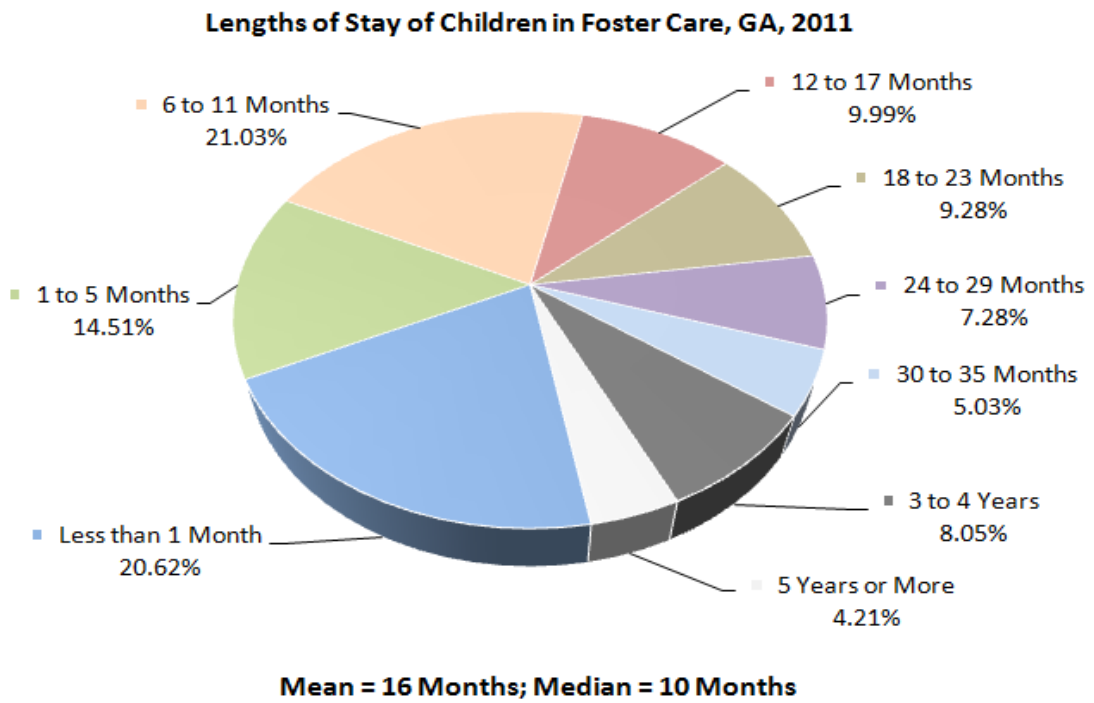


Figure 1.1.2 Pie Chart: Discharge Reasons in Foster Care, GA, 2011

All the above process conducted by the Children and Family Service Agency is to provide a stable and healthy life for foster children. Particularly, the purpose of discharge is to make sure that the children will be under proper care. Whatever the foster children's future permanency is, the priority for foster care service is to provide a stable family life as quickly as possible after the children are removed from home. The longer unstable short-term care the foster children experience, the more risk these children's future life would take [6].

In the year of 2011, the foster children in Georgia had on average 16 months length of stay in the foster care systems. Figure 1.1.3 shows an overall proportion of length staying in foster care of Georgia in year 2011. It can be seen that 56.16 percent of them stay in the foster care no more than 1 year, 20.62 of which is shorter than 1 month, 21.03 of which is from half a year to one year. And 24.57 percent of foster children spend more than one year and less than 2 years in the foster care. It is therefore clear that currently most children stay in the foster care for quite a long time and there is a need to reduce this duration.



Fiigure 1.1.3 Pie Chart: Lengths of Stay in Foster Care, GA, 2011

1.2 Purpose of the study

The most ideal discharge for foster children is reunification. However, not all of them can reunite with their family for certain reasons. Hence, a time-consuming procedure of investigations will be taken to decide whether the children can reunite with their birth parents. Moreover, if the child fails to reunite with their family, another discharge decision needs to be assessed, which would taken additional time and result in longer duration in the foster care of the child without a normal family life.

In order to minimize the time of this decision-making process, a statistical model is needed to discriminate the children with a tendency of unsuccessful reunification from the rest. Once they are properly targeted, an alternative discharge option can be evaluated and prepared concurrently. This will thus prevent the children from staying in the foster care system for an unnecessarily long period of time.

The aim of this study is to derive such a model based on the population including those end up with 'Reunification with parents or caretakers', 'Adoption by other relatives', ' Adoption by non-relatives' and 'Guardianship'. All the other discharge options are excluded because they are either undesired or out of control. For the population of interest, the children with 'Reunification with parents or caretakers' are considered as 'reunification', while all those with 'Adoption by other relatives', 'Adoption by non-relatives' and 'Guardianship' are grouped as 'non-reunification'.

2 METHODS

2.1 Data Source

The Adoption and Foster Care Analysis and Reporting System (AFCARS) provides the data including all states, as well as Puerto Rico and the District of Columbia. This thesis focused on the state of Georgia, years from 2008 to 2011. The whole data is divided into two parts: those from year 2010 to 2011 are used for modeling, while those from year 2008 and 2009 are used for the evaluation of the model.

The AFCARS data is distributed by the National Data Archive on Child Abuse and Neglect (NDACAN) with a total of 66 variables in the data. The first 15 variables are the demographic information, such as gender, birth date, race, and disability status, etc. The rest of the variables are foster care episode information including date and reason for removal from home, placement setting on foster care, caretaker's information, discharge date and type, and date of termination of parental rights (TPR) if applicable.

2.2 Data Cleaning

The data is firstly filtered by the reasons of discharge. As mentioned above, the prediction model is conducted only with the population as 'Reunification with parent or primary caretaker', 'Adoption

by other relatives', 'Adoption by non-relatives' or 'Guardianship'. The rest 'Emancipation', 'Transfer to another agency', 'Runaway', or 'Death of child' are not desired.

Not all the 66 variables in the data are considered to build the relationship with dependent variable ('reunification', 'non-reunification'). As is shown in Appendix B, only 15 variables need to be considered when the logistic model is built. The demographic information related variables are gender, birth date, race, and disability status, etc. Other auxiliary variables are reason for removal from home, placement setting on foster care, principal caretaker family structure, and federal aid, etc. The AFCARS data is cleaned such that all the missing or non-meaningful data are excluded. Same procedure is done for the interested variables. After cleaning the data, the population is reduced from 23079 to 15884 in the years from 2008 to 2011.

2.3 Logistic Regression

The objective of this model is to predict the probability of two outcomes – reunification and non-reunification. The method used here is logistic regression, which is part of generalized linear regression but works specifically for the cases when the dependent variable is dichotomous [7] [8].The expression of the probability is typically written as the equation shown below, where *P* is the probability of an event, *e* is the base of the natural logarithm, and α and β are the parameters of the model. It can be seen that the value of *P* varies between 0 and 1 for all possible values of the independent variable *x*. *P/(1-P)* is called the odds ratio, and *In(P/(1-P))* is the logit. Unlike the least-squares method for linear regression, the best-fitting formula is obtained by the maximum-likelihood method, a computing-intensive algorithm performed by R program in this work.

$$P = \frac{e^{\alpha+\beta x}}{1+e^{\alpha+\beta x}}$$

In this thesis, the case of reunification is denoted by 1 and non-reunification is 0. *P* is the probability of reunification. The logit function is shown below, where x_1 to x_n are the n independent variables

taken into account in the study. Note that some of the independent variables like 'age' are continuous, while others are categorical such as 'gender'.

$$In(\frac{P}{1-P}) = \alpha + \beta_1 x_1 + \beta_2 x_2 + \beta_3 x_3 + \beta_4 x_4 + ... + \beta_n x_n + \varepsilon$$

2.4 Receiver Operating Characteristic (ROC) Curve

In this study, the receiver operating characteristic (ROC) curve method is adopted, which has been widely used in diagnostic medicine [9]. The ROC curve provides a straightforward measure of the accuracy of model predictions which is represented by the sensitivity versus (1-specificity). During World War II, It was firstly introduced in the signal processing of radar signals to depict the tradeoff between the rates of hit and false alarm of enemy and friendly airplanes [10] [11]. In the early 1980s, the ROC analysis became popular and was adopted in the visualization of medical diagnostic system [12] [13]. Nowadays the ROC analysis is widely used in various applications [14].

In a medical diagnostic system, there are only two expected outcomes: 'disease' and 'non-disease'. And these anticipated outcomes are determined by a threshold *t* which can vary over a range of continuous values. If *T* is defined as the test outcome that indicates 'disease', and *D* is defined as the fact that the outcome is true, then the corresponding true and false positive fraction at the threshold *t* can be called *TPF* and *FPF*. It can also be written as $TPF=Pr(T=1|D=1)$; $FPF=Pr(T=1|D=0)$. In the medical field, TPF is also known as sensitivity, while *(1-FPF)* is known as specificity.

Assuming *F(.)* and *G(.)* are distribution functions for 'disease' and 'non-disease', respectively, the ROC curve is the plot of *1-F(t)* Vs. *1-G(t)* $(-\infty < t < +\infty)$. Particularly, at the level *p*= (1-specificity), the ROC curve can be represented as:

$$R(p)=1-F(G^{-1}(1-p)), \qquad 0<p<1$$

where *p* is also *FPF*, G^{-1} is the inverse function of *G(.)*

It is obvious that the ROC curve is a monotonically increasing function as shown below.

