```
# https://www.kaggle.com/tanmoyx/covid19-patient-precondition-dataset?select=covid.cs
# sex: Female - 1, Male - 2
# patien_type:Outpatient - 1, Inpatient - 2
# intubed:Yes - 1, No - 2, Data missing or NA - 97,98,99
# pneumonia:Yes - 1, No - 2, Data missing or NA - 97,98,99
# age: continues variable
# pregnancy Yes - 1, No - 2, Data missing or NA - 97,98,99
# diabetes Yes - 1, No - 2, Data missing or NA - 97,98,99
# copd Yes - 1, No - 2, Data missing or NA - 97,98,99
# asthma Yes - 1, No - 2, Data missing or NA - 97,98,99
# inmsupr Yes - 1, No - 2, Data missing or NA - 97,98,99
# hypertension Yes - 1, No - 2, Data missing or NA - 97,98,99
# other_disease Yes - 1, No - 2, Data missing or NA - 97,98,99
# cardiovascular Yes - 1, No - 2, Data missing or NA - 97,98,99
# obesity Yes - 1, No - 2, Data missing or NA - 97,98,99
# renal_chronic Yes - 1, No - 2, Data missing or NA - 97,98,99
# tobacco Yes - 1, No - 2, Data missing or NA - 97,98,99
# contact_other_covid Yes - 1, No - 2, Data missing or NA - 97,98,99
# covid_res Positive - 1, Negative - 2, Awaiting Results - 3
# icu Yes - 1, No - 2, Data missing or NA - 97,98,99
```

```
import pandas as pd
import datetime
import numpy as np
import matplotlib.pyplot as plt
from sklearn.ensemble import RandomForestClassifier
from sklearn.metrics import classification_report, confusion_matrix
from sklearn.ensemble import GradientBoostingClassifier
from xgboost import XGBClassifier
from sklearn import metrics
from sklearn.tree import DecisionTreeClassifier
from sklearn.datasets import load_digits
from sklearn.model_selection import train_test_split
from sklearn.model_selection import GridSearchCV
from sklearn.model_selection import cross_val_score
from sklearn.model_selection import StratifiedKFold
from sklearn.metrics import accuracy_score
import matplotlib.pyplot as plt
import numpy as np
from sklearn import datasets
```

```
# read data
df = pd.read_csv('covid.csv')

df.head()
```

	id	sex	patient_type	entry_date	date_symptoms	date_died	intubed	pneum
0	16169f	2	1	04-05-2020	02-05-2020	9999-99-99	97	
1	1009bf	2	1	19-03-2020	17-03-2020	9999-99-99	97	
2	167386	1	2	06-04-2020	01-04-2020	9999-99-99	2	
3	0b5948	2	2	17-04-2020	10-04-2020	9999-99-99	2	

```
df.columns
```

```
Index(['id', 'sex', 'patient_type', 'entry_date', 'date_symptoms', 'date_died',
       'intubed', 'pneumonia', 'age', 'pregnancy', 'diabetes', 'copd',
       'asthma', 'inmsupr', 'hypertension', 'other_disease', 'cardiovascular',
       'obesity', 'renal_chronic', 'tobacco', 'contact_other_covid',
       'covid_res', 'icu'],
      dtype='object')
```

```
df.describe()
```

