Alzheimer's Disease and Cognitive Impairment Prediction

ELIUD OMOLLO

In [1]:
```
#numpy and pandas
import pandas as pd
import numpy as np
```

In [2]:
```
#visualization
import matplotlib.pyplot as plt
import seaborn as sns
%matplotlib inline
```

In [3]:
```
#preprocessing
from sklearn.preprocessing import StandardScaler
from sklearn.preprocessing import PolynomialFeatures
```

In [4]:
```
#Regressions
from sklearn.linear_model import LinearRegression
from sklearn.neighbors import KNeighborsRegressor
```

In [5]:
```
#classification
from sklearn.linear_model import LogisticRegressionCV
from sklearn.neighbors import KNeighborsClassifier
from sklearn.discriminant_analysis import LinearDiscriminantAnalysis
from sklearn.discriminant_analysis import QuadraticDiscriminantAnalysis
from sklearn.tree import DecisionTreeClassifier
from sklearn.ensemble import RandomForestClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.pipeline import Pipeline
```

In [6]:
```
#Regression model metrics
from sklearn.metrics import r2_score
from sklearn.model_selection import cross_val_score
```

In [7]:
```
#classification metrics
from sklearn.metrics import accuracy_score
from sklearn.metrics import confusion_matrix
from sklearn.metrics import classification_report
from sklearn.metrics import roc_curve
from sklearn.metrics import auc
```

In [8]:
```
#regularization
from sklearn.linear_model import LassoCV
from sklearn.linear_model import RidgeCV
from sklearn.decomposition import PCA
```

In [9]:
```
#cross validation
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import KFold
```

In [10]:
```
#utilities
from sklearn.model_selection import train_test_split
```

In [11]:
```
#global random state
rnd_state = 41
```

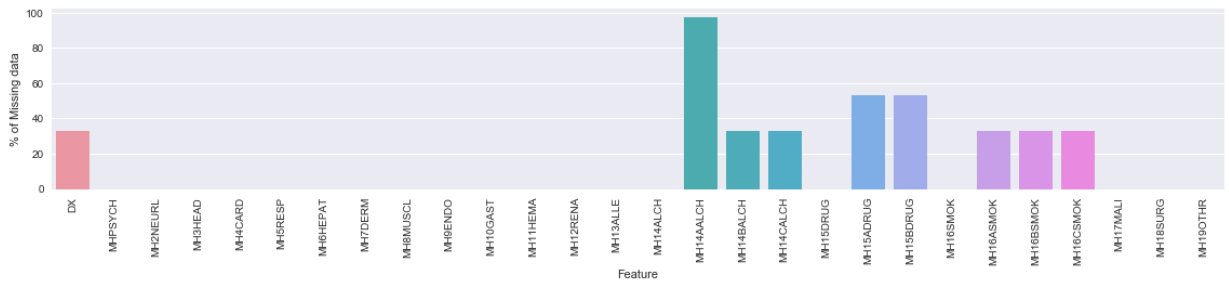
In [12]:
```
import warnings
import sklearn.exceptions
warnings.filterwarnings("ignore", category=sklearn.exceptions.UndefinedMetricWarn
```

In [13]:
```
#import ADNIMERGE
adnimergeDF= pd.read_csv('data\ADNIMERGE.csv')[['RID','DX']]
#import Medical History
medHistDF_r = pd.read_csv('data\MEDHIST.csv', low_memory=False)
medHistDF = medHistDF_r.iloc[: , np.r_[2, 10:37]]
```

In [14]:
```
#Merge all the data into one dataframe
data = pd.merge(adnimergeDF, medHistDF, on='RID', how='inner')
data = data.drop('RID', axis=1)
data.shape
```

Out[14]: (21050, 28)

In [15]:
```
miss_data = {col: (pd.isnull(data[col]).sum()/data.shape[0])*100 for col in list(
miss_data_df = pd.DataFrame.from_dict(data=miss_data, orient='index')
g = sns.factorplot(x=miss_data_df.index , y=0, data=miss_data_df, kind= 'bar', as
g.set_xticklabels(rotation=90, fontsize=10)
g.set_xlabels('Feature')
g.set_ylabels('% of Missing data')
plt.show()
```



In [16]:
```
for col in list(data):
    miss = (pd.isnull(data[col]).sum()/data.shape[0])*100
    if miss > 0:
        print('{} : {} % Missing'.format(col, miss))
```

```
DX : 32.68408551068884 % Missing
MH14AALCH : 97.64845605700712 % Missing
MH14BALCH : 33.04038004750594 % Missing
MH14CALCH : 33.04038004750594 % Missing
MH15ADRUG : 52.99287410926365 % Missing
MH15BDRUG : 52.99287410926365 % Missing
MH16ASMOK : 33.04038004750594 % Missing
MH16BSMOK : 33.04038004750594 % Missing
MH16CSMOK : 33.04038004750594 % Missing
```

In [17]:
```
#Drop null columns. These columns are related to alcohol consumption, drug use an
data = data.drop(['MH14AALCH','MH14BALCH','MH14CALCH', 'MH15ADRUG','MH15BDRUG', '
data = data.dropna(axis=0, how='any')
```

In [18]:
```
data.shape
```

Out[18]: (14170, 20)

Exploratory data analysis

In [19]:
```
#encode the labels
from sklearn import preprocessing
le = preprocessing.LabelEncoder()
data['DX_'] = le.fit_transform(data['DX'])
print(le.inverse_transform([0, 1, 2]))
data = data.drop('DX', axis=1)
```

