In [ ]:

```
# CSE 311 Project Notebook
# Topic- Heart Failure Prediction using ANN Model
# Submitted By- Harsh Gupta
# Roll No-- 2020BCS0187
```

In [ ]:

```
import numpy as np
import pandas as pd
import matplotlib.pyplot as plt
from sklearn import preprocessing
from sklearn.preprocessing import StandardScaler
from sklearn.model_selection import train_test_split
import seaborn as sns
from keras.layers import Dense, BatchNormalization, Dropout, LSTM
from keras.models import Sequential
from tensorflow.keras.utils import to_categorical
from keras import callbacks
from sklearn.metrics import precision_score, recall_score, confusion_matrix, classification_report, accuracy_score, f1_score
```

In [ ]:

```
#loading data
data = pd.read_csv("/content/heart_failure_clinical_records_dataset.csv")
data.head()
```

Out[ ]:

	age	anaemia	creatinine_phosphokinase	diabetes	ejection_fraction	high_blood_pressure	platelets	serum_creatinine	serum_sodium	sex	smoking	time	DEATH_EVENT
0	75.0	0	582	0	20	1	265000.00	1.9	130	1	0	4	1
1	55.0	0	7861	0	38	0	263358.03	1.1	136	1	0	6	1
2	65.0	0	146	0	20	0	162000.00	1.3	129	1	1	7	1
3	50.0	1	111	0	20	0	210000.00	1.9	137	1	0	7	1
4	65.0	1	160	1	20	0	327000.00	2.7	116	0	0	8	1

In [ ]:

```
data.info()
```

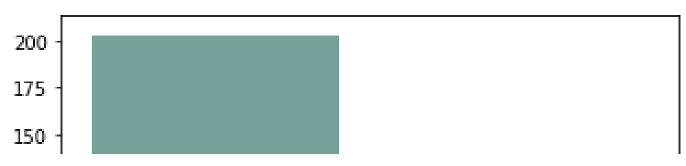
```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 299 entries, 0 to 298
Data columns (total 13 columns):
 #   Column                    Non-Null Count  Dtype
---  ------                    --------------  -----
 0   age                       299 non-null    float64
 1   anaemia                   299 non-null    int64
 2   creatinine_phosphokinase  299 non-null    int64
 3   diabetes                  299 non-null    int64
 4   ejection_fraction         299 non-null    int64
 5   high_blood_pressure       299 non-null    int64
 6   platelets                 299 non-null    float64
 7   serum_creatinine          299 non-null    float64
 8   serum_sodium              299 non-null    int64
 9   sex                       299 non-null    int64
 10  smoking                   299 non-null    int64
 11  time                      299 non-null    int64
 12  DEATH_EVENT               299 non-null    int64
dtypes: float64(3), int64(10)
memory usage: 30.5 KB
```

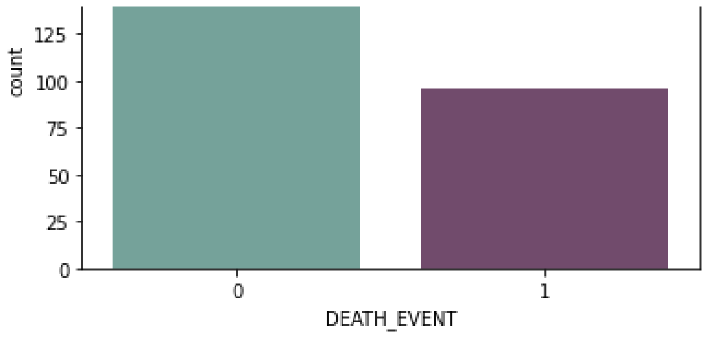
In [ ]:

```
#first of all let us evaluate the target and find out if our data is imbalanced or not
cols= ["#6daa9f","#774571"]
sns.countplot(x= data["DEATH_EVENT"], palette= cols)
```

Out[ ]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f6cf56ec9d0>
```





In [ ]:

```
#assigning values to features as X and target as y
X=data.drop(["DEATH_EVENT"],axis=1)
y=data["DEATH_EVENT"]
```

In [ ]:

```
#Set up a standard scaler for the features
col_names = list(X.columns)
s_scaler = preprocessing.StandardScaler()
X_df= s_scaler.fit_transform(X)
X_df = pd.DataFrame(X_df, columns=col_names)
X_df.describe().T
```

Out[ ]:

	count	mean	std	min	25%	50%	75%	max
age	299.0	5.265205e-16	1.001676	-1.754448	-0.828124	-0.070223	0.771889	2.877170
anaemia	299.0	3.594301e-16	1.001676	-0.871105	-0.871105	-0.871105	1.147968	1.147968
creatinine_phosphokinase	299.0	3.713120e-18	1.001676	-0.576918	-0.480393	-0.342574	0.000166	7.514640
diabetes	299.0	1.113936e-16	1.001676	-0.847579	-0.847579	-0.847579	1.179830	1.179830
ejection_fraction	299.0	3.341808e-18	1.001676	-2.038387	-0.684180	-0.007077	0.585389	3.547716
high_blood_pressure	299.0	-4.841909e-16	1.001676	-0.735688	-0.735688	-0.735688	1.359272	1.359272
platelets	299.0	1.009969e-16	1.001676	-2.440155	-0.520870	-0.013908	0.411120	6.008180
serum_creatinine	299.0	-2.227872e-18	1.001676	-0.865509	-0.478205	-0.284552	0.005926	7.752020
serum_sodium	299.0	-8.627435e-16	1.001676	-5.363206	-0.595996	0.085034	0.766064	2.582144
sex	299.0	-5.940993e-18	1.001676	-1.359272	-1.359272	0.735688	0.735688	0.735688
smoking	299.0	-3.861645e-17	1.001676	-0.687682	-0.687682	-0.687682	1.454161	1.454161
time	299.0	-1.069379e-16	1.001676	-1.629502	-0.739000	-0.196954	0.938759	1.997038

In [ ]:

```
#spliting test and training sets
X_train, X_test, y_train,y_test = train_test_split(X_df,y,test_size=0.25,random_state=7)
```

In [ ]:

```
early_stopping = callbacks.EarlyStopping(
    min_delta=0.001, # minimium amount of change to count as an improvement
    patience=30, # how many epochs to wait before stopping
    restore_best_weights=True)

# Initialising the NN
model = Sequential()

# layers
model.add(Dense(units = 16, kernel_initializer = 'uniform', activation = 'relu', input_dim = 12))
model.add(Dense(units = 8, kernel_initializer = 'uniform', activation = 'relu'))
model.add(Dropout(0.25))
model.add(Dense(units = 4, kernel_initializer = 'uniform', activation = 'relu'))
model.add(Dropout(0.5))
model.add(Dense(units = 1, kernel_initializer = 'uniform', activation = 'sigmoid'))
from tensorflow.keras.optimizers import SGD
# Compiling the ANN
model.compile(optimizer = 'adam', loss = 'binary_crossentropy', metrics = ['accuracy'])
```

In [ ]:

```
# Train the ANN
history = model.fit(X_train, y_train, batch_size = 32, epochs = 500,callbacks=[early_stopping], validation_split=0.2)
```

```
Epoch 1/500

6/6 [==============================] - 1s 33ms/step - loss: 0.6928 - accuracy: 0.6257 - val_loss: 0.6922 - val_accuracy: 0.6667

Epoch 2/500

6/6 [==============================] - 0s 6ms/step - loss: 0.6920 - accuracy: 0.6480 - val_loss: 0.6913 - val_accuracy: 0.6667

Epoch 3/500

6/6 [==============================] - 0s 5ms/step - loss: 0.6912 - accuracy: 0.6480 - val_loss: 0.6905 - val_accuracy: 0.6667

Epoch 4/500

6/6 [==============================] - 0s 5ms/step - loss: 0.6904 - accuracy: 0.6480 - val_loss: 0.6895 - val_accuracy: 0.6667