	sex	patient_type	intubed	pneumonia	age	pre
count	566602.000000	566602.000000	566602.000000	566602.000000	566602.000000	566602
mean	1.506726	1.215165	76.562952	1.846262	42.622483	50
std	0.499955	0.410937	39.058676	0.560939	16.659973	47
min	1.000000	1.000000	1.000000	1.000000	0.000000	1
25%	1.000000	1.000000	97.000000	2.000000	31.000000	2
50%	2.000000	1.000000	97.000000	2.000000	41.000000	97
75%	2.000000	1.000000	97.000000	2.000000	53.000000	97
max	2.000000	2.000000	99.000000	99.000000	120.000000	98

```
# missing values
# avoid acciendentally delete ages = 97,98,99

#intubed
df=df[df['intubed']!=99]
df=df[df['intubed']!=98]
df=df[df['intubed']!=97]

#pneumonia
df=df[df['pneumonia']!=99]
df=df[df['pneumonia']!=98]
df=df[df['pneumonia']!=97]

#pregnancy
```

```
    #pregnancy
    df=df[df['pregnancy']!=99]
    df=df[df['pregnancy']!=98]
    df=df[df['pregnancy']!=97]

    #diabetes
    df=df[df['diabetes']!=99]
    df=df[df['diabetes']!=98]
    df=df[df['diabetes']!=97]

    #copd
    df=df[df['copd']!=99]
    df=df[df['copd']!=98]
    df=df[df['copd']!=97]

    #asthma
    df=df[df['asthma']!=99]
    df=df[df['asthma']!=98]
    df=df[df['asthma']!=97]

    #inmsupr
    df=df[df['inmsupr']!=99]
    df=df[df['inmsupr']!=98]
    df=df[df['inmsupr']!=97]

    #hypertension
    df=df[df['hypertension']!=99]
    df=df[df['hypertension']!=98]
    df=df[df['hypertension']!=97]

    #other_disease
    df=df[df['other_disease']!=99]
    df=df[df['other_disease']!=98]
    df=df[df['other_disease']!=97]

    #cardiovascular
    df=df[df['cardiovascular']!=99]
    df=df[df['cardiovascular']!=98]
    df=df[df['cardiovascular']!=97]

    #obesity
    df=df[df['obesity']!=99]
    df=df[df['obesity']!=98]
    df=df[df['obesity']!=97]

    #renal_chronic
    df=df[df['renal_chronic']!=99]
    df=df[df['renal_chronic']!=98]
    df=df[df['renal_chronic']!=97]

    #tobacco
    df=df[df['tobacco']!=99]
```

```
df=df[df['tobacco']!=98]
df=df[df['tobacco']!=97]

#contact_other_covid
df=df[df['contact_other_covid']!=99]
df=df[df['contact_other_covid']!=98]
df=df[df['contact_other_covid']!=97]

#covid_res
df=df[df['covid_res']!=99]
df=df[df['covid_res']!=98]
df=df[df['covid_res']!=97]

#icu
df=df[df['icu']!=99]
df=df[df['icu']!=98]
df=df[df['icu']!=97]

df.head()
df.describe()
```

	sex	patient_type	intubed	pneumonia	age	pregnancy	
count	23158.0	23158.0	23158.000000	23158.000000	23158.000000	23158.000000	23
mean	1.0	2.0	1.889412	1.351585	50.538734	1.975775	
std	0.0	0.0	0.313628	0.477475	20.730387	0.153750	
min	1.0	2.0	1.000000	1.000000	0.000000	1.000000	
25%	1.0	2.0	2.000000	1.000000	37.000000	2.000000	
50%	1.0	2.0	2.000000	1.000000	52.000000	2.000000	
75%	1.0	2.0	2.000000	2.000000	65.000000	2.000000	
max	1.0	2.0	2.000000	2.000000	115.000000	2.000000	

```
# all sex = 1 and all patient_type = 2, drop the first two columns: only focus on fem
# we don't care about id: drop it


df = df.drop(['id','sex','patient_type'], axis = 1)

df.describe()
df.head()
```

	entry_date	date_symptoms	date_died	intubed	pneumonia	age	pregnancy	dia
21	02-06-2020	02-06-2020	9999-99-99	2	2	25	2	
30	22-06-2020	17-06-2020	9999-99-99	2	2	52	2	
71	17-06-2020	12-06-2020	9999-99-99	2	1	51	2	