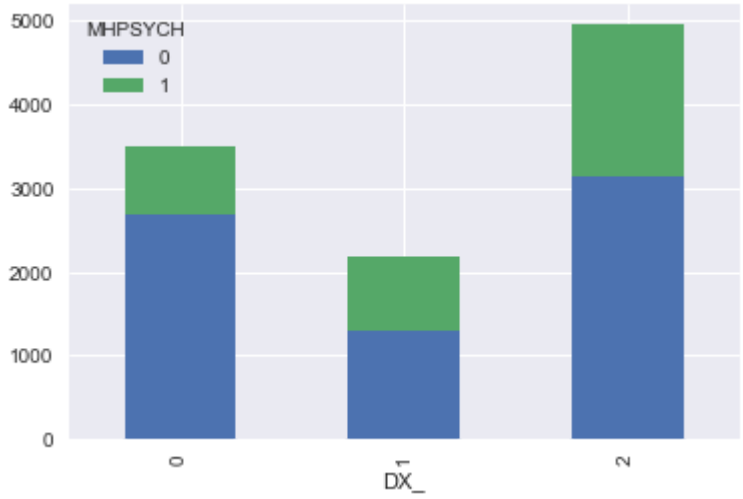
```
['CN' 'Dementia' 'MCI']
```

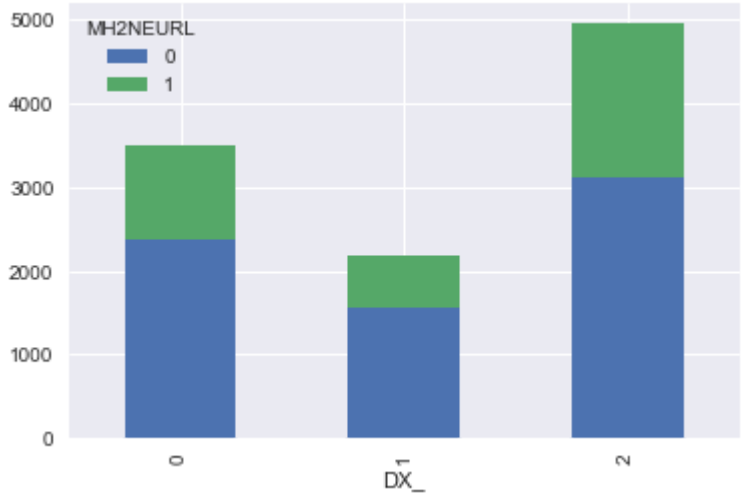
In [20]:
```
#Split the data into  75% train and 25% test splits
train, test = train_test_split(data, test_size=0.25, random_state=rnd_state)
```

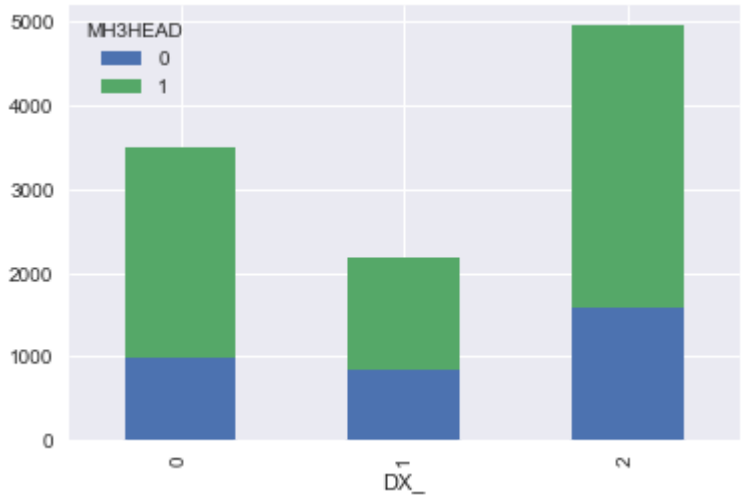
In [21]:
```
#Initial Analysis
print('Shape ', train.shape)
```

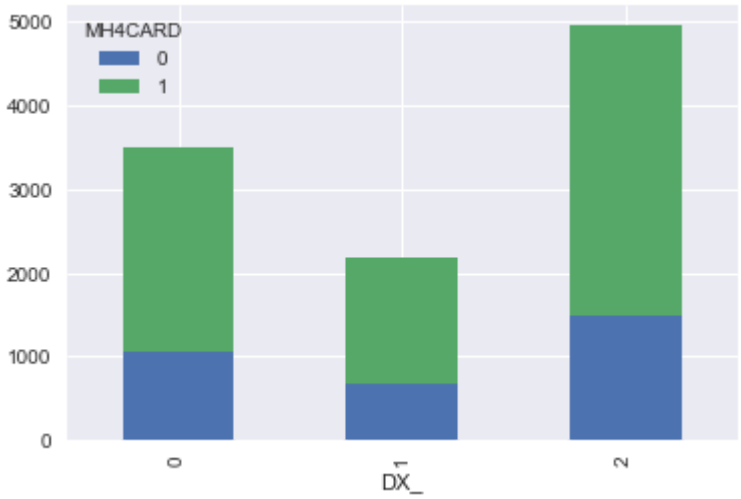
```
Shape  (10627, 20)
```

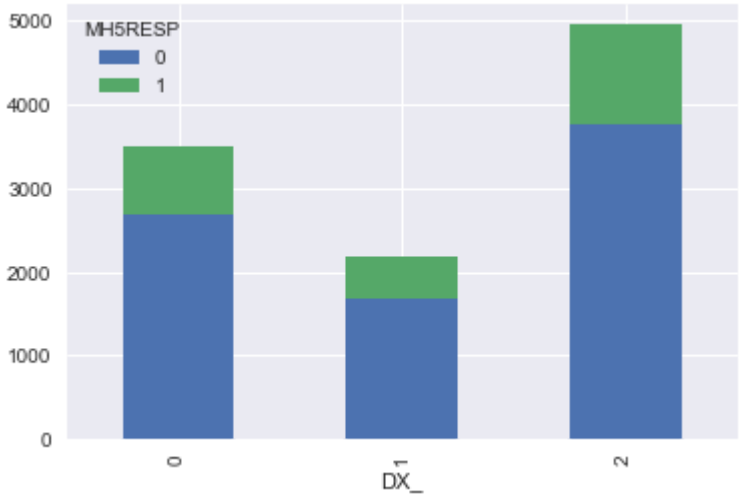
In [22]:
```
for col in list(train):
    train.groupby(['DX_', col]).size().unstack().plot(kind = 'bar', stacked=True)
```