Epoch 5/500

6/6 [==============================] - 0s 5ms/step - loss: 0.6896 - accuracy: 0.6480 - val_loss: 0.6886 - val_accuracy: 0.6667
```

```
Epoch 6/500
6/6 [==============================] - 0s 6ms/step - loss: 0.6888 - accuracy: 0.6480 - val_loss: 0.6875 - val_accuracy: 0.6667
Epoch 7/500
6/6 [==============================] - 0s 7ms/step - loss: 0.6880 - accuracy: 0.6480 - val_loss: 0.6864 - val_accuracy: 0.6667
Epoch 8/500
6/6 [==============================] - 0s 5ms/step - loss: 0.6870 - accuracy: 0.6480 - val_loss: 0.6854 - val_accuracy: 0.6667
Epoch 9/500
6/6 [==============================] - 0s 7ms/step - loss: 0.6864 - accuracy: 0.6480 - val_loss: 0.6843 - val_accuracy: 0.6667
Epoch 10/500
6/6 [==============================] - 0s 5ms/step - loss: 0.6850 - accuracy: 0.6480 - val_loss: 0.6830 - val_accuracy: 0.6667
Epoch 11/500
6/6 [==============================] - 0s 6ms/step - loss: 0.6848 - accuracy: 0.6480 - val_loss: 0.6816 - val_accuracy: 0.6667
Epoch 12/500
6/6 [==============================] - 0s 6ms/step - loss: 0.6819 - accuracy: 0.6480 - val_loss: 0.6799 - val_accuracy: 0.6667
Epoch 13/500
6/6 [==============================] - 0s 6ms/step - loss: 0.6807 - accuracy: 0.6480 - val_loss: 0.6779 - val_accuracy: 0.6667
Epoch 14/500
6/6 [==============================] - 0s 5ms/step - loss: 0.6783 - accuracy: 0.6480 - val_loss: 0.6754 - val_accuracy: 0.6667
Epoch 15/500
6/6 [==============================] - 0s 6ms/step - loss: 0.6775 - accuracy: 0.6480 - val_loss: 0.6724 - val_accuracy: 0.6667
Epoch 16/500
6/6 [==============================] - 0s 6ms/step - loss: 0.6754 - accuracy: 0.6480 - val_loss: 0.6690 - val_accuracy: 0.6667
Epoch 17/500
6/6 [==============================] - 0s 5ms/step - loss: 0.6708 - accuracy: 0.6480 - val_loss: 0.6648 - val_accuracy: 0.6667
Epoch 18/500
6/6 [==============================] - 0s 5ms/step - loss: 0.6692 - accuracy: 0.6480 - val_loss: 0.6599 - val_accuracy: 0.6667
Epoch 19/500
6/6 [==============================] - 0s 6ms/step - loss: 0.6669 - accuracy: 0.6480 - val_loss: 0.6543 - val_accuracy: 0.6667
Epoch 20/500
6/6 [==============================] - 0s 7ms/step - loss: 0.6553 - accuracy: 0.6480 - val_loss: 0.6479 - val_accuracy: 0.6667
Epoch 21/500
6/6 [==============================] - 0s 6ms/step - loss: 0.6540 - accuracy: 0.6480 - val_loss: 0.6403 - val_accuracy: 0.6667
Epoch 22/500
6/6 [==============================] - 0s 5ms/step - loss: 0.6493 - accuracy: 0.6480 - val_loss: 0.6316 - val_accuracy: 0.6667
Epoch 23/500
6/6 [==============================] - 0s 5ms/step - loss: 0.6277 - accuracy: 0.6480 - val_loss: 0.6213 - val_accuracy: 0.6667
Epoch 24/500
6/6 [==============================] - 0s 6ms/step - loss: 0.6182 - accuracy: 0.6480 - val_loss: 0.6098 - val_accuracy: 0.6667
Epoch 25/500
6/6 [==============================] - 0s 6ms/step - loss: 0.6213 - accuracy: 0.6480 - val_loss: 0.5979 - val_accuracy: 0.6667
Epoch 26/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5953 - accuracy: 0.6536 - val_loss: 0.5859 - val_accuracy: 0.6667
Epoch 27/500
6/6 [==============================] - 0s 7ms/step - loss: 0.5999 - accuracy: 0.6816 - val_loss: 0.5738 - val_accuracy: 0.6667
Epoch 28/500
6/6 [==============================] - 0s 7ms/step - loss: 0.6019 - accuracy: 0.6927 - val_loss: 0.5638 - val_accuracy: 0.6667
Epoch 29/500
6/6 [==============================] - 0s 5ms/step - loss: 0.5793 - accuracy: 0.7207 - val_loss: 0.5539 - val_accuracy: 0.7111
Epoch 30/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5489 - accuracy: 0.7542 - val_loss: 0.5422 - val_accuracy: 0.7333