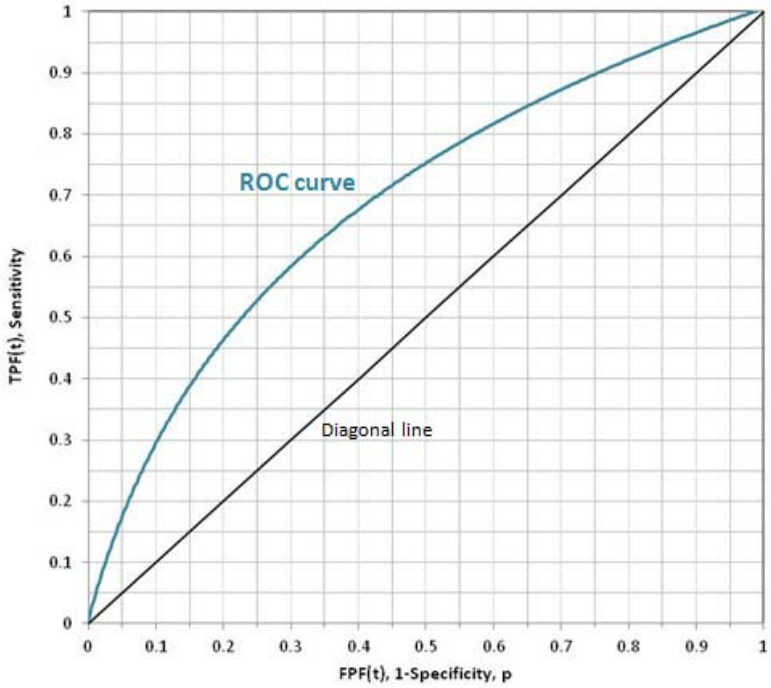


Figure 2.4 ROC curve

The areas under the ROC (AUC) curve can provide a common summary statistic for the power of a predictor in a binary discrimination. Specially, if the AUC is 1, the model for the binary discrimination is perfect. If the AUC is 0.5, the model has no power for the discrimination analysis. As the AUC increases from 0.5 to 1, the ROC curve leaves the diagonal line toward the upper left-hand corner, meaning the model is more powerful.

2.5 Statistical Analysis

All the statistical analyses are performed with the software platform R 2.10.1 for Windows.

Univariate analysis is firstly carried out for the selected variables listed in Appendix B. The significance and direction of the relationship between the dependent variable, in this case the discharge outcomes ('reunification' and 'non-reunification'), and each independent variable are investigated. In the univariate analysis, the continuous variables are reported as mean ± SD (standard deviation), whereas

the categorical variables are described as the number and percentage of subjects with the characteristic of interest. By using *non-parametric test,* the comparisons between groups of continuous variables are explored [15] [16]. Meanwhile, the categorical variables are compared between groups using *chi-square test*. As a second testing procedure, a multivariate analysis is conducted which assumes that the dependent variable is influenced by all the variables of the model simultaneously. The significant effects are selected by multivariate analysis. These effects could provide a simple understanding of which variable influence the discharge outcome. The significance level is set at 0.01 for all tests.

After having a general idea of these 15 selected variables, logistic regression is used because the impact of a set of independent variables on a dependent categorical variable with two categories ('reunification' and 'non-reunification') is supposed to be assessed. In the logistic regression, 1 denotes 'reunification' and 0 means 'non-reunification' [17]. All interactions of the main effects are also added to the model, such as the interaction between race and disability status, gender and disability status, or race and removal reasons, etc. A stepwise logistic regression (Backward Wald) [18] is used to independently identify significant factors in predicting discharge status after univariate analyses have been performed. The significance level for the stepwise logistic regression is specified at 0.05. The significant dependent variables are chosen at this significant level including all main effects and interaction effects. If the interaction effect is significant, the involved main effects will also be included in the logistic predict model even the main effects itself is not significant. Meanwhile, the multivariate analysis is also conducted to ensure that all effects in the model have influence on dependent variables. In this procedure the main effect will be kept if it is included in the significant interaction effect, no matter whether it is significant by itself.

In addition, receiver operating characteristic (ROC) curve is produced to assess the discrimination for the prediction model and the areas under the ROC curves (AUC) are estimated. The discrimination power, defined as the ability of the model to discriminate between 'reunification' and 'non-

reunification' discharges, is assessed by evaluating the ROC curve. The closer the ROC curve is to the upper left-hand corner of the graph, the more accurate the result is considered because the true-reunification rate is 1 and the false-reunification rate is 0 [19] [20]. This situation results in an AUC of 1. The diagonal line (i.e. reference line) in the graph indicates no discrimination. The diagonal line shows the result would be generated purely by chance, such as 50 percent guessing to 'reunification' and 50 percent guessing to 'non-reunification'. Overall, an AUC of 1 indicates a perfect discrimination between 'reunification' and 'non-reunification' in the validation set, whereas an AUC of 0.5 (close to the diagonal line) indicates no predictive capability.

ROC curve generally shows the predictive power of the model built by the stepwise logistic regression. But in the logistic regression the cut-off point of separation of the 'reunification' from 'non-reunification' needs to be chosen properly. The logistic model provides the probability of the observation's potential 'reunification' discharge outcome. A cut-off point is chosen to set as a reference level for the probability of reunification. If the probability of reunification is higher than the cut-off point then this observation is decided to be 'reunification'. Otherwise, the observation is predicted as 'non-reunification'. The optimal cut-off point for this predicting model is identified as the score leading to the best Youden index (maximum [sensitivity + specificity -1]) [21]. After ROC curve analysis the estimate of AUC is computed. Sensitivity, specificity, positive predictive values (PPVs), and negative predictive values (NPVs) are then calculated at the optimal cut-off values for the assessment of the decision. This information also documents the performance of the predictive model. For example, sensitivity will provide the power in 'reunification' prediction and specificity can show the ability in 'non-reunification' prediction. The performance of the model with the corresponding optimal cut-off point for this predicting procedure is evaluated. The accuracy of the 'non-reunification' is more interested because the children welfare system prefers to arrange these foster children with a stable family life as soon as possible. Therefore, a high specificity is expected in the overall model performance.

After the model for the discrimination between 'reunification' and 'non-reunification' is built, a validation check is conducted. By using different year data the model is tested for its capability of predicting the discharge outcome. The simulated model outcomes are compared to the real discharge destination. Then the true-reunification prediction ratio and true-non-reunification prediction ratio are obtained. This information can prove the ability of this logistic model in predicting the discharge outcomes. Finally, the validation check is conducted. The results of the validation check are expected to be as same as the performance of the model building, which can prove the stability and the accuracy of the prediction model.

3 RESULTS

3.1 Model based on two years data

The logistic model for predicting 'reunification' and 'non-reunification' is firstly built by data from year 2010 and 2011. Then the validation check for this model is conducted by the data from 2008 and 2009.

3.1.1 Univariate and logistic regression analysis of children with respect to discharge outcomes

As listed in Table 3.1.1a, the mean age of all children is 6.67 ± 5.15 years, and 51% of these children are male. The most common underlying removal reason is 'Neglect' (72.24%). About half of the total population suffers from disability, among which the most contributor is emotional disturbed. The population for reunification is 3337 (53.36%). The mean age of 'reunification' population is 7.50 ± 5.25, which is older than the mean age of the whole population. The most common underlying removal reason is 'neglect' which is as same as the whole population. Other performances of the 'reunification' population are almost the same as those of the all population. The proportion of the children whose race are Black is around 43.54 percent of all population and 45.43 percent of 'reunification' population.

‘Neglect’ consists 70.54 percent in the reasons of removal from home for ‘reunification’ population, while this number is 72.24 percent for the whole population. For the ‘non-reunification’ population, all the characteristics are as same as those of the whole population except the age. The mean age is younger in ‘non-reunification’ population than the whole population. The ‘reunification’ population has the largest mean age.

The main effects of independent variables are investigated. By choosing 0.01 as the significant level, the variables having influence on the outcome of discharge decisions are studied. The major variables under investigation are: Gender, Age, Race, Child Hispanic Origin, Number of Placement setting on Foster care, Physically Disabled, Other Diagnosed Condition Disability, Physical Abuse, Alcohol Abuse, Drug Abuse, Child Behavior Problem, Parent Incarceration, Caretaker Inability to Cope, Relinquishment, Inadequate Housing, Caretaker Family Structure and Eligible for Federal Aid Indicator.