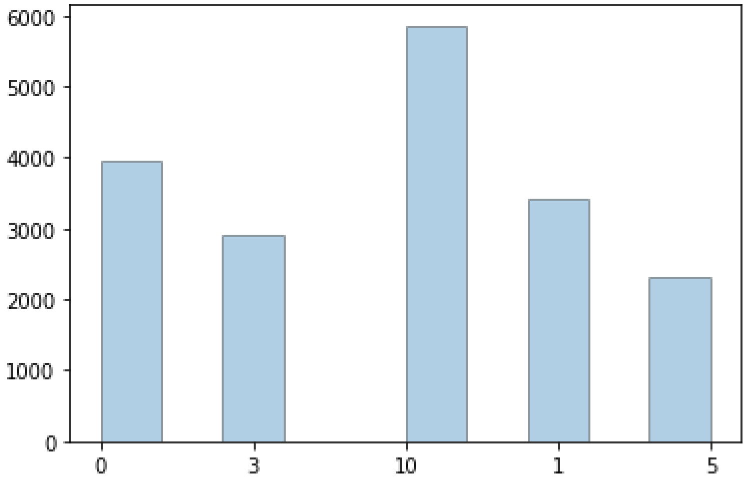
```
# New column fatality: Yes-dead; No-Recovered
# df['fatality'] = np.where(df['date_died'] != '9999-99-99', 'Yes', 'No')
df['fatality'] = np.where(df['date_died'] != '9999-99-99', 1, 2)

# calculate entry - symptoms; only include valid records
df['entry_symptoms'] = pd.DataFrame(pd.to_datetime(df['entry_date']) - pd.to_datetime

# dropping units
df['entry_symptoms'] = pd.to_numeric(df['entry_symptoms'].astype(str).str[:-4], error

# only include valid records
df = df[df['entry_symptoms'] >= 0]

df.head()
```

her_disease	cardiovascular	obesity	renal_chronic	tobacco	contact_other_covid
2	2	2	2	2	1
2	2	1	2	1	1
2	2	1	2	2	1
2	2	2	2	2	1
2	1	2	2	2	2

```
# drop useless columns
df = df.drop(['entry_date','date_symptoms','date_died'], axis = 1)

df.describe()
```

	intubed	pneumonia	age	pregnancy	diabetes	copd
count	18458.000000	18458.000000	18458.000000	18458.000000	18458.000000	18458.000000
mean	1.889479	1.366508	50.030285	1.974808	1.711561	1.953624

```
conditions = [
    (df['entry_symptoms'] <= 1),
    (df['entry_symptoms'] > 1) & (df['entry_symptoms'] <= 3),
    (df['entry_symptoms'] > 3) & (df['entry_symptoms'] <= 5),
    (df['entry_symptoms'] > 5) & (df['entry_symptoms'] <= 10),
    (df['entry_symptoms'] > 10)
    ]

values = ['0', '1', '3', '5','10']

df['date_diff_level'] = np.select(conditions, values)

plt.hist(df['date_diff_level'], edgecolor='k', alpha=0.35)
plt.show()
```



```
df.head()
```

	intubed	pneumonia	age	pregnancy	diabetes	copd	asthma	inmsupr	hyperten
21	2	2	25	2	2	2	2	2	
30	2	2	52	2	2	2	2	2	
79	1	1	67	2	1	2	2	2	
93	2	1	59	2	1	2	2	2	
215	2	2	52	2	1	2	2	2	

```
# no longer need entry-symptoms: drop column
```

```
df = df.drop(['entry_symptoms'], axis = 1)
```

```
df.head()
```

	intubed	pneumonia	age	pregnancy	diabetes	copd	asthma	inmsupr	hyperter
21	2	2	25	2	2	2	2	2	
30	2	2	52	2	2	2	2	2	
79	1	1	67	2	1	2	2	2	
93	2	1	59	2	1	2	2	2	
215	2	2	52	2	1	2	2	2	

```
df.describe()
```

_disease	cardiovascular	obesity	renal_chronic	tobacco	contact_other_co
58.000000	18458.000000	18458.000000	18458.000000	18458.000000	18458.000
1.954383	1.946527	1.776303	1.951457	1.957688	1.695
0.208659	0.224980	0.416733	0.214916	0.201306	0.460
1.000000	1.000000	1.000000	1.000000	1.000000	1.000
2.000000	2.000000	2.000000	2.000000	2.000000	1.000
2.000000	2.000000	2.000000	2.000000	2.000000	2.000
2.000000	2.000000	2.000000	2.000000	2.000000	2.000
2.000000	2.000000	2.000000	2.000000	2.000000	2.000

```
df.to_csv(path_or_buf="data_ready.csv")
```

```
#CLASSIFICATION TREE
```

```
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.2, random_state
```

```
dt = DecisionTreeClassifier() # default tree
dt.fit(x_train,y_train)
dt.predict(x_test)
```

```
array([2, 1, 2, ..., 1, 2, 2])
```

```
dt.score(x_test, y_test)
```

```
    0.7765438786565547
```