Epoch 31/500
```

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6/6 [==============================] - 0s 5ms/step - loss: 0.5821 - accuracy: 0.7263 - val_loss: 0.5322 - val_accuracy: 0.7111
Epoch 32/500
6/6 [==============================] - 0s 7ms/step - loss: 0.5622 - accuracy: 0.7207 - val_loss: 0.5244 - val_accuracy: 0.7333
Epoch 33/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5698 - accuracy: 0.7877 - val_loss: 0.5169 - val_accuracy: 0.7333
Epoch 34/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5522 - accuracy: 0.8268 - val_loss: 0.5111 - val_accuracy: 0.7778
Epoch 35/500
6/6 [==============================] - 0s 8ms/step - loss: 0.5451 - accuracy: 0.7821 - val_loss: 0.5062 - val_accuracy: 0.8222
Epoch 36/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5432 - accuracy: 0.8156 - val_loss: 0.5018 - val_accuracy: 0.8222
Epoch 37/500
6/6 [==============================] - 0s 5ms/step - loss: 0.5688 - accuracy: 0.7598 - val_loss: 0.4976 - val_accuracy: 0.8222
Epoch 38/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5659 - accuracy: 0.7989 - val_loss: 0.4950 - val_accuracy: 0.8222
Epoch 39/500
6/6 [==============================] - 0s 5ms/step - loss: 0.5577 - accuracy: 0.7989 - val_loss: 0.4920 - val_accuracy: 0.8222
Epoch 40/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5369 - accuracy: 0.7374 - val_loss: 0.4893 - val_accuracy: 0.8222
Epoch 41/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4860 - accuracy: 0.8268 - val_loss: 0.4853 - val_accuracy: 0.8222
Epoch 42/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4800 - accuracy: 0.7989 - val_loss: 0.4815 - val_accuracy: 0.8444
Epoch 43/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5182 - accuracy: 0.7933 - val_loss: 0.4774 - val_accuracy: 0.8444
Epoch 44/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5265 - accuracy: 0.7654 - val_loss: 0.4755 - val_accuracy: 0.8444
Epoch 45/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4815 - accuracy: 0.8156 - val_loss: 0.4734 - val_accuracy: 0.8444
Epoch 46/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5152 - accuracy: 0.7989 - val_loss: 0.4712 - val_accuracy: 0.8444
Epoch 47/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5018 - accuracy: 0.7877 - val_loss: 0.4686 - val_accuracy: 0.8444
Epoch 48/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5360 - accuracy: 0.7877 - val_loss: 0.4661 - val_accuracy: 0.8444
Epoch 49/500
6/6 [==============================] - 0s 7ms/step - loss: 0.5248 - accuracy: 0.7933 - val_loss: 0.4653 - val_accuracy: 0.8444
Epoch 50/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5213 - accuracy: 0.7765 - val_loss: 0.4651 - val_accuracy: 0.8444
Epoch 51/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5093 - accuracy: 0.7598 - val_loss: 0.4647 - val_accuracy: 0.8444
Epoch 52/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5256 - accuracy: 0.7933 - val_loss: 0.4634 - val_accuracy: 0.8444
Epoch 53/500
6/6 [==============================] - 0s 5ms/step - loss: 0.5239 - accuracy: 0.7821 - val_loss: 0.4636 - val_accuracy: 0.8444
Epoch 54/500
6/6 [==============================] - 0s 5ms/step - loss: 0.5002 - accuracy: 0.7821 - val_loss: 0.4635 - val_accuracy: 0.8444
Epoch 55/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4844 - accuracy: 0.8324 - val_loss: 0.4625 - val_accuracy: 0.8444
Epoch 56/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5403 - accuracy: 0.7933 - val_loss: 0.4615 - val_accuracy: 0.8444
Epoch 57/500
```