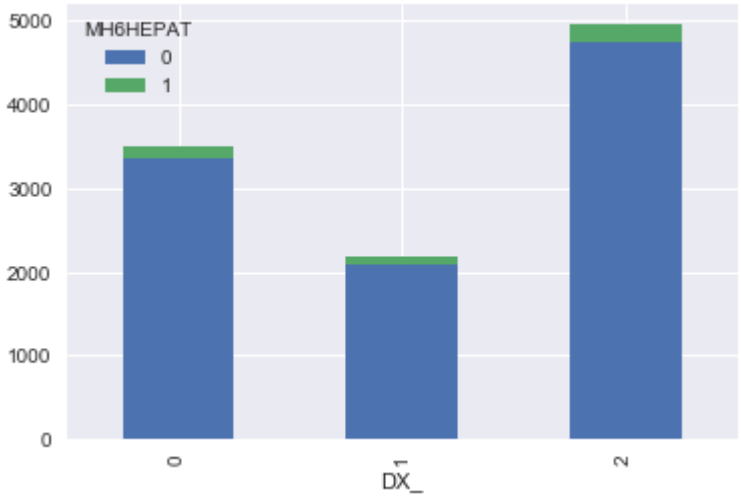


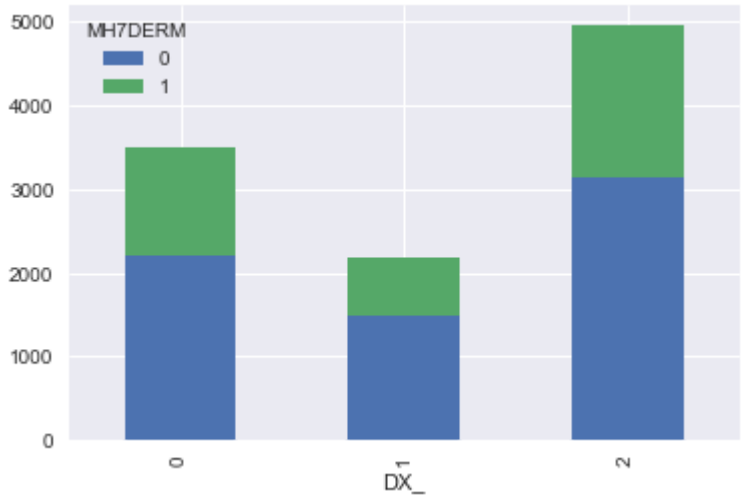


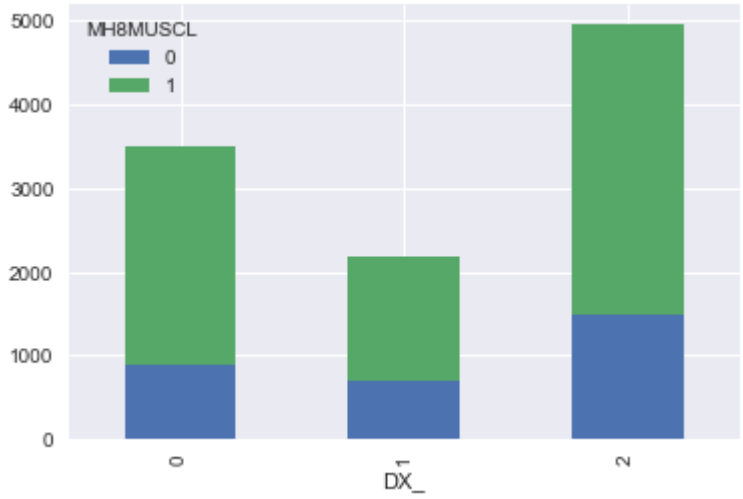


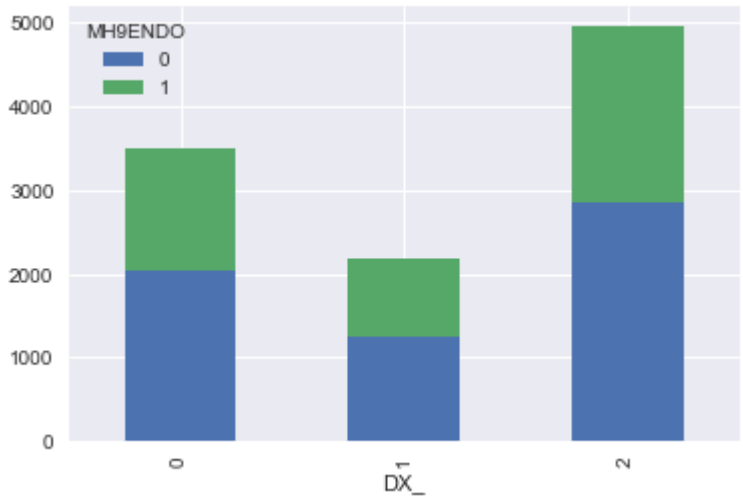

MH4CARD
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

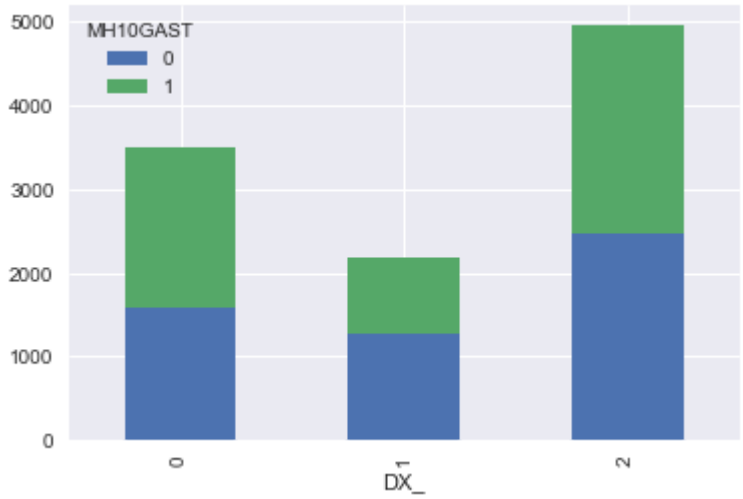

MH5RESP
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

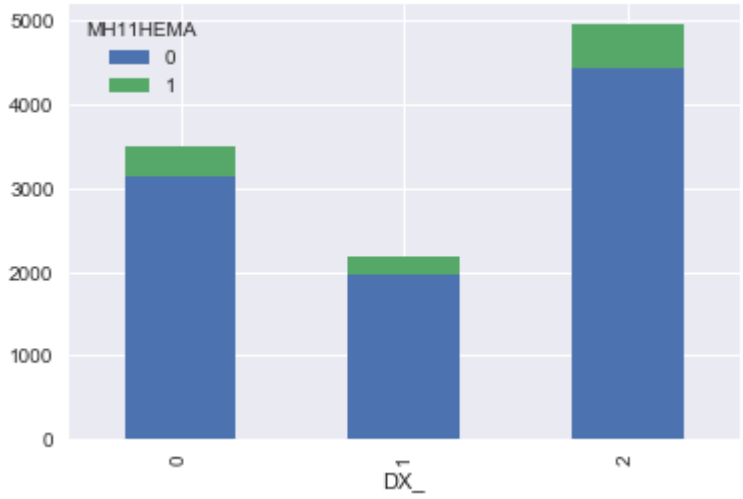

MH6HEPAT
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

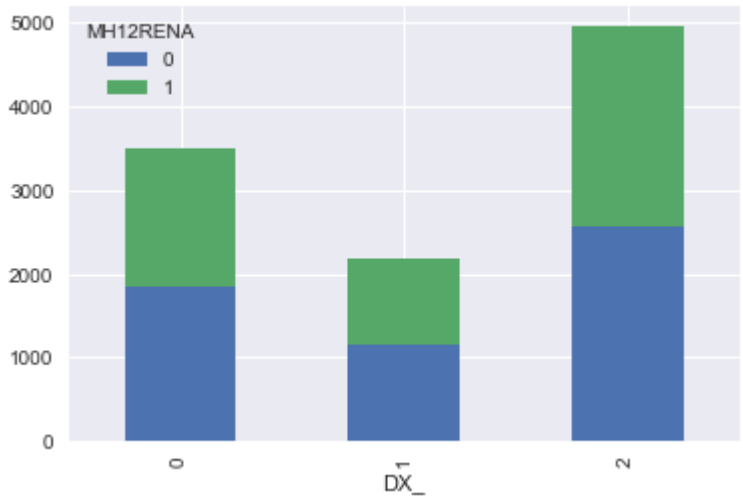

MH7DERM