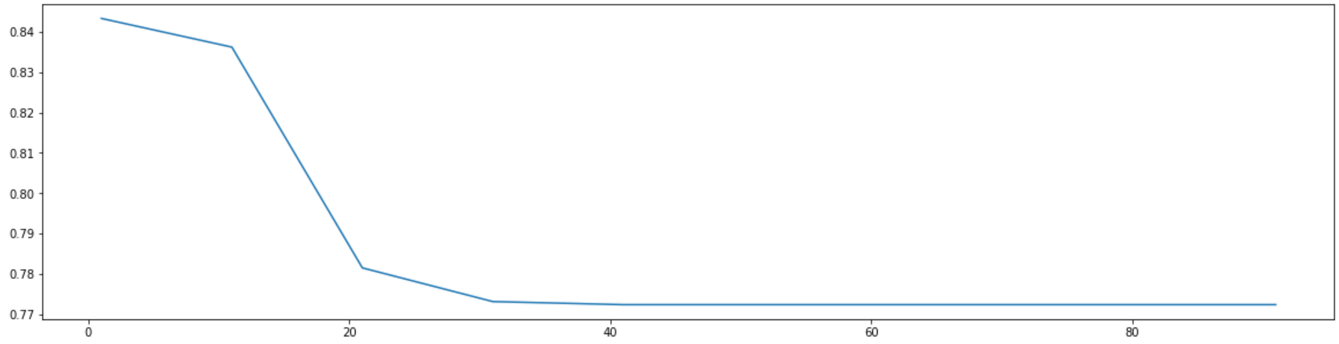
```
dt1 = DecisionTreeClassifier(random_state = 66)
score = cross_val_score(dt1,x_train,y_train,cv=10).mean()
print('gini score: %.5f'%score)
dt2 = DecisionTreeClassifier(criterion = 'entropy',random_state = 66)
score = cross_val_score(dt2,x_train,y_train,cv=10).mean()
print('entropy score: %.5f'%score)
```

```
    gini score: 0.77841
    entropy score: 0.77888
```