When the significant variables from the univariate analysis are obtained, they are then put into multivariate analysis, with interaction effects and quadratic effects taken into account. Several terms fit the stepwise logistic regression model and show statistical significance at 0.01 significant level. After using stepwise logistic to select the significant effects, a multivariate analysis is conducted. Then repeat a stepwise logistic selection until all the remaining variables in the model are significant. Results of the backward stepwise logistic regression analyses show that 26 terms meeting the model selection entry criteria (Table 3.1.1b)

Table 3.1.1a Univariate Analysis: 2010 & 2011 years data

Variable	All Children (n=6254)	Reunification (n=3337)	Non-reunification (n=2917)	*p*
Male, no. (%)	3194 (51.07)	1722 (51.60)	1472 (50.46)	<.0001
Age, mean ± SD (y)	6.67 ± 5.15	7.50 ± 5.25	5.71 ± 4.85	<.0001
Race, no. (%)				
Black	2723 (43.54)	1516 (45.43)	1207 (41.38)	0.0014
Other	278 (4.45)	119 (3.57)	159 (5.45)	0.0004
No. of Placement setting	2.42 ± 1.97	2.14 ± 1.86	2.74 ± 2.04	<.0001
Child Hispanic Origin, no. (%)	519 (8.30)	337 (10.10)	182 (6.24)	<.0001
Diagnosed Disability, no. (%)				
Mental Retardation	63 (1.01)	35 (1.05)	28 (0.96)	0.8223
Visually Or Hearing Impaired	54 (0.86)	29 (0.87)	25 (0.86)	0.9316
Physically Disabled	601 (9.61)	278 (8.33)	323 (11.07)	0.0003
Emotionally Disturbed	1915 (30.62)	995 (29.82)	920 (31.54)	0.1480
Other Diagnosed Condition	366 (5.85)	154 (4.61)	212 (7.27)	<.0001
Reason for Removal, no. (%)				
Physical Abuse	843 (13.48)	495 (14.83)	348 (11.93)	0.0009
Sexual Abuse	318 (5.08)	187 (5.60)	131 (4.49)	0.0523
Neglect	4518 (72.24)	2354 (70.54)	2162 (72.12)	0.0015
Alcohol Abuse	480 (7.68)	259 (7.76)	221 (7.58)	0.8205
Drug Abuse	1892 (30.25)	851 (25.59)	1041 (35.69)	<.0001
Child Behavior Problem	518 (8.28)	334 (10.01)	184 (6.31)	<.0001
Parent Incarceration	890 (9.81)	419 (12.56)	471 (16.15)	<.0001
Caretaker Inability To Cope	1149 (14.23)	568 (17.02)	581 (19.92)	0.0035
Abandonment	966 (15.45)	545 (16.33)	421 (14.43)	0.0415
Relinquishment	67 (1.07)	24 (0.72)	43 (1.47)	0.0056
Inadequate Housing	1476 (23.60)	665 (19.93)	811 (27.80)	<.0001
Caretaker Family Structure, no. (%)				
Unmarried couple	338 (5.40)	191 (5.72)	147 (5.04)	0.2552
Single female	4851 (77.57)	2505 (75.07)	2346 (80.43)	<.0001
Single male	707 (11.30)	236 (7.07)	122 (4.18)	<.0001
Not Eligible for Federal Aid	667 (10.67)	410 (12.29)	257 (8.81)	<.0001

Table 3.1.1b Logistic Regression Analysis: 2010 & 2011 years data

Variable	Estimation	*p*
(Intercept)	0.867	<.0001
Male	0.178	0.0142
Age	0.049	<.0001
Race		
Black	0.093	0.2018
Other	0.155	0.4224
Child Hispanic Origin, no. (%)	1.428	<.0001
No. of Placement Setting	-0.503	<.0001
No. of Placement Setting^2	0.021	<.0001
Diagnosed Disability, no. (%)		
Physically Disabled	-0.663	<.0001
Emotionally Disturbed	-0.212	0.0032
Other Diagnosed Condition	-1.227	<.0001
Reason for Removal, no. (%)		
Drug Abuse	-0.803	<.0001
Abandonment	-0.337	0.0064
Child Behavior Problem	0.267	0.0147
Parent Incarceration	-0.569	0.0003
Caretaker Inability To Cope	-0.460	<.0001
Relinquishment	-0.888	0.0014
Inadequate Housing	-0.177	0.0707
Caretaker Family Structure, no. (%)		
Single female	0.856	0.0011
Single male	0.293	0.0132
Not Eligible for Federal Aid	0.292	0.0013
Interaction		
Age & Place.No	0.009	0.0044
Age & Dis. Phy	0.049	0.0094
Age & Single. Male	-0.064	0.0077
Age & Incarce	-0.061	0.0001
Male & Race. Other	-0.786	0.0146
Male & Abu. Drug	0.286	0.0030
Male & Inhousing	-0.413	0.0013
Race. Black & Dis. Phy	0.427	0.0231
Race. Black & Abu. Drug	-0.308	0.0176
Culture. Spanish & Place. No	-0.182	0.0224
Culture Spanish & Single. Fe	-0.781	0.0026
Place. No & Dis. Other	0.224	<.0001
Place. No & Abu. Drug	0.133	0.0002
Place. No & Incarce	0.236	<.0001
Place. No & CaterInabi	0.934	0.0117
Place. No & Aband	0.091	0.0218
Place. No & Single. Fe	-0.117	0.0021
Dis. Emot & Inhousing	0.400	0.0051
Dis. Other & Abu. Drug	0.683	0.0069

3.1.2 ROC curve analysis based on the logistic regression

Figure 3.1.2 shows the ROC curve to evaluate the performance of the logistic regression model in this study. The AUC value for the logistic model on prediction of discharge is 0.7024 (95% CI 0.6896 to 0.7152) and is significantly larger than 0.5. The ROC curve below rises quickly from (0, 0), meaning that the model would predict most of the true 'reunification' with fewer false 'reunification'. This also indicates that the model would predict most of the true 'non-reunification' with fewer false 'non-reunification'. Since it is the 'non-reunification' outcomes that are more important, the overall level of sensitivity is accepted. The diagonal line represents the random case: the model predicts pure randomly, so the chance of a true 'reunification' is equal to that of a false 'reunification' at any given threshold. In other words, a diagonal line of ROC curve means that the model has no capability of prediction. The area under the ROC curves is larger than 0.7 indicating that the performance of the logistic model on predicting the discharge outcome is good.

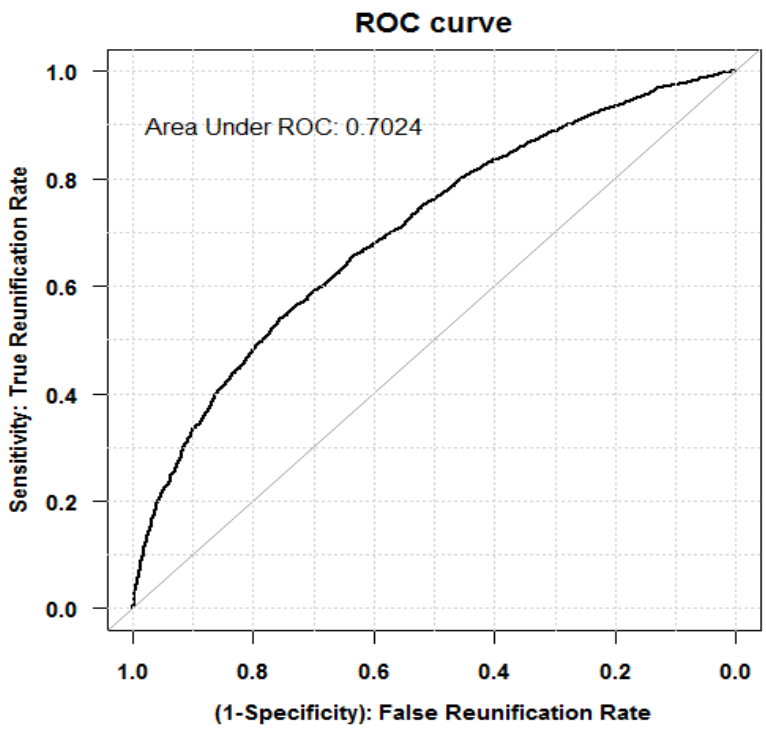


Figure 3.1.2 ROC Curve: Logistic Regression: 2010 & 2011 years data

3.1.3 Cut-off point selection of reunification probability

Using Youden Index, the optimal cut-off, which is associated with the maximized (sensitivity + specificity -1), leads to an estimate of the prediction of the discharge outcomes to be 0.582. Figure3.1.3 provides a visual understanding of the performance of the model. Form the figure 3.1.3, the model successful 'reunification' discrimination is 1801, and the accurate 'non-reunification' discrimination is 2204. 53.97 percent is chosen correctly for the 'reunification' discharge prediction. The percentage of correctly selection for the non-reunification discharge prediction is 75.56%. The total accurate prediction number is 4005, which is 64.04 percent of the whole population. Table 3.1.3 shows the sensitivity and specificity corresponding to the optimal cut-off point.