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

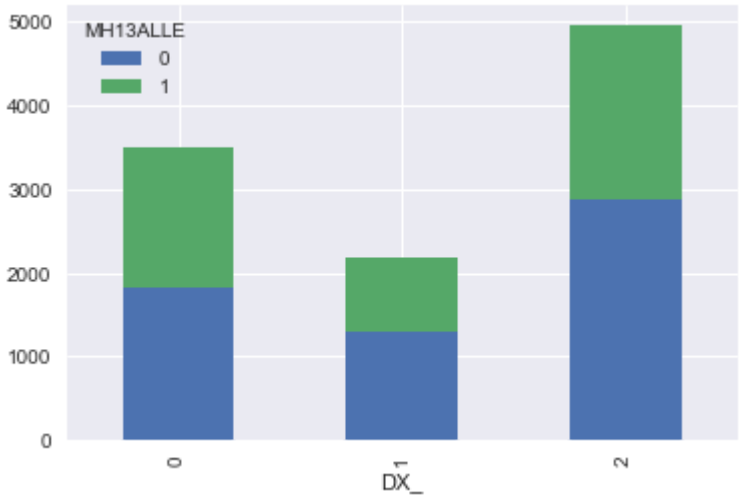

MH8MUSCL
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

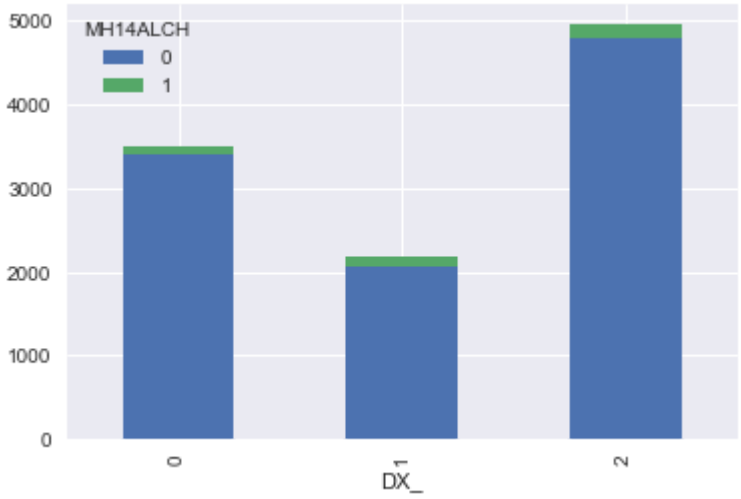

MH9ENDO
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

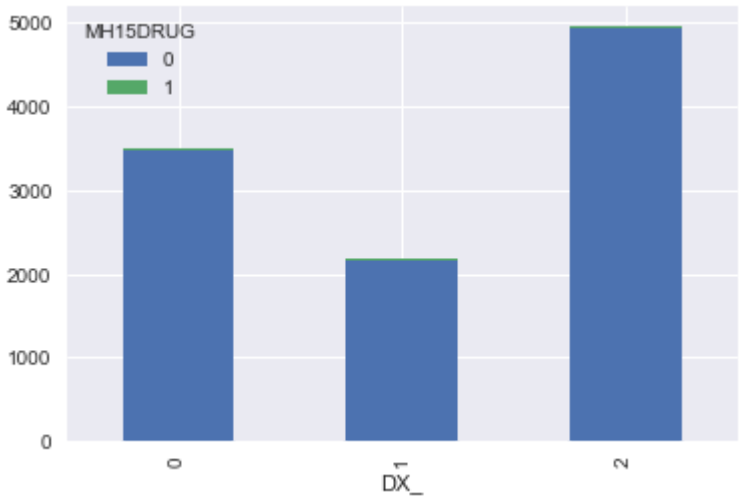

MH10GAST
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

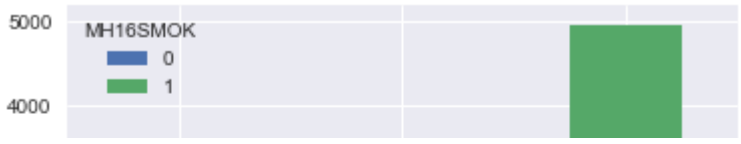

MH11HEMA
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

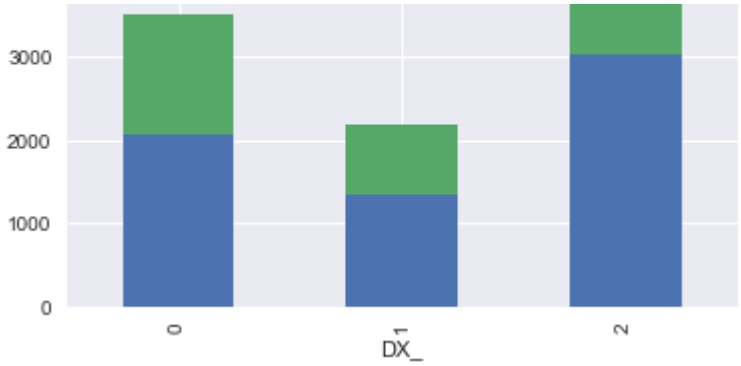