It can be seen above that the result using entropy is slightly better than using gini.

```
# draw the plot for parameter:max_depth
ScoreAll = []
for i in range(1,100,10):
    dt = DecisionTreeClassifier(criterion = 'entropy',max_depth = i,random_state = 66
    score = cross_val_score(dt,x,y,cv=10).mean()
    ScoreAll.append([i,score])
ScoreAll = np.array(ScoreAll)

max_score = np.where(ScoreAll==np.max(ScoreAll[:,1]))[0][0]
print("best parameter and score:",ScoreAll[max_score])
# print(ScoreAll[,0])
plt.figure(figsize=[20,5])
plt.plot(ScoreAll[:,0],ScoreAll[:,1])
plt.show()
```

```
    best parameter and score: [1.         0.84326627]
```



```
param = {'criterion':['gini'],'max_depth':[15,20,30,50,60,100],'min_samples_leaf':[2,
grid = GridSearchCV(DecisionTreeClassifier(),param_grid=param,cv=10)
grid.fit(x_train,y_train)
```

```
print('best classifier:',grid.best_params_,'best score:', grid.best_score_)

     best classifier: {'criterion': 'gini', 'max_depth': 15, 'min_impurity_decrease':
```

```
dt3 = DecisionTreeClassifier(max_depth=15,min_samples_leaf=2,min_impurity_decrease=0.
dt3.fit(x_train,y_train)
y_pred = dt3.predict(x_test)
print('train set score', dt3.score(x_train,y_train),'test set score',dt3.score(x_test

     train set score 0.8348232425843153 test set score 0.83261105092091
```

```
# RANDOM FOREST
```

```
y = df['fatality']
x = df.drop('fatality',axis = 1)
```

```
# all default
rf0 = RandomForestClassifier(oob_score=True, random_state=10)
rf0.fit(x,y)
print(rf0.oob_score_)
y_predprob = rf0.predict_proba(x)[:,1]
print("AUC Score (Train): %f" % metrics.roc_auc_score(y, y_predprob))

     0.8252248347599956
     AUC Score (Train): 0.990963
```

```
print(rf0.feature_importances_)

     [0.12004049 0.0456253  0.42619197 0.00258172 0.02771941 0.01518592
      0.00950621 0.01235143 0.02652667 0.01306905 0.01601859 0.02990498
      0.0152589  0.0142912  0.02859993 0.06717499 0.02562033 0.10433292]
```

```
feat_importances = pd.Series(rf0.feature_importances_, index=x.columns)
feat_importances.nlargest(5).plot(kind='barh')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fc94bed12e8>
```

```
param_test1 = {'n_estimators':range(10,201,10)}
gsearch1 = GridSearchCV(estimator = RandomForestClassifier(min_samples_split=100,
                                  min_samples_leaf=20,max_depth=8,max_features='sqrt'
                       param_grid = param_test1, scoring='roc_auc',cv=5)
gsearch1.fit(x,y)
print(gsearch1.best_params_, gsearch1.best_score_)
```

```
{'n_estimators': 70} 0.8173103675660242
          |                                       |
```

```
param_test2 = {'max_depth':range(2,18,2)}
gsearch2 = GridSearchCV(estimator = RandomForestClassifier(n_estimators=70,min_sample
                                  min_samples_leaf=20,max_features='sqrt',oob_score=T
   param_grid = param_test2, scoring='roc_auc',iid=False, cv=5)
gsearch2.fit(x,y)
print(gsearch2.best_params_, gsearch2.best_score_)
```

```
/usr/local/lib/python3.6/dist-packages/sklearn/model_selection/_search.py:823: F
  "removed in 0.24.", FutureWarning
{'max_depth': 8} 0.8173103675660242
```

```
param_test3 = {'min_samples_split':range(80,150,20), 'min_samples_leaf':range(5,50,5)
gsearch3 = GridSearchCV(estimator = RandomForestClassifier(n_estimators=70, max_depth
                                  max_features='sqrt' ,oob_score=True, random_state=1
   param_grid = param_test3, scoring='roc_auc',iid=False, cv=5)
gsearch3.fit(x,y)
print(gsearch3.best_params_, gsearch3.best_score_)
```

```
/usr/local/lib/python3.6/dist-packages/sklearn/model_selection/_search.py:823: F
  "removed in 0.24.", FutureWarning
{'min_samples_leaf': 10, 'min_samples_split': 80} 0.8182691645547792
```

```
param_test4 = {'max_features':range(2,18,1)}
gsearch4 = GridSearchCV(estimator = RandomForestClassifier(n_estimators=70, max_depth
                                  min_samples_leaf=10 ,oob_score=True, random_state=1
   param_grid = param_test4, scoring='roc_auc',iid=False, cv=5)
gsearch4.fit(x,y)
print(gsearch4.best_params_, gsearch4.best_score_)
```

```
/usr/local/lib/python3.6/dist-packages/sklearn/model_selection/_search.py:823: F
  "removed in 0.24.", FutureWarning
{'max_features': 4} 0.8182691645547792
```

```
rf1 = RandomForestClassifier(n_estimators= 70, max_depth=8, min_samples_split=80,
                                  min_samples_leaf=10,max_features=4 ,oob_score=True,
rf1.fit(x,y)
rf1.oob_score_
```