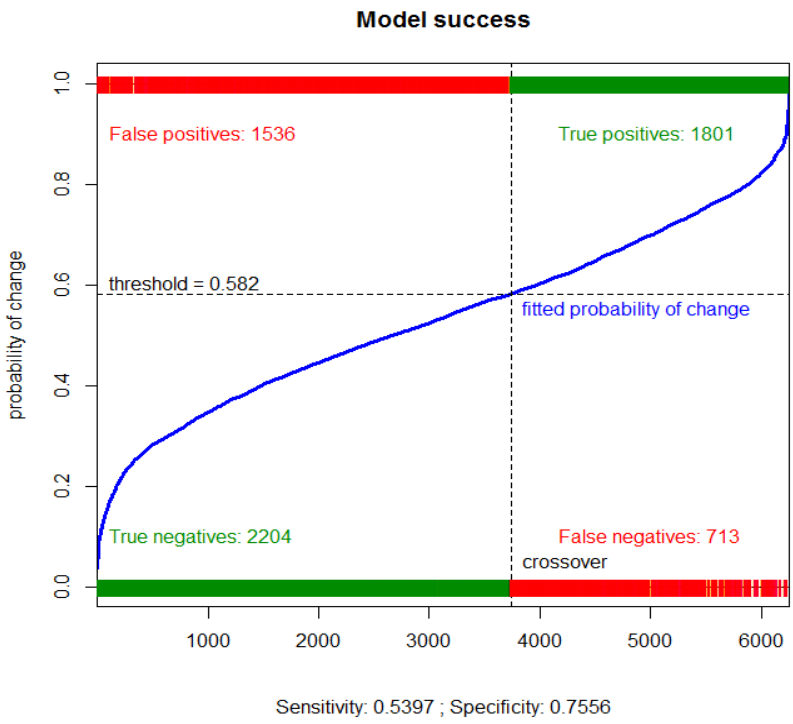


Figure 3.1.3 Model Success: 2010 & 2011 years data

By choosing the optimal cut-off point, the corresponding sensitivity is 0.5397 (95%CI is from 0.5226 to 0.5567) and the specificity is 0.7556 (95%CI is from 0.7396 to 0.7711). The specificity means

the model can successfully predict the true 'non-reunification' discharges at an accuracy of 75.56% (Table 3.1.3). The sensitivity shows that the model can successfully predict the true 'reunification' discharges at an accuracy of 53.97%. Comparing these results to the original data, if all the children are waiting for whether they should reunify with their parents, 46.64 percent of them would waste the time then get a 'non-reunification' discharge. By simulating the model, the accuracy for predicting 'non-reunification' discharge is increased to 75.56 percent from 50 percent of guessing. Then those children who are predicted with 'non-reunification' discharge can be arranged for adoption or other 'non-reunification' discharge. Therefore more children can receive proper and stable care as soon as possible.

Table 3.1.3 Sensitivity, Specificity, PPV, NPV corresponding to the optimal cut-off point: 2010 & 2011 years data

Terms	Estimation	**95% Confidence Interval**
sensitivity	0.5397	(0.5226, 0.5567)
specificity	0.7556	(0.7396, 0.7711)
PPV (positive predictive value)	0.7164	(0.6983, 0.7339)
NPV (negative predictive value)	0.5893	(0.5734, 0.6051)

3.1.4 Validation

The data from year 2008 and 2009 for Georgia is used for validation. As listed in the Table 3.1.4a, the mean age of the validation data for all the population is 6.61 ± 5.05. And 49.58% of these children are male. Same as the data of year 2010 and 2011, the most common underlying removal reason is Neglect (82.04%). About half of the total population suffers from disability, among which the most contributor is emotional disturbed. The population of reunification is 4790 (49.74%). The other characteristics are similar to the whole population. The main effects of these variables are firstly investigated.

By choosing 0.01 as the significant level, the variables having influence on the outcomes of the discharge decision are chosen to be Age, Number of Placement setting on Foster Care, Child Hispanic Origin, Physically Disable, Physical Abuse, Alcohol Abuse, Drug Abuse, Inadequate Housing, Caretaker Family Structure and Eligible for Federal Aid Indicator. They are not exactly the same as above. For instance, the percentage of 'other diagnosed condition' in the 'diagnosed disability' is around 5.85, 4.61 and 7.27 for 'all children', 'reunification' and 'non-reunification' in years 2010 and 2011, respectively. But they are around 10.60%, 10.08% and 11.12% for 'all children', 'reunification' and 'non-reunification' in the data of year 2008 and 2009, which increases by a factor of two. This also changes the significance of the other diagnosed conditions in the multivariate analysis. 'Physical abuse' as a reason of removal shows a similar phenomenon as well. However, these differences do not change the overall performance considerably.

Table 3.1.4a Univariate Analysis: 2008 & 2009 years data

Variable	All Children (n=9630)	Reunification (n=4790)	Non-reunification (n=4840)	*p*
Male, no. (%)	4775 (49.58)	2369 (49.46)	2406 (49.71)	0.3738
Age, mean ± SD (y)	6.61 ± 5.05	7.39 ± 5.16	5.83 ± 4.82	<.0001
Race, no. (%)				
Black	4486 (46.58)	2177 (45.45)	2309 (47.71)	0.0278
Other	350 (3.63)	156 (3.26)	194 (4.01)	0.0554
No. of Placement setting	2.64 ± 2.12	2.28 ± 1.93	3.00 ± 2.24	<.0001
Child Hispanic Origin, no. (%)	712 (7.39)	443 (9.25)	269 (5.56)	<.0001
Diagnosed Disability, no. (%)				
Mental Retardation	63 (2.25)	91 (1.90)	126 (2.60)	0.0240
Visually Or Hearing Impaired	54 (0.72)	25 (0.52)	44 (0.91)	0.0331
Physically Disabled	601 (3.96)	145 (3.03)	236 (4.88)	<.0001
Emotionally Disturbed	1915 (23.39)	1086 (22.67)	1166 (24.09)	0.1051
Other Diagnosed Condition	366 (10.60)	483 (10.08)	538 (11.12)	0.1070
Reason for Removal, no. (%)				
Physical Abuse	3797 (39.43)	1770 (36.95)	2027 (41.88)	<.0001
Sexual Abuse	437 (4.54)	244 (5.09)	193 (3.99)	0.0105
Neglect	7900 (82.04)	3808 (79.50)	4092 (84.55)	<.0001
Alcohol Abuse	514 (5.34)	253 (5.28)	261 (5.39)	0.8443
Drug Abuse	3033 (31.50)	1317 (27.49)	1716 (35.45)	<.0001
Child Behavior Problem	359 (3.73)	247 (5.16)	112 (2.31)	<.0001
Parent Incarceration	1066 (11.07)	542 (11.32)	524 (10.83)	0.4642
Caretaker Inability To Cope	1433 (14.88)	702 (14.66)	731 (15.10)	0.5561
Abandonment	763 (7.92)	365 (7.62)	398 (8.22)	0.2901
Relinquishment	59 (0.61)	28 (0.58)	31 (0.64)	0.8250
Inadequate Housing	1935 (20.09)	907 (18.94)	1028 (21.24)	0.0052
Caretaker Family Structure, no. (%)				
Unmarried couple	1329 (13.80)	683 (14.26)	646 (13.35)	0.2050
Single female	7082 (73.54)	3477 (72.59)	3605 (74.48)	0.0371
Single male	452 (4.69)	255 (5.32)	197 (4.07)	0.0042
Not Eligible for Federal Aid	4082 (42.39)	2078 (43.38)	2004 (41.40)	0.0521

Table3.1.4b is the check of model accuracy. The true 'reunification' prediction is 53.63%, and the true 'non-reunification' prediction is 67.25%. The overall accuracy is 60.48%. The accuracy check indicates that the model built from year 2010 and 2011 performs very well.

Table 3.1.4b Diagnostic test of validation data: 2008 & 2009 years data

Terms	Reunification	Non-reunification
Predicted Reunification	2569	1585
Predicted Non-reunification	2221	3255

3.2 Model based on one year data

After the analysis of model built on two-year data is finished above, a model that is based on one year data is studied. In this section, the logistic model is obtained by the data of year 2011, and the validation check for this predictive model is conducted with the data of year 2010.

3.2.1 Univariate and logistic regression analysis of children with respect to discharge outcomes

The univariate analysis is also firstly conducted and can provide general information of the one-year data. The mean age of all children is 6.62 ± 5.12 years, and 52.25 percent of these children are male (Table 3.2.1a). The most common underlying removal reason is also 'neglect' (66.68%) which is as same as the two-year data in model building. About half of the total population suffers from disability, among which the most contributor is emotional disturbed. This result is also as same as the two-year data. But, the 'other diagnosed condition disability' reduces to 1.51%, 0.94% and 2.19% comparing to two-year data which are 5.85%, 4.61% and 7.27% for 'all children', 'reunification' and 'non-reunification', respectively. The population for 'reunification' is 1482 (54.56%). The mean age of reunification is 7.45 ± 5.20, which is older than the mean age of the whole population. The most common underlying removal reason is neglect as same as the whole population. And the other performances of reunification are also same as the whole population performance. For the 'non-reunification', all the characteristics are the

same as those of the whole population except the age. The main effects of the independent variables are investigated. By choosing 0.01 as the significant level, the variables having influence on the outcomes of discharge decision are selected to be Gender, Age, Race, Child Hispanic Origin, Number of Placement setting on Foster care, Other Diagnosed Condition Disability, Physical Abuse, Neglect, Parent Incarceration, Relinquishment, Inadequate Housing and Caretaker Family Structure. Note that this is simpler than the previous model built upon the two-year data.

Similar to above procedure, the significant variables are selected and shown in Table 3.2.1b. After using stepwise logistic to select the significant effects, a multivariate analysis is conducted. Finally, for the one-year data, there are 25 terms in the predictive logistic model including main and interaction effects. Compared with the two-year predictive model that has 40 terms, the one-year model is simpler and easier to compute.