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Epoch 57/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4837 - accuracy: 0.7933 - val_loss: 0.4594 - val_accuracy: 0.8444
Epoch 58/500
6/6 [==============================] - 0s 7ms/step - loss: 0.4811 - accuracy: 0.8045 - val_loss: 0.4581 - val_accuracy: 0.8444
Epoch 59/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4945 - accuracy: 0.7933 - val_loss: 0.4578 - val_accuracy: 0.8444
Epoch 60/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4930 - accuracy: 0.8101 - val_loss: 0.4567 - val_accuracy: 0.8444
Epoch 61/500
6/6 [==============================] - 0s 9ms/step - loss: 0.5144 - accuracy: 0.8324 - val_loss: 0.4555 - val_accuracy: 0.8444
Epoch 62/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4744 - accuracy: 0.8045 - val_loss: 0.4548 - val_accuracy: 0.8444
Epoch 63/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5436 - accuracy: 0.7598 - val_loss: 0.4537 - val_accuracy: 0.8444
Epoch 64/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5208 - accuracy: 0.7933 - val_loss: 0.4532 - val_accuracy: 0.8444
Epoch 65/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4849 - accuracy: 0.8156 - val_loss: 0.4523 - val_accuracy: 0.8444
Epoch 66/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4636 - accuracy: 0.8324 - val_loss: 0.4512 - val_accuracy: 0.8444
Epoch 67/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4859 - accuracy: 0.8156 - val_loss: 0.4503 - val_accuracy: 0.8444
Epoch 68/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4803 - accuracy: 0.8156 - val_loss: 0.4496 - val_accuracy: 0.8444
Epoch 69/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4625 - accuracy: 0.8045 - val_loss: 0.4486 - val_accuracy: 0.8444
Epoch 70/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4425 - accuracy: 0.8380 - val_loss: 0.4478 - val_accuracy: 0.8444
Epoch 71/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4915 - accuracy: 0.7933 - val_loss: 0.4479 - val_accuracy: 0.8444
Epoch 72/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5052 - accuracy: 0.8156 - val_loss: 0.4472 - val_accuracy: 0.8444
Epoch 73/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4852 - accuracy: 0.7765 - val_loss: 0.4460 - val_accuracy: 0.8444
Epoch 74/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5137 - accuracy: 0.8156 - val_loss: 0.4460 - val_accuracy: 0.8444
Epoch 75/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4936 - accuracy: 0.8156 - val_loss: 0.4470 - val_accuracy: 0.8444
Epoch 76/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4781 - accuracy: 0.8436 - val_loss: 0.4484 - val_accuracy: 0.8444
Epoch 77/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5241 - accuracy: 0.7765 - val_loss: 0.4492 - val_accuracy: 0.8444
Epoch 78/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4498 - accuracy: 0.8380 - val_loss: 0.4492 - val_accuracy: 0.8444
Epoch 79/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4696 - accuracy: 0.8045 - val_loss: 0.4499 - val_accuracy: 0.8444
Epoch 80/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4611 - accuracy: 0.8156 - val_loss: 0.4512 - val_accuracy: 0.8444
Epoch 81/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4504 - accuracy: 0.8101 - val_loss: 0.4513 - val_accuracy: 0.8222
Epoch 82/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4684 - accuracy: 0.8380 - val_loss: 0.4504 - val_accuracy: 0.8222