MH12RENA
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

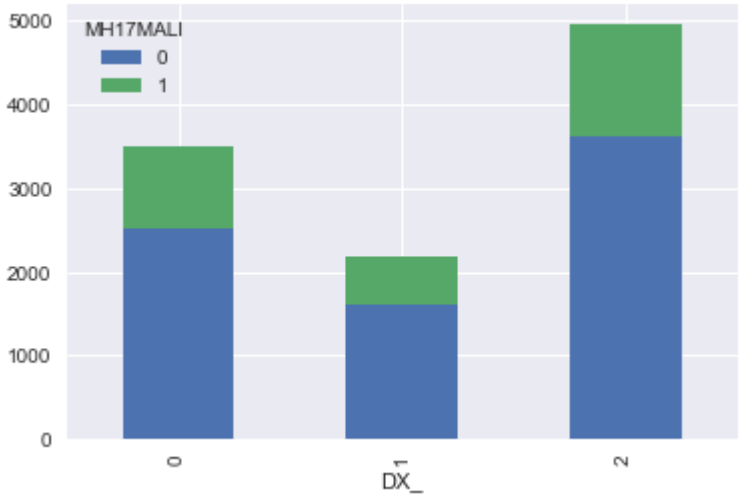

MH13ALLE
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

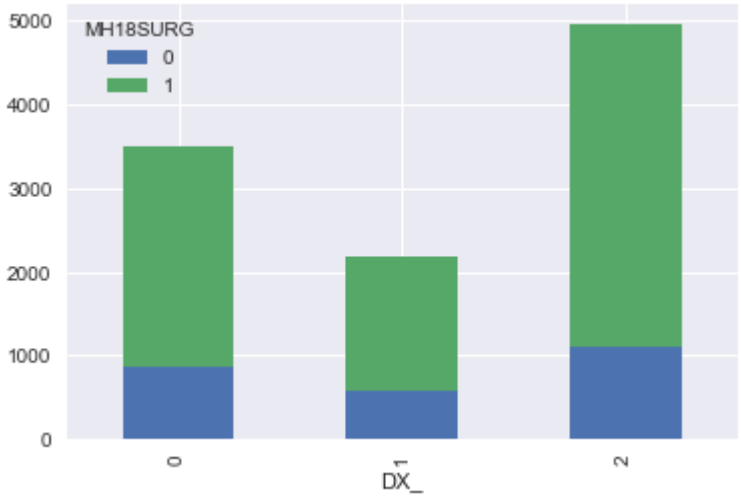

MH14ALCH
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

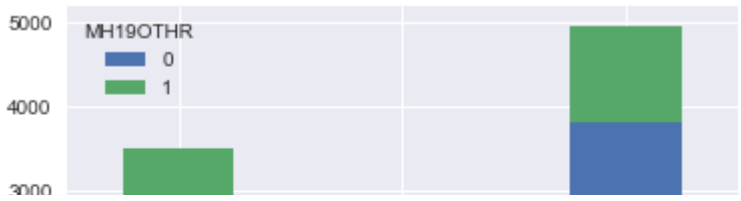

MH15DRUG
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

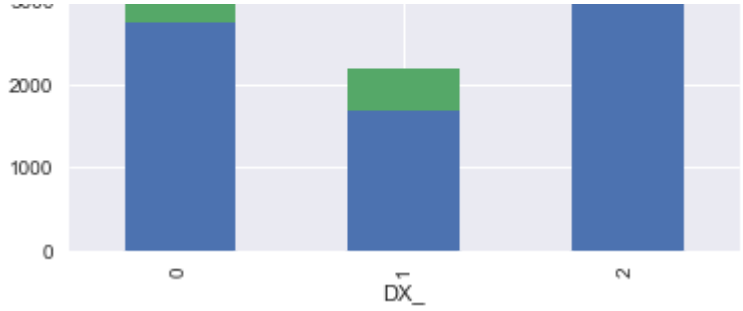

MH16SMOK
0
1
5000
4000

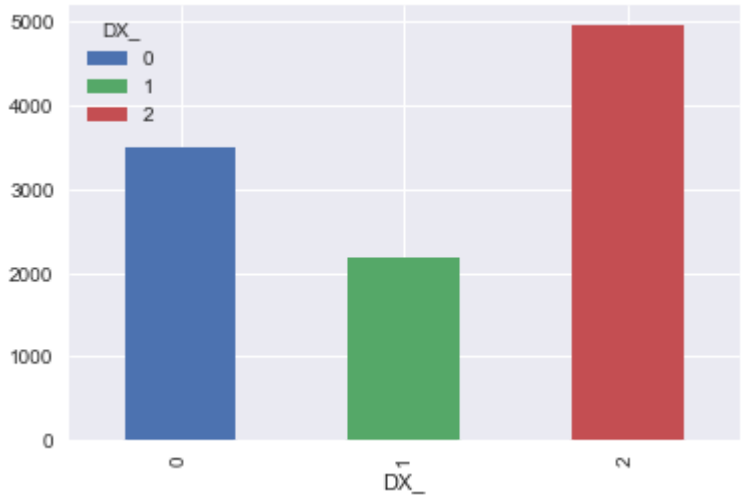

3000
2000
1000
0
0
1
2