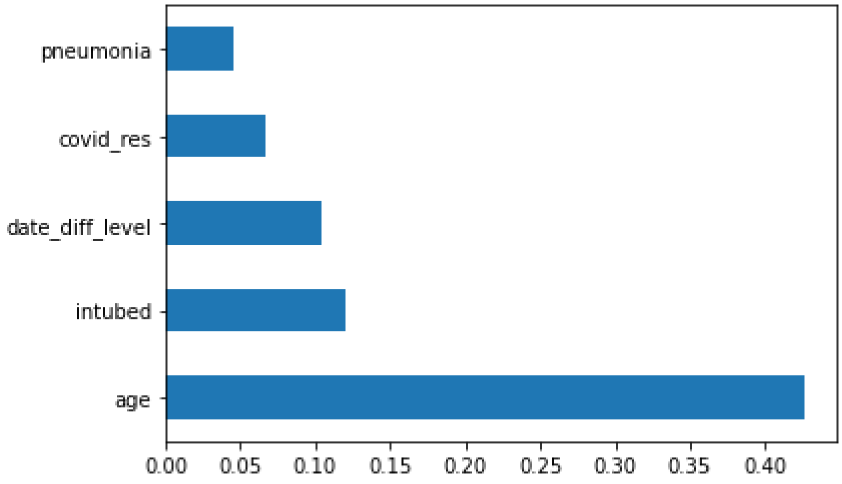
```
0.8590313143352476
```

```
print(rf1.feature_importances_)
```

```
[0.42408717 0.12972798 0.15079871 0.00139062 0.02527071 0.00403375
 0.00133224 0.0023524  0.02621899 0.00175527 0.00342501 0.00564984
 0.00579134 0.0020879  0.01153909 0.15610273 0.03071886 0.01771739]
```

```
feat_importances = pd.Series(rf0.feature_importances_, index=x.columns)
feat_importances.nlargest(5).plot(kind='barh')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fc94fbe1358>
```



```
#BOOSTING
```

```
x_train, x_test, y_train, y_test = train_test_split(x, y, test_size=0.2, random_state
```

```
lr_list = [0.05, 0.075, 0.1, 0.25, 0.5, 0.75, 1]

for learning_rate in lr_list:
    gb_clf = GradientBoostingClassifier(n_estimators=20, learning_rate=learning_rate,
    gb_clf.fit(x_train, y_train)

    print("Learning rate: ", learning_rate)
    print("Accuracy score (training):", gb_clf.score(x_train, y_train))
    print("Accuracy score (validation)",gb_clf.score(x_test, y_test))
```

```
Learning rate:  0.05
Accuracy score (training): 0.8348232425843153
Accuracy score (validation) 0.83261105092091
Learning rate:  0.075
Accuracy score (training): 0.8348232425843153
Accuracy score (validation) 0.83261105092091
Learning rate:  0.1
Accuracy score (training): 0.8397670323716646
Accuracy score (validation) 0.8388407367280607
Learning rate:  0.25
Accuracy score (training): 0.8545984017337126
Accuracy score (validation) 0.8534669555796316
Learning rate:  0.5
Accuracy score (training): 0.8545306785859407
Accuracy score (validation) 0.855092091007584
Learning rate:  0.75
Accuracy score (training): 0.8548692943248002
Accuracy score (validation) 0.8567172264355363
Learning rate:  1
Accuracy score (training): 0.8533116619260463
Accuracy score (validation) 0.8545503791982665
```

```
# select learning rate = 0.75
```

```
gb_clf2 = GradientBoostingClassifier(n_estimators=20, learning_rate=0.75, max_feature
gb_clf2.fit(x_train, y_train)
predictions = gb_clf2.predict(x_test)

print("Confusion Matrix:")
print(confusion_matrix(y_test, predictions))

print("Classification Report")
print(classification_report(y_test, predictions))
```