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Epoch 83/500
6/6 [==============================] - 0s 6ms/step - loss: 0.5185 - accuracy: 0.7821 - val_loss: 0.4504 - val_accuracy: 0.8222
Epoch 84/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4573 - accuracy: 0.8156 - val_loss: 0.4510 - val_accuracy: 0.8222
Epoch 85/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4530 - accuracy: 0.8380 - val_loss: 0.4512 - val_accuracy: 0.8222
Epoch 86/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4350 - accuracy: 0.8101 - val_loss: 0.4506 - val_accuracy: 0.8222
Epoch 87/500
6/6 [==============================] - 0s 7ms/step - loss: 0.5209 - accuracy: 0.7989 - val_loss: 0.4498 - val_accuracy: 0.8222
Epoch 88/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4610 - accuracy: 0.7933 - val_loss: 0.4484 - val_accuracy: 0.8222
Epoch 89/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4899 - accuracy: 0.8101 - val_loss: 0.4471 - val_accuracy: 0.8222
Epoch 90/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4466 - accuracy: 0.8101 - val_loss: 0.4465 - val_accuracy: 0.8222
Epoch 91/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4500 - accuracy: 0.8101 - val_loss: 0.4459 - val_accuracy: 0.8000
Epoch 92/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4826 - accuracy: 0.8156 - val_loss: 0.4454 - val_accuracy: 0.8222
Epoch 93/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4906 - accuracy: 0.8101 - val_loss: 0.4452 - val_accuracy: 0.8000
Epoch 94/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4228 - accuracy: 0.8603 - val_loss: 0.4429 - val_accuracy: 0.8000
Epoch 95/500
6/6 [==============================] - 0s 7ms/step - loss: 0.4502 - accuracy: 0.8212 - val_loss: 0.4408 - val_accuracy: 0.8222
Epoch 96/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4475 - accuracy: 0.8324 - val_loss: 0.4400 - val_accuracy: 0.8222
Epoch 97/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4363 - accuracy: 0.8771 - val_loss: 0.4399 - val_accuracy: 0.8444
Epoch 98/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4936 - accuracy: 0.7709 - val_loss: 0.4408 - val_accuracy: 0.8444
Epoch 99/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4666 - accuracy: 0.8212 - val_loss: 0.4400 - val_accuracy: 0.8444
Epoch 100/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4499 - accuracy: 0.8492 - val_loss: 0.4397 - val_accuracy: 0.8222
Epoch 101/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4476 - accuracy: 0.8156 - val_loss: 0.4394 - val_accuracy: 0.8222
Epoch 102/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4242 - accuracy: 0.8212 - val_loss: 0.4392 - val_accuracy: 0.8222
Epoch 103/500
6/6 [==============================] - 0s 7ms/step - loss: 0.4403 - accuracy: 0.8380 - val_loss: 0.4381 - val_accuracy: 0.8222
Epoch 104/500
6/6 [==============================] - 0s 8ms/step - loss: 0.4527 - accuracy: 0.8324 - val_loss: 0.4364 - val_accuracy: 0.8222
Epoch 105/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4525 - accuracy: 0.8380 - val_loss: 0.4361 - val_accuracy: 0.8222
Epoch 106/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4658 - accuracy: 0.8156 - val_loss: 0.4354 - val_accuracy: 0.8222
Epoch 107/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4378 - accuracy: 0.8492 - val_loss: 0.4350 - val_accuracy: 0.8222
Epoch 108/500
```