DX_


MH17MALI
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

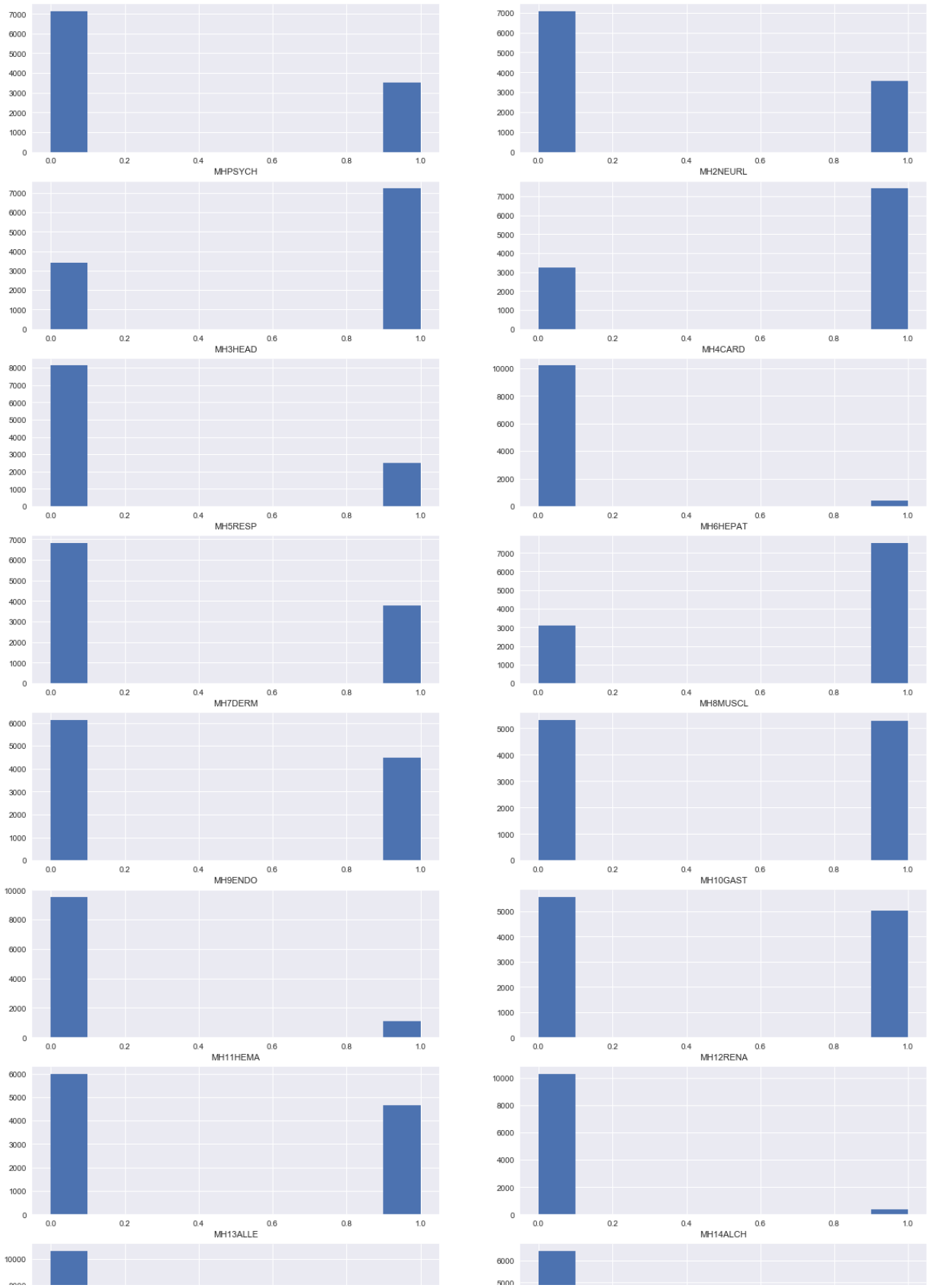

MH18SURG
0
1
5000
4000
3000
2000
1000
0
0
1
2
DX_

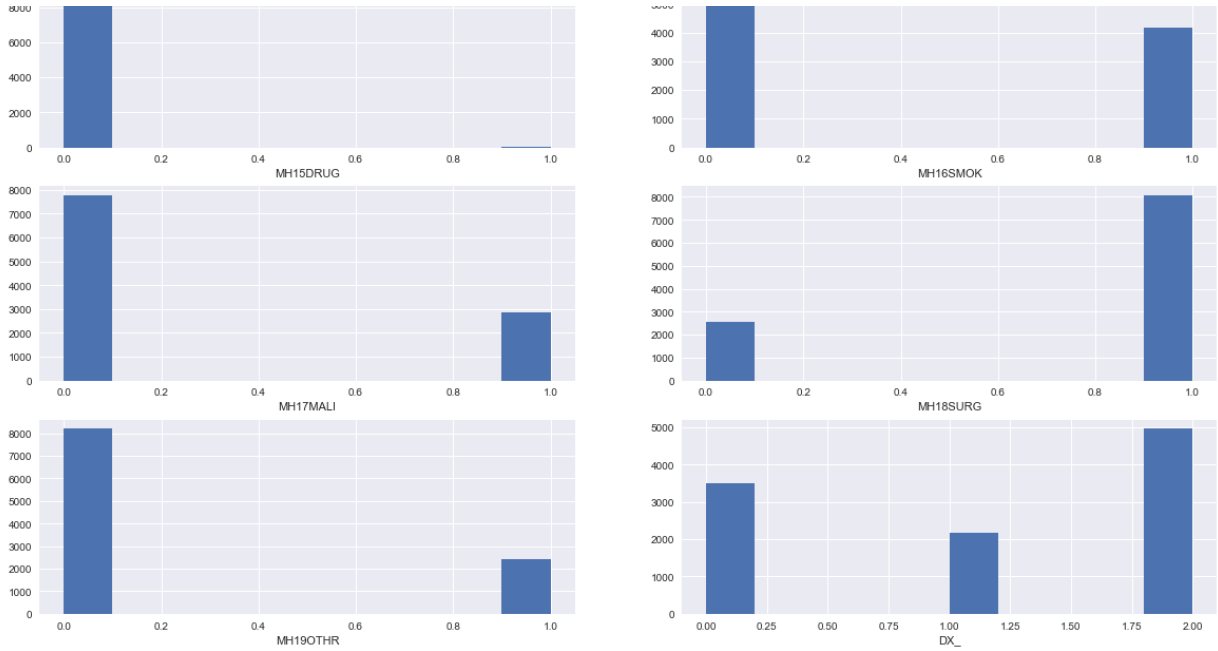

MH19OTHR
0
1
5000
4000
3000


2000
1000
0
0
1
2
DX_


5000
4000
3000
2000
1000
0
DX_
0
1
2
0
1
2
DX_

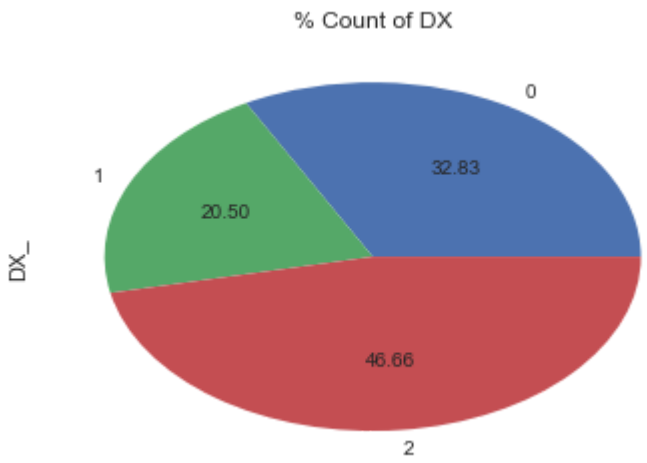
In [23]:
```
plt.figure(figsize=(20, 40))
for k, p in enumerate(train.columns):
    plt.subplot(10,2, k+1)
    train[p].hist()
    plt.xlabel(p)
plt.show()
```