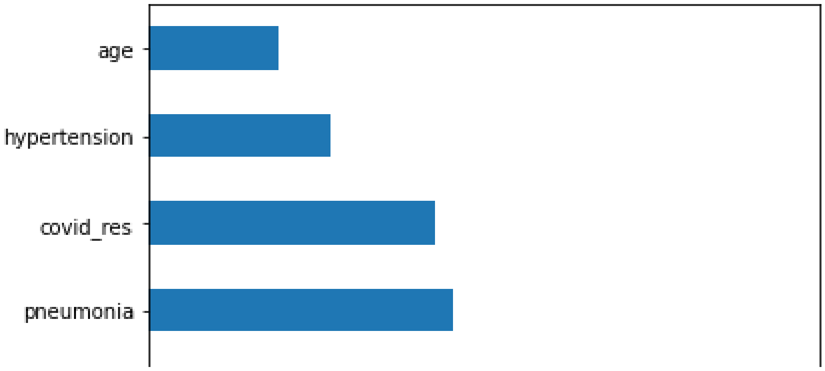
```
Confusion Matrix:
[[ 154  464]
 [  65 3009]]
Classification Report
              precision    recall  f1-score   support

           1       0.70      0.25      0.37       618
           2       0.87      0.98      0.92      3074

    accuracy                           0.86      3692
   macro avg       0.78      0.61      0.64      3692
weighted avg       0.84      0.86      0.83      3692
```

```
gb_clf2.feature_importances_
```

```
array([3.82104872e-01, 1.81913329e-01, 7.75160802e-02, 3.96470952e-03,
       1.80246054e-02, 7.19061622e-04, 4.49845684e-04, 2.18785324e-04,
       1.08708797e-01, 1.01214500e-03, 7.79165942e-04, 5.15157284e-03,
       0.00000000e+00, 1.81211554e-03, 1.91654633e-02, 1.71416604e-01,
       2.41496573e-02, 2.89319013e-03])
```

```
feat_importances = pd.Series(gb_clf2.feature_importances_, index=x.columns)
feat_importances.nlargest(5).plot(kind='barh')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fc94baa84a8>
```



```
x_train['date_diff_level'] = pd.to_numeric(x_train['date_diff_level'])
x_test['date_diff_level'] = pd.to_numeric(x_test['date_diff_level'])
```

```
xgb_clf3 = XGBClassifier()
xgb_clf3.fit(x_train, y_train)
```

```
XGBClassifier(base_score=0.5, booster='gbtree', colsample_bylevel=1,
              colsample_bynode=1, colsample_bytree=1, gamma=0,
              learning_rate=0.1, max_delta_step=0, max_depth=3,
              min_child_weight=1, missing=None, n_estimators=100, n_jobs=1,
              nthread=None, objective='binary:logistic', random_state=0,
              reg_alpha=0, reg_lambda=1, scale_pos_weight=1, seed=None,
              silent=None, subsample=1, verbosity=1)
```

```
score = xgb_clf3.score(x_test, y_test)
print(score)
```

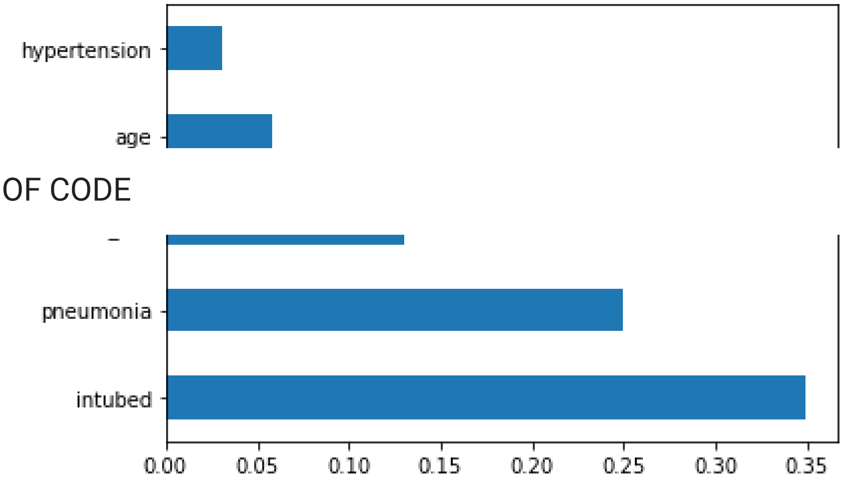
```
0.8580715059588299
```

```
xgb_clf3.feature_importances_
```

```
array([0.34893763, 0.24987316, 0.05811411, 0.00360326, 0.02819734,
       0.01367755, 0.01048905, 0.01532699, 0.03117329, 0.01278323,
       0.0086069 , 0.01742312, 0.01083909, 0.00928206, 0.02856785,
       0.13041076, 0.00714213, 0.01555254], dtype=float32)
```

```
feat_importances = pd.Series(xgb_clf3.feature_importances_, index=x.columns)
feat_importances.nlargest(5).plot(kind='barh')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fc942b82908>
```


hypertension
age
pneumonia
intubed
0.00
0.05
0.10
0.15
0.20
0.25
0.30
0.35

END OF CODE