```
6/6 [==============================] - 0s 6ms/step - loss: 0.4689 - accuracy: 0.8268 - val_loss: 0.4343 - val_accuracy: 0.8222
Epoch 109/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4726 - accuracy: 0.8101 - val_loss: 0.4339 - val_accuracy: 0.8222
Epoch 110/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4673 - accuracy: 0.8268 - val_loss: 0.4345 - val_accuracy: 0.8444
Epoch 111/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4661 - accuracy: 0.8045 - val_loss: 0.4353 - val_accuracy: 0.8444
Epoch 112/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4813 - accuracy: 0.8212 - val_loss: 0.4343 - val_accuracy: 0.8444
Epoch 113/500
6/6 [==============================] - 0s 7ms/step - loss: 0.4778 - accuracy: 0.8380 - val_loss: 0.4347 - val_accuracy: 0.8444
Epoch 114/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4465 - accuracy: 0.8380 - val_loss: 0.4365 - val_accuracy: 0.8444
Epoch 115/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4860 - accuracy: 0.8156 - val_loss: 0.4389 - val_accuracy: 0.8222
Epoch 116/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4376 - accuracy: 0.8380 - val_loss: 0.4397 - val_accuracy: 0.8222
Epoch 117/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4225 - accuracy: 0.8547 - val_loss: 0.4407 - val_accuracy: 0.8222
Epoch 118/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4274 - accuracy: 0.8492 - val_loss: 0.4401 - val_accuracy: 0.8222
Epoch 119/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4332 - accuracy: 0.8268 - val_loss: 0.4394 - val_accuracy: 0.8222
Epoch 120/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4539 - accuracy: 0.8380 - val_loss: 0.4384 - val_accuracy: 0.8222
Epoch 121/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4899 - accuracy: 0.8156 - val_loss: 0.4389 - val_accuracy: 0.8222
Epoch 122/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4480 - accuracy: 0.8324 - val_loss: 0.4384 - val_accuracy: 0.8222
Epoch 123/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4614 - accuracy: 0.8101 - val_loss: 0.4384 - val_accuracy: 0.8222
Epoch 124/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4357 - accuracy: 0.8492 - val_loss: 0.4389 - val_accuracy: 0.8222
Epoch 125/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4377 - accuracy: 0.8045 - val_loss: 0.4390 - val_accuracy: 0.8222
Epoch 126/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4016 - accuracy: 0.8492 - val_loss: 0.4390 - val_accuracy: 0.8222
Epoch 127/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4785 - accuracy: 0.8101 - val_loss: 0.4390 - val_accuracy: 0.8222
Epoch 128/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4202 - accuracy: 0.8492 - val_loss: 0.4388 - val_accuracy: 0.8222
Epoch 129/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4321 - accuracy: 0.8380 - val_loss: 0.4389 - val_accuracy: 0.8222
Epoch 130/500
6/6 [==============================] - 0s 5ms/step - loss: 0.4375 - accuracy: 0.8659 - val_loss: 0.4389 - val_accuracy: 0.8222
Epoch 131/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4042 - accuracy: 0.8771 - val_loss: 0.4410 - val_accuracy: 0.8222
Epoch 132/500
6/6 [==============================] - 0s 9ms/step - loss: 0.4403 - accuracy: 0.7989 - val_loss: 0.4412 - val_accuracy: 0.8222
Epoch 133/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4407 - accuracy: 0.8547 - val_loss: 0.4407 - val_accuracy: 0.8222
```