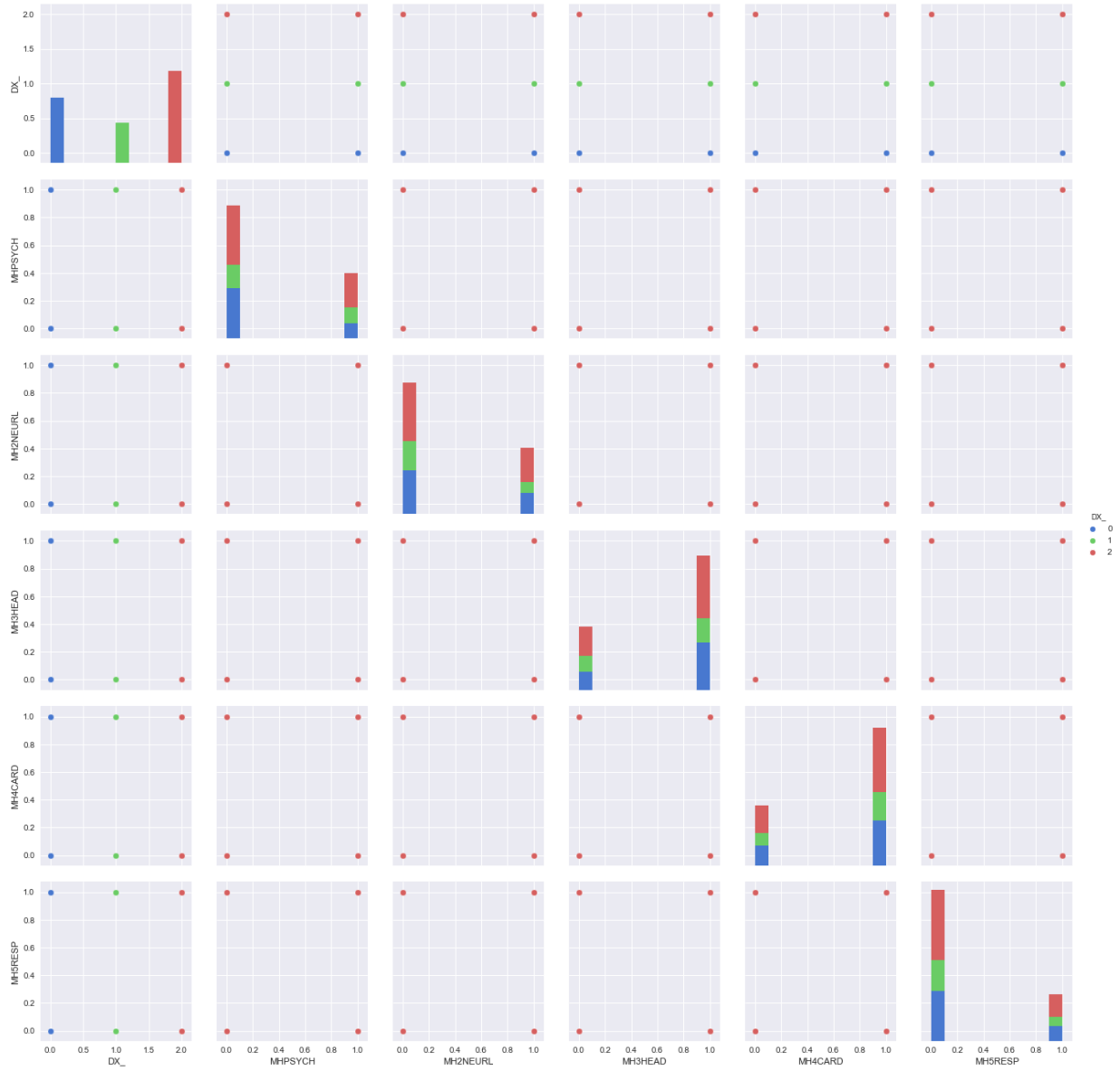


In [24]:
```
train['DX_'].value_counts(sort=False).plot.pie(autopct='%.2f').set_title('% Count
```

Out[24]: <matplotlib.text.Text at 0x2e98f2d3358>



In [25]:
```
g = sns.pairplot(train.iloc[:, np.r_[19, 0:5]], hue='DX_',palette='muted',size=3)
```



Predictions

In [26]:
```
#identify the target variable
X_train = train.drop('DX_', axis=1)
y_train = train['DX_']
X_test = test.drop('DX_', axis=1)
y_test = test['DX_']
```

In [27]:
```
X_train.shape
```

Out[27]: (10627, 19)

In [28]:
```
#Baseline Model: LogisticRegression with Cross Validation
#This is the model that we will ue for comparison

lgr= LogisticRegressionCV(Cs=10, random_state=rnd_state, penalty='l2', cv = 5, mu
lgr.fit(X_train, y_train)
print('LogisticRegression Train Score', lgr.score(X_train, y_train))
print('LogisticRegression Test Score', lgr.score(X_test, y_test))
```

```
LogisticRegression Train Score 0.465982873812
LogisticRegression Test Score 0.459779847587
```

In [29]:
```
#Confusion Matrix and Classfication Report
print('Confusion Matrix:\n', confusion_matrix(y_test,lgr.predict(X_test)))
print('Classificaton Report: \n', classification_report(y_test,lgr.predict(X_test
```

```
Confusion Matrix:
 [[ 268    0  887]
 [  95    3  636]
 [ 295    1 1358]]
Classificaton Report:
              precision    recall  f1-score   support

          0       0.41      0.23      0.30      1155
          1       0.75      0.00      0.01       734
          2       0.47      0.82      0.60      1654

avg / total       0.51      0.46      0.38      3543
```

In [63]:
```
 # Linear Discriminant Analysis
ld = LinearDiscriminantAnalysis()
ld.fit(X_train, y_train)
print('Train Score', ld.score(X_train, y_train))
print('Test Score', ld.score(X_test, y_test))
print('Confusion Matrix:\n', confusion_matrix(y_test,ld.predict(X_test)))
print('Classificaton Report: \n', classification_report(y_test,ld.predict(X_test)
```

```
Train Score 0.463536275525
Test Score 0.456957380751
Confusion Matrix:
 [[ 251    8  896]
 [  93    6  635]
 [ 290    2 1362]]
Classificaton Report:
              precision    recall  f1-score   support

          0       0.40      0.22      0.28      1155
          1       0.38      0.01      0.02       734
          2       0.47      0.82      0.60      1654

avg / total       0.43      0.46      0.37      3543
```

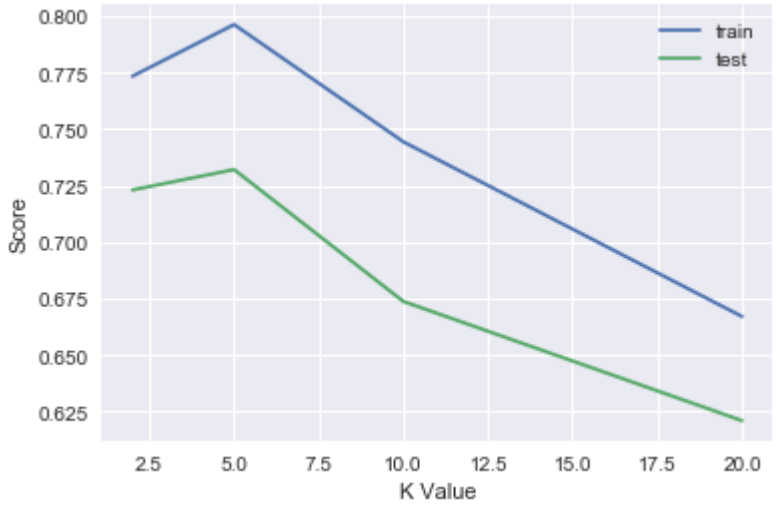
In [64]:
```
#- Quadratic Discriminant Analysis
qd =QuadraticDiscriminantAnalysis()
qd.fit(X_train, y_train)
print('Train Score', qd.score(X_train, y_train))
print('Test Score', qd.score(X_test, y_test))
print('Confusion Matrix:\n', confusion_matrix(y_test,qd.predict(X_test)))
print('Classificaton Report: \n', classification_report(y_test,qd.predict(X_test)
```

```
Train Score 0.515667639033
Test Score 0.505221563647
Confusion Matrix:
 [[742  87 326]
 [255 126 353]
 [560 172 922]]
Classificaton Report:
              precision    recall  f1-score   support

          0       0.48      0.64      0.55      1155
          1       0.33      0.17      0.23       734
          2       0.58      0.56      0.57      1654

avg / total       0.49      0.51      0.49      3543
```