Table 3.2.1a Univariate Analysis: 2011 year data

Variable	All Children (n=2716)	Reunification (n=1482)	Non-reunification (n=1234)	*p*
Male, no. (%)	1419 (52.25)	2798 (53.85)	621 (50.32)	<.0001
Age, mean ± SD (y)	6.62 ± 5.12	7.45 ± 5.20	5.63 ± 4.84	<.0001
Race, no. (%)				
Black	1112 (40.94)	661 (44.60)	451 (36.55)	<.0001
Other	111 (4.09)	40 (2.70)	71 (5.75)	<.0001
No. of Placement setting	2.29 ± 1.82	2.00 ± 1.73	2.65 ± 1.86	<.0001
Child Hispanic Origin, no. (%)	242 (8.91)	169 (11.40)	73 (5.92)	<.0001
Diagnosed Disability, no. (%)				
Mental Retardation	23 (1.01)	16 (1.08)	7 (0.57)	0.2147
Visually Or Hearing Impaired	25 (0.85)	13 (0.88)	12 (0.97)	0.9545
Physically Disabled	425 (15.65)	201 (13.56)	224 (15.15)	0.0013
Emotionally Disturbed	962 (35.42)	518 (34.95)	444 (35.98)	0.6049
Other Diagnosed Condition	41 (1.51)	14 (0.94)	27 (2.19)	0.0129
Reason for Removal, no. (%)				
Physical Abuse	3357 (13.14)	234 (15.79)	2123 (9.97)	<.0001
Sexual Abuse	142 (5.23)	82 (5.53)	60 (4.86)	0.4868
Neglect	1811 (66.68)	937 (63.23)	874 (70.83)	<.0001
Alcohol Abuse	181 (6.66)	102 (6.88)	79 (6.40)	0.6724
Drug Abuse	772 (28.42)	327 (22.06)	445 (36.06)	<.0001
Child Behavior Problem	232 (8.54)	153 (10.32)	79 (6.40)	0.0004
Parent Incarceration	354 (13.03)	179 (12.08)	175 (14.18)	0.1179
Caretaker Inability To Cope	527 (19.40)	276 (18.62)	251 (20.34)	0.2811
Abandonment	425 (15.65)	244 (16.46)	181 (14.67)	0.2187
Relinquishment	29 (1.07)	13 (0.88)	16 (1.30)	0.3835
Inadequate Housing	627 (23.09)	263 (17.75)	364 (29.50)	<.0001
Caretaker Family Structure, no. (%)				
Unmarried couple	1116 (4.27)	70 (4.72)	46 (3.73)	0.0001
Single female	1766 (65.02)	915 (61.74)	851 (68.96)	<.0001
Single male	133 (4.90)	98 (6.61)	35 (2.84)	0.2370
Not Eligible for Federal Aid	259 (9.54)	157 (10.59)	102 (8.27)	0.0465

Table 3.2.1b Logistic Regression Analysis: 2011 year data

Variable	Estimation	*p*
(Intercept)	0.577	0.0056
Male	0.399	<.0001
Age	0.032	0.0424
Race		
Black	0.224	0.0241
Child Hispanic Origin, no. (%)	0.900	0.0088
No. of Placement Setting	-0.599	<.0001
No. of Placement Setting^2	0.032	<.0001
Diagnosed Disability, no. (%)		
Other Diagnosed Condition	0.392	0.5462
Reason for Removal, no. (%)		
Physical Abuse	0.521	0.0002
Neglect	0.007	0.9387
Parent Incarceration	-0.450	0.0040
Relinquishment	-2.683	0.0026
Inadequate Housing	-0.553	0.0053
Caretaker Family Structure, no. (%)		
Single female	0.379	0.0192
Single male	0.601	0.0066
Unmarried	-0.465	0.0976
Interaction		
Age & Place.No	0.015	0.0091
Age & Culture. Spanish	0.143	0.0005
Male & Inhousing	-0.532	0.0066
Race. Black & Incarceration	0.789	0.0029
Race. Black & Unmarried	1.201	0.0088
Culture. Spanish & Place. No	-0.504	0.0011
Place. No & Relinquishment	0.932	0.0045
Place. No & Single. Fe	-0.211	0.0002
Place. No & Inhousing	0.194	0.0021
Dis. Other & Abu. Drug	-1.822	0.0227

3.2.2 ROC curve analysis based on the logistic regression

Figure 3.2.2 shows the ROC curve to evaluate the performance of the logistic regression model in this study. The AUC value for the logistic model on prediction of discharge outcome is 0.7294 (95% CI 0.7106 to 0.7482) and is also much larger than 0.5. The area under the ROC curves is larger than 0.7 indicating that the performance of the logistic model on predicting the discharge outcome is good. Compared to the two-year predictive model, which is 0.7024 in AUC, the one-year model is better in the overall performance

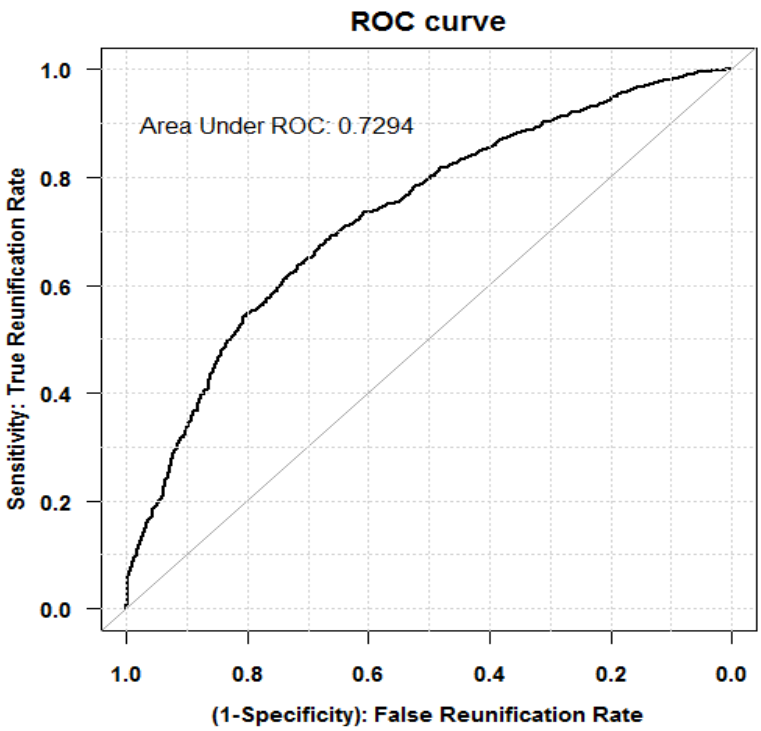


Figure 3.2.2 ROC Curve: Logistic Regression: 2011 year data

3.2.3 Cut-off point selection of reunification probability

The optimal cut-off point is also chosen according to the Youden Index and the value is 0.543 for discriminating the discharge outcomes ('reunification' versus 'non-reunification'). With 0.543 as the cut-

off point, the model's accurate 'reunification' discrimination is 1011, and the accurate 'non-reunification' discrimination is 829 (Figure3.2.3). 68.22 percent is chosen correctly for 'reunification' discharge prediction. On the other hand, 67.18 percent is selected properly for the 'non-reunification' discharge prediction. The total accurate prediction number is 1840, which is 67.75 percent of whole population. The table3.2.3 shows the sensitivity and specificity at the optimal cut-off point.

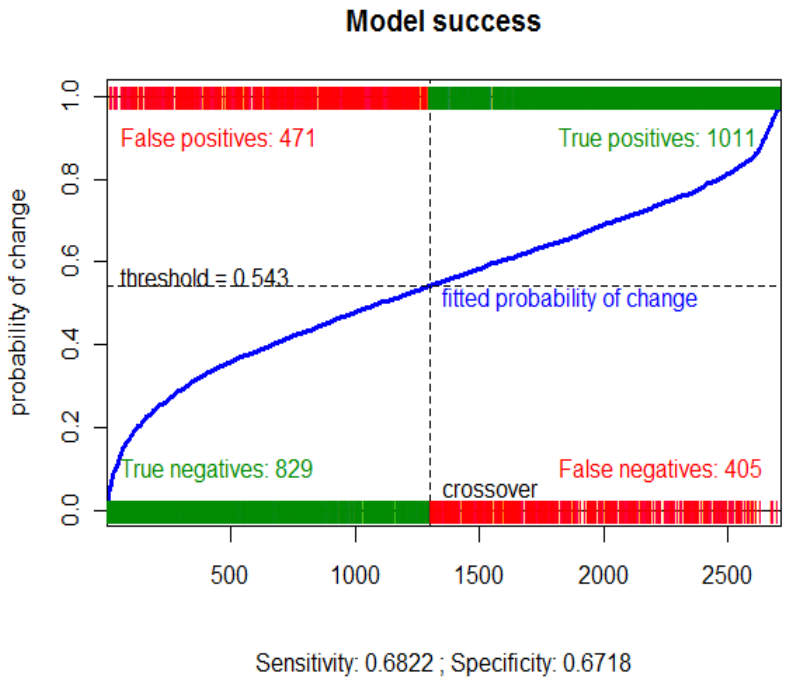


Figure 3.2.3 Model Success: 2011 year data

By choosing the optimal cut-off point, the corresponding sensitivity is 0.6822 (95%CI is 0.6578 to 0.7058) and the specificity is 0.6718 (95%CI is 0.6448 to 0.6910). The specificity shows the model can successfully predict the true 'non-reunification' discharges at an accuracy of 67.18% (Table 3.2.3). And the sensitivity shows that the model can successfully predict the true 'reunification' discharges at an accuracy of 68.22%. Compared to the two-year data, the sensitivity increases from 0.5397 to 0.6822, which is a huge improvement. But the specificity reduces to 0.6718 from 0.7556. Since the cut-off points are different in these two models, it is hard to simply say which model is better than the other.