```
Epoch 134/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4331 - accuracy: 0.8436 - val_loss: 0.4410 - val_accuracy: 0.8222
Epoch 135/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4662 - accuracy: 0.7933 - val_loss: 0.4419 - val_accuracy: 0.8222
Epoch 136/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4525 - accuracy: 0.8324 - val_loss: 0.4418 - val_accuracy: 0.8222
Epoch 137/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4779 - accuracy: 0.8156 - val_loss: 0.4425 - val_accuracy: 0.8222
Epoch 138/500
6/6 [==============================] - 0s 6ms/step - loss: 0.4539 - accuracy: 0.8324 - val_loss: 0.4420 - val_accuracy: 0.8222
Epoch 139/500
6/6 [==============================] - 0s 7ms/step - loss: 0.4560 - accuracy: 0.8380 - val_loss: 0.4421 - val_accuracy: 0.8222
```

In [ ]:

```
val_accuracy = np.mean(history.history['val_accuracy'])
print("\n%s: %.2f%%" % ('val_accuracy', val_accuracy*100))
```

```
val_accuracy: 79.41%
```

In [ ]:

```
# Predicting the test set results
y_pred = model.predict(X_test)
y_pred = (y_pred > 0.5)
np.set_printoptions()
```

In [ ]:

```
y_test
```

Out[ ]:

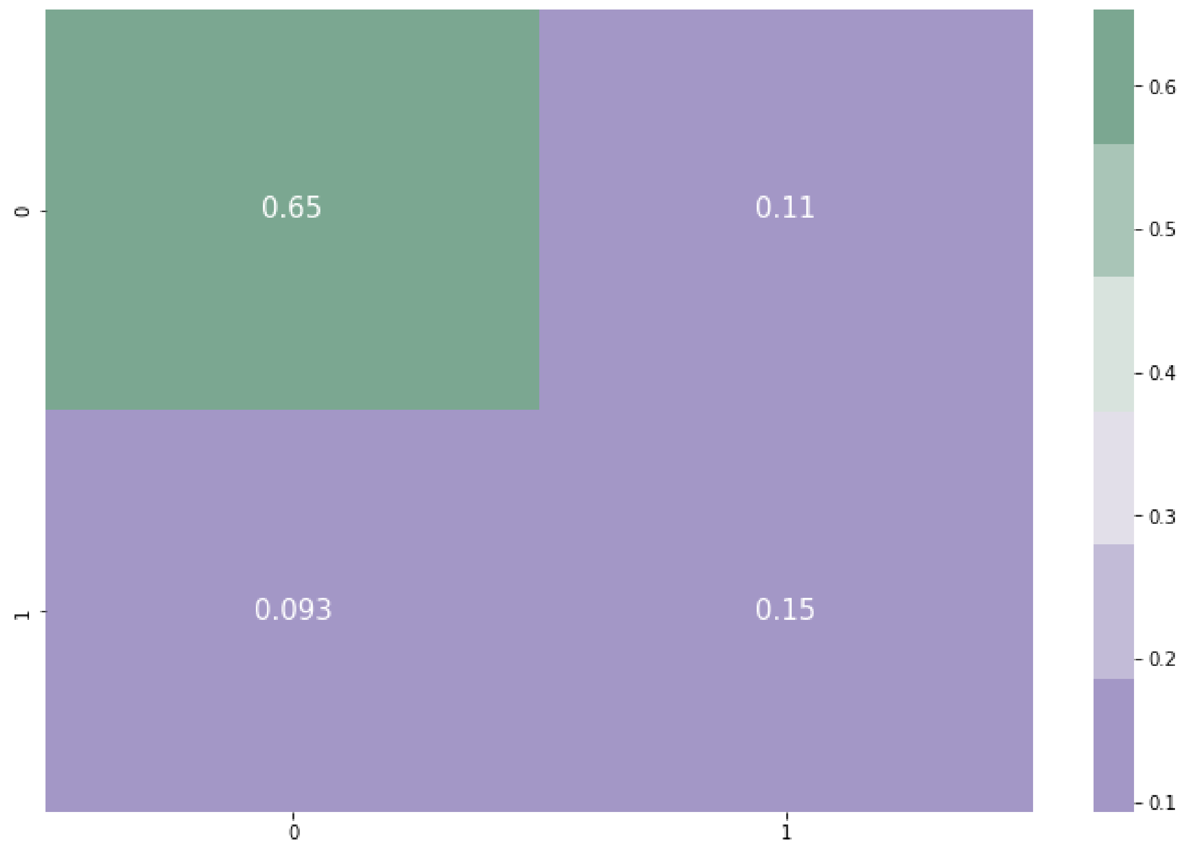
```
268    0
240    0
278    0
176    0
202    0
      ..
24     1
62     0
249    0
90     0
50     1
Name: DEATH_EVENT, Length: 75, dtype: int64
```

In [ ]:

```
cmap1 = sns.diverging_palette(275,150,  s=40, l=65, n=6)
plt.subplots(figsize=(12,8))
cf_matrix = confusion_matrix(y_test, y_pred)
sns.heatmap(cf_matrix/np.sum(cf_matrix), cmap = cmap1, annot = True, annot_kws = {'size':15})
```

Out[ ]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x7f6ce89e3490>
```



In [ ]:

In [ ]:

```

```

In [ ]:

```

```