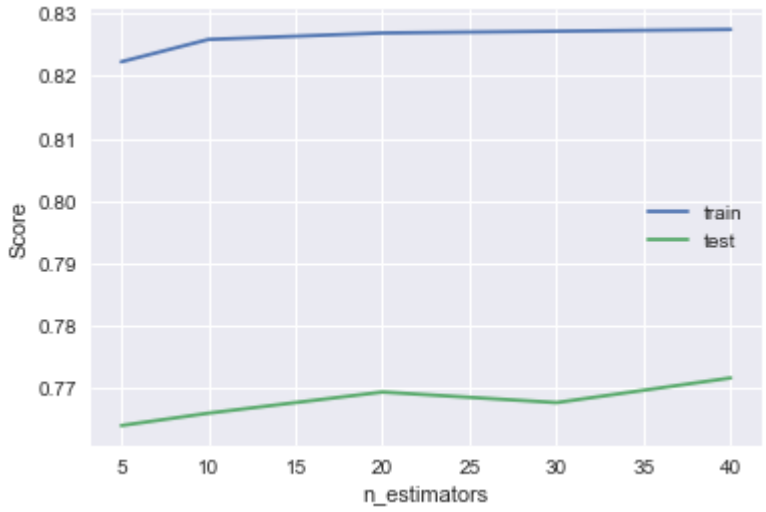
In [67]:
```
kvalues = [2, 5, 10, 20]
knntest = []
knntrain = []
for k in kvalues:
    knn= KNeighborsClassifier(n_neighbors=k)
    knn.fit(X_train, y_train)
    knntrain.append(knn.score(X_train, y_train))
    knntest.append(knn.score(X_test, y_test))
    print('Confusion Matrix for K = {}\n {}'.format(k, confusion_matrix(y_test,kn
    print('Classificaton Report: K = {} \n {}'.format(k, classification_report(y_
plt.plot(kvalues, knntrain, label = 'train')
plt.plot(kvalues, knntest, label = 'test')
plt.xlabel('K Value')
plt.ylabel('Score')
plt.legend()
plt.show()
```

```
Confusion Matrix for K = 2
 [[1032   43   80]
 [  91  506  137]
 [ 258  372 1024]]
Classificaton Report: K = 2
              precision    recall  f1-score   support

          0       0.75      0.89      0.81      1155
          1       0.55      0.69      0.61       734
          2       0.83      0.62      0.71      1654

avg / total       0.74      0.72      0.72      3543

Confusion Matrix for K = 5
 [[ 968   40  147]
 [ 101  362  271]
 [ 218  172 1264]]
Classificaton Report: K = 5
              precision    recall  f1-score   support

          0       0.75      0.84      0.79      1155
          1       0.63      0.49      0.55       734
          2       0.75      0.76      0.76      1654

avg / total       0.73      0.73      0.73      3543

Confusion Matrix for K = 10
 [[ 914   44  197]
 [ 138  291  305]
 [ 270  202 1182]]
Classificaton Report: K = 10
              precision    recall  f1-score   support

          0       0.69      0.79      0.74      1155
          1       0.54      0.40      0.46       734
          2       0.70      0.71      0.71      1654

avg / total       0.67      0.67      0.67      3543
```

```
Confusion Matrix for K = 20
 [[ 792   59  304]
 [ 146  206  382]
 [ 307  145 1202]]
Classificaton Report: K = 20
              precision    recall  f1-score   support

          0       0.64      0.69      0.66      1155
          1       0.50      0.28      0.36       734
          2       0.64      0.73      0.68      1654

avg / total       0.61      0.62      0.61      3543
```



In [59]:
```
est = [5, 10, 20, 30, 40]
rndtrain = []
rndtest = []

for s in est:
    rnd= RandomForestClassifier(random_state= rnd_state, n_estimators= s)
    rnd.fit(X_train, y_train)
    rndtrain.append(rnd.score(X_train, y_train))
    rndtest.append(rnd.score(X_test, y_test))

plt.plot(est, rndtrain, label = 'train')
plt.plot(est, rndtest, label = 'test')
plt.xlabel('n_estimators')
plt.ylabel('Score')
plt.legend()
plt.show()
```



In [60]:

```
pipe= Pipeline([('clr', RandomForestClassifier()),])
params= [


         #Multi classs Logistic Regression with quadratic terms
        {


        'clr': (LogisticRegressionCV(),),
        'clr__multi_class' : ('multinomial', 'ovr'),
        'clr__penalty' : ('l2',),

        },

         #RandomForestClassifier Parameter Tuning
        {

        'clr': (RandomForestClassifier(random_state= rnd_state, n_jobs = -1),
        'clr__n_estimators' : (10, 20),
        'clr__max_features': ('sqrt', None),

        },
        {
            #Linear Discriminant Analysis

        'clr': (LinearDiscriminantAnalysis(), )
        },
        {
            #- Quadratic Discriminant Analysis

            'clr': (QuadraticDiscriminantAnalysis(),)
        },


        {
            #- KNeighborsClassifier Parameter Tuning

        'clr': (KNeighborsClassifier(),),
        'clr__n_neighbors': (2, 5, 10, 20),
        }
        ]
gsearch = GridSearchCV(pipe, param_grid= params, cv=5)
gsearch.fit(X_train, y_train)
print('Train Score: ', gsearch.score(X_train, y_train))
print('Test Score: ', gsearch.score(X_test, y_test))
```

```
Train Score:  0.826856121201
Test Score:  0.76883996613
```

In [61]:
```
gsearch.best_params_
```

Out[61]:
```
{'clr': RandomForestClassifier(bootstrap=True, class_weight=None, criterion='gi
ni',
            max_depth=None, max_features=None, max_leaf_nodes=None,
            min_impurity_split=1e-07, min_samples_leaf=1,
            min_samples_split=2, min_weight_fraction_leaf=0.0,
            n_estimators=20, n_jobs=-1, oob_score=False, random_state=41,
            verbose=0, warm_start=False),
 'clr__max_features': None,
 'clr__n_estimators': 20}
```

In [62]:
```
#Confusion Matrix and Classfication Report
print('Confusion Matrix:\n', confusion_matrix(y_test,gsearch.predict(X_test)))
print('Classificaton Report: \n', classification_report(y_test,gsearch.predict(X_
```

```
Confusion Matrix:
 [[ 981   32  142]
 [  63  417  254]
 [ 151  177 1326]]
Classificaton Report:
              precision    recall  f1-score   support

          0       0.82      0.85      0.83      1155
          1       0.67      0.57      0.61       734
          2       0.77      0.80      0.79      1654

avg / total       0.77      0.77      0.77      3543
```

In [ ]:
```

```