Table 3.2.3 Sensitivity, Specificity, PPV, NPV corresponding to the optimal cut-off point: 2011 year data

Terms	Estimation	95% Confidence Interval
sensitivity	0.6822	(0.6578, 0.7058)
specificity	0.6718	(0.6448, 0.6980)
PPV (positive predictive value)	0.7140	(0.6897, 0.7374)
NPV (negative predictive value)	0.6377	(0.6109, 0.6639)

3.2.4 Validation

The data from year 2010 for Georgia is used for validation to check the one-year data predictive model. As listed in Table 3.2.4a, the mean age of the validation data for all children is 6.69 ± 5.15 years. And 50.17% of these children are male. The most common underlying removal reason is Neglect (76.51%).Over half of them do not suffer from disability, and the most disability is emotional disturbed. The population of 'reunification' is 1855 (52.43%). Except the other diagnosed condition disability, the other characters are similar to one-year model building data. The main effects of these variables are investigated. By choosing 0.01 as the significant level, the variables having influence on the outcomes of the discharge decision are chosen (Age, Number of Placement setting on Foster Care, Child Hispanic Origin, Other Diagnosed Disability Condition, Drug Abuse, Child Behavior Problem, Parent Incarceration, Caretaker Inability to Cope, Reliquishment, Inadequate Housing, Caretaker Family Structure and Eligible for Federal Aid Indicator), which are mostly the same as above in the one-year model building.

Table 3.2.4 a Univariate Analysis: 2010 year data

Variable	All Children (n=3538)	Reunification (n=1855)	Non-reunification (n=1683)	*p*
Male, no. (%)	1775 (50.17)	924 (49.81)	851 (50.56)	0.2748
Age, mean ± SD (y)	6.69 ± 5.16	7.54 ± 5.29	5.77 ± 4.86	<.0001
Race, no. (%)				
Black	1611 (45.53)	855 (46.09)	756 (44.92)	<.0001
Other	167 (4.72)	79 (4.26)	88 (5.23)	<.0001
No. of Placement setting	2.52 ± 2.07	2260 ± 1.95	2.81 ± 2.17	<.0001
Child Hispanic Origin, no. (%)	277 (7.83)	168 (9.06)	109 (6.48)	<.0001
Diagnosed Disability, no. (%)				
Mental Retardation	40 (1.13)	19 (1.02)	21 (1.24)	0.2147
Visually Or Hearing Impaired	29 (1.10)	16 (0.86)	13 (0.77)	0.9545
Physically Disabled	176 (4.97)	77 (4.15)	99 (5.88)	0.0013
Emotionally Disturbed	953 (26.94)	477 (25.71)	476 (35.98)	0.6049
Other Diagnosed Condition	325 (9.19)	140 (7.55)	185 (8.28)	0.0129
Reason for Removal, no. (%)				
Physical Abuse	3486 (13.74)	261 (14.07)	225 (13.37)	0.5781
Sexual Abuse	176 (4.97)	105 (5.66)	71 (4.22)	0.0584
Neglect	2707 (76.51)	1417 (76.39)	1290 (76.65)	0.8863
Alcohol Abuse	299 (8.45)	157 (8.46)	142 (8.44)	0.9741
Drug Abuse	1120 (31.66)	524 (28.25)	596 (35.41)	<.0001
Child Behavior Problem	286 (8.08)	181 (9.76)	105 (6.24)	0.0002
Parent Incarceration	536 (15.15)	240 (12.94)	296 (17.59)	0.0001
Caretaker Inability To Cope	622 (17.58)	292 (15.74)	330 (19.61)	0.0029
Abandonment	541 (15.29)	301 (16.23)	240 (14.26)	0.1150
Relinquishment	38 (1.07)	11 (0.59)	27(1.60)	0.0059
Inadequate Housing	849 (24.00)	402 (21.67)	447 (26.56)	0.0008
Caretaker Family Structure, no. (%)				
Unmarried couple	222 (6.27)	121 (6.52)	101 (6.00)	0.5689
Single female	3085 (87.20)	1590 (85.71)	1495 (88.83)	0.0065
Single male	225 (6.36)	138 (7.44)	87 (5.17)	0.0071
Not Eligible for Federal Aid	408 (11.53)	253 (13.64)	155 (9.21)	0.0004

Table3.2.4b is the model accuracy check. The true 'reunification' prediction is 56.28%, and the true 'non-reunification' prediction is 63.28%. The overall accuracy is 59.61%. The accuracy check indicates that the model built from year 2011 performs very well. These numbers provide evidence that the performance of the model built by data of year 2011 is good enough. This validation performance is same as the two-year data shown in table 3.2.4b.

Table 3.2.4b Diagnostic test of validation data: 2011 year data

Terms	Reunification	Non-reunification
Predicted Reunification	1044	811
Predicted Non-reunification	618	1065

4 CONCLUSIONS

In this thesis, a prediction model is obtained to discriminate the foster youth with high probability of 'non-reunification' from the others. Logistic regression is adopted to derive the model with the AFCARS data from year 2008 to 2011 in Georgia. Two models based on one year data and two year data are studied and evaluated with the ROC curve separately. It shows that the models can well predict the discharge outcomes of the foster children. More particularly, the accuracy of non-reunification prediction is more than 70% in both models. By using the models, the 'non-reunification' children could be arranged to adoption for a stable life in a short time.

The prediction models provide an insight of the significant factors that influence the discharge outcomes. In the two year model, Gender and Race do not influence the discharge decision. But there are some interaction effects associated with these variables. More attention should be paid to physical, emotional and other diagnosed disabilities. Other removal reasons also need to be considered such as Drug Abuse, Child Behavior Problem, Parent Incarceration, Caretaker Inability to Cope, Relinquishment,

and Inadequate Housing. In most cases, if the children are not stable in the foster care system, they tend to end up with ‘non-reunification’ discharge.

In the one year model, the Gender has the effect on the outcome. But the Race still does not influence the discharge decision. Also, disability does not influence the discharge decision noticeably. The children and family service is willing to help this kind of children reunite with their family and provide the appropriate federal aids. There are big influences of Physical Abuse, Parent Incarceration, Relinquishment and Inadequate Housing underling the reasons for removal from home. Moreover, Incarceration, Relinquishment and Inadequate Housing are shown in both one-year and two-year predictive models which should be paid more attention.

The one year model is simpler and easier to compute, with an AUC of 0.7294 which is higher than that of the two year model. The specificity, however, is higher in the two year model. Which model should be chosen is therefore dependent on the real case scenario. Nevertheless, the models derived here can help to better target the children predicted to be ‘non-reunification’ and plan in advance such that they can return to a normal life in a timely manner.

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APPENDICES

Appendix A: Summary Output for Each Model in the Results Section

A 1.1 Two years: Logistic regression analysis

```
Call:
glm(formula = Re ~ Gender.Male + Age.nu + Race.Black + Race.Other +
    Culture.Spanish + Place.nu + Place22 + Dis.Phy + Dis.Emot +
    Dis.Other + Abu.Drug + Aband + Behav.Prob + Incarce + CaterInabi +
    Reliqu + Inhousing + Single.Fe + Single.Male + Not.Elige +
    Age.nu:Place.nu + Age.nu:Dis.Phy + Age.nu:Single.Male + Age.nu:Incarce +
    Gender.Male:Race.Other + Gender.Male:Abu.Drug + Gender.Male:Inhousing +
    Race.Black:Dis.Phy + Race.Black:Abu.Drug + Culture.Spanish:Place.nu +
    Culture.Spanish:Single.Fe + Place.nu:Dis.Other + Place.nu:Abu.Drug +
    Place.nu:Incarce + Place.nu:CaterInabi + Place.nu:Aband +
    Place.nu:Single.Fe + Dis.Emot:Inhousing + Dis.Other:Abu.Drug,
    family = binomial, data = foster)


Deviance Residuals:
   Min      1Q  Median      3Q     Max
-2.418  -1.093   0.619   1.035   2.309


Coefficients:
                    Estimate Std. Error z value Pr(>|z|)
(Intercept)         0.866664   0.154429   5.612 2.00e-08 ***
```

Gender.Male	0.178306	0.072721	2.452	0.014210	*
Age.nu	0.049128	0.010332	4.755	1.98e-06	***
Race.Black	0.093293	0.073085	1.276	0.201780	
Race.Other	0.154946	0.193135	0.802	0.422400	
Culture.Spanish	1.427634	0.293476	4.865	1.15e-06	***
Place.nu	-0.503269	0.053601	-9.389	< 2e-16	***
Place22	0.021234	0.003266	6.502	7.94e-11	***
Dis.Phy	-0.662554	0.164516	-4.027	5.64e-05	***
Dis.Emot	-0.211810	0.071836	-2.949	0.003193	**
Dis.Other	-1.226897	0.210146	-5.838	5.27e-09	***
Abu.Drug	-0.802933	0.125465	-6.400	1.56e-10	***
Aband	-0.336740	0.123591	-2.725	0.006437	**
Behav.Prob	0.267480	0.109585	2.441	0.014653	*
Incarce	-0.568918	0.157652	-3.609	0.000308	***
CaterInabi	-0.460172	0.116857	-3.938	8.22e-05	***
Reliqu	-0.888141	0.277475	-3.201	0.001370	**
Inhousing	-0.177191	0.098051	-1.807	0.070742	.
Single.Fe	0.292982	0.118261	2.477	0.013234	*
Single.Male	0.855516	0.262225	3.263	0.001104	**
Not.Elige	0.291539	0.090519	3.221	0.001279	**
Age.nu:Place.nu	0.009362	0.003284	2.851	0.004356	**
Age.nu:Dis.Phy	0.049321	0.019003	2.595	0.009446	**
Age.nu:Single.Male	-0.063760	0.023918	-2.666	0.007680	**
Age.nu:Incarce	-0.060564	0.015606	-3.881	0.000104	***

```
Gender.Male:Race.Other    -0.786019   0.264438  -2.972 0.002955 **
Gender.Male:Abu.Drug       0.286323   0.117288   2.441 0.014638 *
Gender.Male:Inhousing     -0.412611   0.127942  -3.225 0.001260 **
Race.Black:Dis.Phy         0.427401   0.188176   2.271 0.023130 *
Race.Black:Abu.Drug       -0.307861   0.129673  -2.374 0.017590 *
Culture.Spanish:Place.nu  -0.182006   0.079708  -2.283 0.022406 *
Culture.Spanish:Single.Fe -0.781158   0.259263  -3.013 0.002587 **
Place.nu:Dis.Other         0.243954   0.057162   4.268 1.97e-05 ***
Place.nu:Abu.Drug          0.133841   0.035473   3.773 0.000161 ***
Place.nu:Incarce           0.235868   0.046928   5.026 5.00e-07 ***
Place.nu:CaterInabi        0.093406   0.037029   2.522 0.011653 *
Place.nu:Aband             0.090524   0.039461   2.294 0.021790 *
Place.nu:Single.Fe        -0.117422   0.038192  -3.075 0.002108 **
Dis.Emot:Inhousing         0.399835   0.142610   2.804 0.005052 **
Dis.Other:Abu.Drug         0.682583   0.252800   2.700 0.006932 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 8641.7  on 6253  degrees of freedom
Residual deviance: 7822.8  on 6214  degrees of freedom
AIC: 7902.8
```

Number of Fisher Scoring iterations: 4

Analysis of Deviance Table

Model: binomial, link: logit

Response: Re

Terms added sequentially (first to last)

	Df	Deviance	Resid. Df	Resid. Dev	P(>|Chi|)	
NULL			6253	8641.7		
Gender.Male	1	0.810	6252	8640.8	0.3680937	
Age.nu	1	192.159	6251	8448.7	< 2.2e-16	***
Race.Black	1	4.032	6250	8444.7	0.0446321	*
Race.Other	1	5.414	6249	8439.2	0.0199755	*
Culture.Spanish	1	37.583	6248	8401.7	8.762e-10	***
Place.nu	1	182.735	6247	8218.9	< 2.2e-16	***
Place22	1	85.409	6246	8133.5	< 2.2e-16	***
Dis.Phy	1	4.159	6245	8129.4	0.0414260	*
Dis.Emot	1	4.563	6244	8124.8	0.0326793	*
Dis.Other	1	9.196	6243	8115.6	0.0024258	**
Abu.Drug	1	36.418	6242	8079.2	1.593e-09	***
Aband	1	0.511	6241	8078.7	0.4745014	

Behav.Prob	1	5.447	6240	8073.2	0.0196031 *
Incarce	1	20.637	6239	8052.6	5.551e-06 ***
CaterInabi	1	10.257	6238	8042.3	0.0013619 **
Reliqu	1	11.016	6237	8031.3	0.0009032 ***
Inhousing	1	22.385	6236	8008.9	2.231e-06 ***
Single.Fe	1	3.123	6235	8005.8	0.0771795 .
Single.Male	1	4.150	6234	8001.7	0.0416440 *
Not.Elige	1	8.878	6233	7992.8	0.0028863 **
Age.nu:Place.nu	1	15.369	6232	7977.4	8.844e-05 ***
Age.nu:Dis.Phy	1	6.038	6231	7971.4	0.0140015 *
Age.nu:Single.Male	1	4.989	6230	7966.4	0.0255144 *
Age.nu:Incarce	1	10.009	6229	7956.4	0.0015577 **
Gender.Male:Race.Other	1	8.540	6228	7947.8	0.0034738 **
Gender.Male:Abu.Drug	1	5.742	6227	7942.1	0.0165655 *
Gender.Male:Inhousing	1	8.353	6226	7933.7	0.0038512 **
Race.Black:Dis.Phy	1	5.248	6225	7928.5	0.0219671 *
Race.Black:Abu.Drug	1	5.125	6224	7923.4	0.0235828 *
Culture.Spanish:Place.nu	1	5.744	6223	7917.6	0.0165432 *
Culture.Spanish:Single.Fe	1	7.590	6222	7910.0	0.0058679 **
Place.nu:Dis.Other	1	15.130	6221	7894.9	0.0001003 ***
Place.nu:Abu.Drug	1	13.031	6220	7881.9	0.0003064 ***
Place.nu:Incarce	1	20.749	6219	7861.1	5.235e-06 ***
Place.nu:CaterInabi	1	7.409	6218	7853.7	0.0064882 **
Place.nu:Aband	1	5.821	6217	7847.9	0.0158315 *

```
Place.nu:Single.Fe        1    9.488      6216     7838.4 0.0020683 **
Dis.Emot:Inhousing        1    8.347      6215     7830.1 0.0038627 **
Dis.Other:Abu.Drug        1    7.205      6214     7822.8 0.0072705 **
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1
```

A 1.2 Two years: ROC analysis

```
Call:
roc.default(response = foster$Re, predictor = remodel2$fitted)

Data: remodel2$fitted in 2917 controls (response 0) < 3337 cases (response 1).
Area under the curve: 0.7024
```

A 1.3 Two years: Cut-off point selection

```
    sensitivity specificity   threshold
  0.5397063   0.7555708   0.5819908
> sum((remodel2$fitted >= 0.582) & foster$Re)
[1] 1801
> sum((remodel2$fitted >= 0.582) & !foster$Re)
[1] 713
> sum((remodel2$fitted < 0.582) & foster$Re)
[1] 1536
> sum((remodel2$fitted < 0.582) & !foster$Re)
[1] 2204
> epi.tests(a, b, c, d, conf.level = 0.95)
```

```
$aprev
      est     lower     upper
1 0.4019827 0.3897994 0.4142576

$tprev
      est     lower     upper
1 0.5335785 0.5211214 0.5460043

$se
      est    lower    upper
1 0.5397063 0.522617 0.556726

$sp
      est     lower    upper
1 0.7555708 0.7395524 0.771075

$da
      est     lower     upper
1 0.6403902 0.6283535 0.6522958

$dor
     est    lower   upper
1 3.624470 3.251913 4.03971
```

```
$nnd
     est    lower    upper
1 3.386649 3.050632 3.814328

$youden
      est     lower     upper
1 0.2952771 0.2621694 0.3278009

$ppv
      est     lower     upper
1 0.7163882 0.6983245 0.7339466

$npv
      est     lower     upper
1 0.5893048 0.5733396 0.6051303

$lr.pos
     est    lower   upper
1 2.208027 2.056525 2.37069

$lr.neg
      est     lower     upper
1 0.6091999 0.5840615 0.6354204
```

A 1.4 Two years: Validation

```
> sum((valcheck$Predict >= 0.582) & valcheck$True)

[1] 2569

> sum((valcheck$Predict < 0.582) & valcheck$True)

[1] 2221

> sum((valcheck$Predict < 0.582) & !valcheck$True)

[1] 3255

> sum((valcheck$Predict >= 0.582) & !valcheck$True)

[1] 1585
```

A 2.1 One year: Logistic regression analysis

```
Call:

glm(formula = Re ~ Gender.Male + Age.nu + Race.Black + Culture.Spanish +

    Place.nu + Place22 + Dis.Other + Abu.Phy + Abu.Neg + Incarce +

    Reliqu + Inhousing + Single.Male + Unmarri + Single.Fe +

    Age.nu:Place.nu + Age.nu:Culture.Spanish + Gender.Male:Inhousing +

    Race.Black:Unmarri + Race.Black:Incarce + Culture.Spanish:Place.nu +

    Place.nu:Reliqu + Place.nu:Single.Fe + Place.nu:Inhousing +

    Dis.Other:Abu.Neg, family = binomial, data = foster)


Deviance Residuals:

    Min       1Q   Median       3Q      Max

-2.6449  -1.0636   0.5854   0.9791   2.3143
```

Coefficients:

	Estimate	Std. Error	z value	Pr(>|z|)	
(Intercept)	0.576654	0.208234	2.769	0.005618	**
Gender.Male	0.399107	0.097328	4.101	4.12e-05	***
Age.nu	0.032053	0.015791	2.030	0.042370	*
Race.Black	0.224142	0.099359	2.256	0.024078	*
Culture.Spanish	0.899805	0.343671	2.618	0.008839	**
Place.nu	-0.599180	0.077077	-7.774	7.62e-15	***
Place22	0.031676	0.005986	5.291	1.21e-07	***
Dis.Other	0.391537	0.648864	0.603	0.546229	
Abu.Phy	0.521445	0.138793	3.757	0.000172	***
Abu.Neg	0.007427	0.096582	0.077	0.938704	
Incarce	-0.450311	0.156495	-2.877	0.004009	**
Reliqu	-2.683403	0.890477	-3.013	0.002583	**
Inhousing	-0.552729	0.198066	-2.791	0.005260	**
Single.Male	0.601181	0.221502	2.714	0.006645	**
Unmarri	-0.464853	0.280576	-1.657	0.097564	.
Single.Fe	0.379045	0.161840	2.342	0.019176	*
Age.nu:Place.nu	0.015158	0.005809	2.609	0.009075	**
Age.nu:Culture.Spanish	0.142723	0.040853	3.494	0.000477	***
Gender.Male:Inhousing	-0.531707	0.195592	-2.718	0.006559	**
Race.Black:Unmarri	1.200715	0.458416	2.619	0.008812	**
Race.Black:Incarce	0.788762	0.264428	2.983	0.002855	**
Culture.Spanish:Place.nu	-0.504364	0.153992	-3.275	0.001056	**

```
Place.nu:Reliqu          0.932361   0.328587   2.837 0.004547 **
Place.nu:Single.Fe      -0.211146   0.056477  -3.739 0.000185 ***
Place.nu:Inhousing       0.193796   0.063017   3.075 0.002103 **
Dis.Other:Abu.Neg       -1.822436   0.799723  -2.279 0.022677 *
---
Signif. codes:  0 ‘***’ 0.001 ‘**’ 0.01 ‘*’ 0.05 ‘.’ 0.1 ‘ ’ 1

(Dispersion parameter for binomial family taken to be 1)

    Null deviance: 3742.5  on 2715  degrees of freedom
Residual deviance: 3285.0  on 2690  degrees of freedom
AIC: 3337

Number of Fisher Scoring iterations: 5
Analysis of Deviance Table

Model: binomial, link: logit

Response: Re

Terms added sequentially (first to last)
```

```
                    Df Deviance Resid. Df Resid. Dev P(>|Chi|)
NULL                             2715     3742.5
Gender.Male            1    3.348      2714     3739.2 0.0672948 .
Age.nu                 1   87.637      2713     3651.5 < 2.2e-16 ***
Race.Black             1   11.614      2712     3639.9 0.0006544 ***
Culture.Spanish        1   35.180      2711     3604.7 3.005e-09 ***
Place.nu               1  116.664      2710     3488.1 < 2.2e-16 ***
Place22                1   62.671      2709     3425.4 2.442e-15 ***
Dis.Other              1    4.627      2708     3420.8 0.0314729 *
Abu.Phy                1   19.033      2707     3401.7 1.285e-05 ***
Abu.Neg                1    0.301      2706     3401.4 0.5834984
Incarce                1    1.799      2705     3399.6 0.1798539
Reliqu                 1    1.759      2704     3397.9 0.1847244
Inhousing              1   15.773      2703     3382.1 7.142e-05 ***
Single.Male            1   10.310      2702     3371.8 0.0013228 **
Unmarri                1    0.226      2701     3371.6 0.6343918
Single.Fe              1    1.736      2700     3369.8 0.1876161
Age.nu:Place.nu        1    9.314      2699     3360.5 0.0022736 **
Age.nu:Culture.Spanish 1    8.453      2698     3352.1 0.0036453 **
Gender.Male:Inhousing  1    6.289      2697     3345.8 0.0121497 *
Race.Black:Unmarri     1    5.355      2696     3340.4 0.0206683 *
Race.Black:Incarce     1    7.861      2695     3332.5 0.0050517 **
Culture.Spanish:Place.nu 1 10.743      2694     3321.8 0.0010466 **
Place.nu:Reliqu        1    8.836      2693     3313.0 0.0029540 **
```

```
Place.nu:Single.Fe       1   12.742      2692     3300.2 0.0003576 ***

Place.nu:Inhousing       1    9.839      2691     3290.4 0.0017085 **

Dis.Other:Abu.Neg        1    5.394      2690     3285.0 0.0202035 *

---

Signif. codes:  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

A 2.2 One year: ROC analysis

```
Call:

roc.default(response = foster$Re, predictor = bremodel5$fitted)


Data: bremodel5$fitted in 1234 controls (response 0) < 1482 cases (response 1).

Area under the curve: 0.7294
```

A 2.3 One year: Cut-off point selection

```
    sensitivity specificity   threshold

  0.682861    0.671799    0.542965

> sum((bremodel5$fitted >= 0.543) & foster$Re)

[1] 1011

> sum((bremodel5$fitted >= 0.543) & !foster$Re)

[1] 405

> sum((bremodel5$fitted < 0.543) & foster$Re)

[1] 471

> sum((bremodel5$fitted < 0.543) & !foster$Re)

[1] 829

$aprev
```

```
      est     lower     upper
1 0.5213549 0.5023694 0.5402944

$tprev
      est    lower     upper
1 0.5456554 0.526705 0.5645073

$se
      est    lower     upper
1 0.6821862 0.657799 0.7058493

$sp
     est     lower     upper
1 0.671799 0.6448092 0.6979675

$da
      est     lower     upper
1 0.6774669 0.6595187 0.6950317

$dor
     est    lower    upper
1 4.393693 3.738536 5.163664

$nnd
```

```
     est    lower    upper
1 2.824976 2.476371 3.304603

$youden
      est     lower     upper
1 0.3539853 0.3026082 0.4038167

$ppv
     est     lower     upper
1 0.713983 0.6896655 0.7374095

$npv
      est     lower     upper
1 0.6376923 0.6108908 0.6638696

$lr.pos
     est    lower    upper
1 2.078563 1.905254 2.267636

$lr.neg
      est    lower     upper
1 0.4730786 0.434889 0.5146219
```

A 2.4 One year: Validation

```
> sum((valcheck$Predict >= 0.582) & valcheck$True)

[1] 932

> sum((valcheck$Predict >= 0.543) & valcheck$True)

[1] 1044

> sum((valcheck$Predict < 0.543) & valcheck$True)

[1] 811

> sum((valcheck$Predict < 0.543) & !valcheck$True)

[1] 1065

> sum((valcheck$Predict >= 0.543) & !valcheck$True)

[1] 618
```

Appendix B: Selected Independent variables

Term	Name	Definition	Details
data[, 69]	age	The age of the person	
data[, 7]	Sex	The gender of the person	1: Male 2: Female (Baseline)
data[, 8]	Race	The race of the person	1: White (Baseline) 2: Black 3,4: Other
data[, 9]	Ethnicity	Child Hispanic Origin	1: Yes 2: No (Baseline)
data[, 10]	Disability	Diagnosed Disability	1: Yes 2: No (Baseline)
data[, 11]	MentalRetardation	Indicator (Mental Retardation)	1: Yes
data[, 12]	VisualHearingImpaired	Indicator (Visually Or Hearing Impaired)	1: Yes
data[, 13]	PhysicallyDisabled	Indicator (Physically Disabled)	1: Yes
data[, 14]	EmotionallyDisturbed	Indicator (Emotionally Disturbed)	1: Yes
data[, 15]	OtherMedicalConditions	Indicator (Other Diagnosed Condition)	1: Yes
data[, 24]	PlcsThisRemoval	Number of Placement Settings	
data[, 26]	RRPhysical	Reason for Removal	1:Physical Abuse
data[, 27]	RRSexual	Reason for Removal	1: Sexual Abuse
data[, 28]	RRNeglect	Reason for Removal	1: Neglect
data[, 29] **data[, 30]**	unused.RRAlcoholParent unused.RRDrugsParent	Reason for Removal	1: Alcohol Abuse
data[, 31] **data[, 32]**	unused.RRAlcoholChild unused.RRDrugsChild	Reason for Removal	1: Drug Abuse
data[, 34]	RRChildBehavior	Reason for Removal	1: Child Behavior Problem
data[, 36]	RRParentIncarceration	Reason for Removal	1: Parent Incarceration
data[, 37]	RRCaretakerCantCope	Reason for Removal	1: Caretaker Inability To Cope
data[, 38]	RRAbandonment	Reason for Removal	1: Abandonment
data[, 39]	RRRelinquishment	Reason for Removal	1: Relinquishment
data[, 40]	RRInadequateHousing	Reason for Removal	1: Inadequate Housing
data[, 44]	CaretakerFamilyStructure	Principal Caretaker Family Structure	1: Married couple (Baseline) 2: Unmarried couple 3: Single female 4: Single male
data[, 63]	EligXIXMedicaid	Federal Aid	1: Yes (Baseline) 0: No

Appendix C: Abbreviations and Acronyms

CAS: Children's Aid Society

AFCARS: Adoption and Foster Care Analysis and Reporting System

DFCS: Division of Family and Child Services

NDACAN: National Data Archive on Child Abuse and Neglect

TPR: Termination of Parental Rights