```
import pandas as pd
import numpy as np

data=pd.read_csv('/content/metadata.csv')
data_extracted_initial=data[['finding','clinical_notes']]
nrow=data_extracted_initial.shape[0]


ncol=data_extracted_initial.shape[1]
print(nrow,ncol)

#Check if the rows with null values have to be removed
data_extracted_initial=data_extracted_initial.dropna()
nrow=data_extracted_initial.shape[0]
ncol=data_extracted_initial.shape[1]
print(nrow,ncol)
```

```
950 2
768 2
```

```
data_extracted_initial['finding'] = data_extracted_initial['finding'].str.replace("Pneumon
data_extracted_initial['finding'] = data_extracted_initial['finding'].str.replace("Pneumon
data_extracted_initial['finding'] = data_extracted_initial['finding'].str.replace("^Pneumo



virus = ['COVID-19','SARS','ARDS']
data_extracted = data_extracted_initial[data_extracted_initial.finding.str.contains('|'.jo

nrow=data_extracted.shape[0]
ncol=data_extracted.shape[1]
print(nrow,ncol)
data_extracted.finding.value_counts()
```

```
584 2
COVID-19    487
ARDS         81
SARS         16
Name: finding, dtype: int64
```

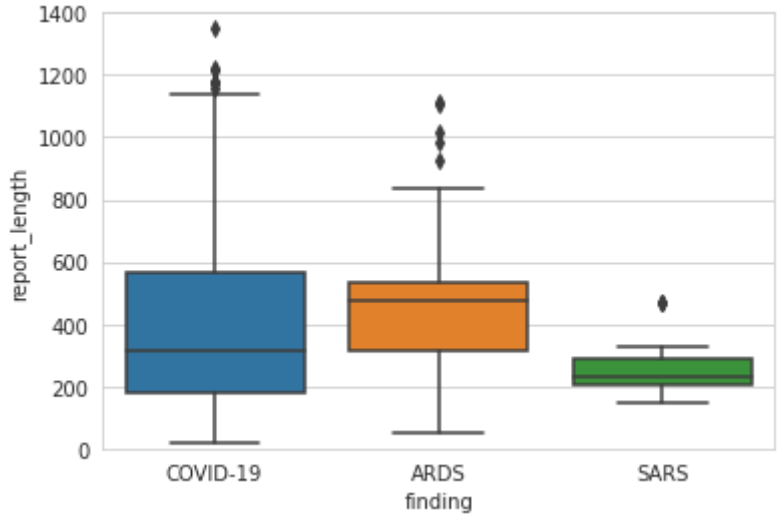
```
data_extracted["report_length"]= data_extracted["clinical_notes"].str.len()
data_extracted.head(10)
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:1: SettingWithCopyWarnir
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
  """Entry point for launching an IPython kernel.
```

	finding	clinical_notes	report_length
0	COVID-19	On January 22, 2020, a 65-year-old man with a ...	699
1	COVID-19	On January 22, 2020, a 65-year-old man with a ...	917
2	COVID-19	On January 22, 2020, a 65-year-old man with a ...	917
3	COVID-19	On January 22, 2020, a 65-year-old man with a ...	644

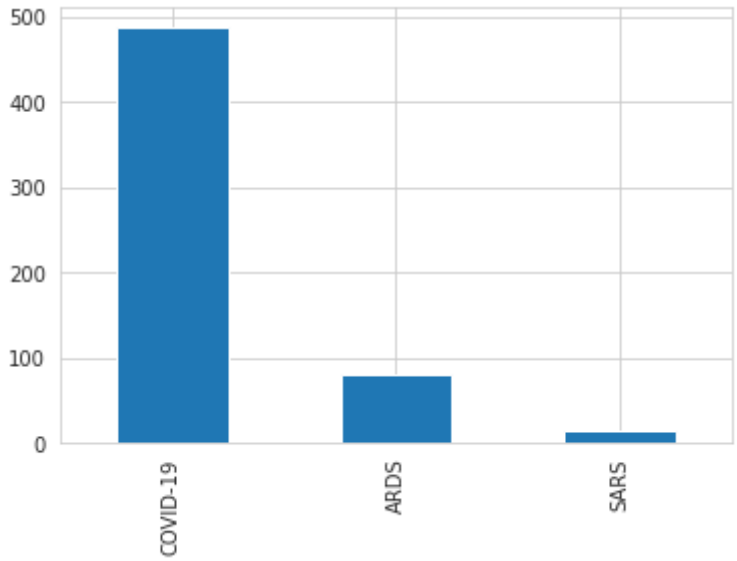
```
import seaborn as sns
sns.set_style("whitegrid")
ax=sns.boxplot(x = data_extracted['finding'], y = data_extracted['report_length'])
ax.set(ylim=(0, 1400))
```

```
[(0.0, 1400.0)]
```




```
data_extracted['finding'].value_counts().plot(kind='bar')
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa42dba69d0>
```



```
#Remove punctuation and convert everything to lower case
data_extracted['punctuation']=data_extracted['clinical_notes'].str.lower()
data_extracted['punctuation']=data_extracted['punctuation'].str.replace('[^\w\s]','')
data_extracted.head(10)
```

```
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:2: SettingWithCopyWarnir
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us

/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:3: SettingWithCopyWarnir
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
  This is separate from the ipykernel package so we can avoid doing imports until
```

	finding	clinical_notes	report_length	punctuation
0	COVID-19	On January 22, 2020, a 65-year-old man with a ...	699	on january 22 2020 a 65yearold man with a hist...
1	COVID-19	On January 22, 2020, a 65-year-old man with a ...	917	on january 22 2020 a 65yearold man with a hist...
2	COVID-19	On January 22, 2020, a 65-year-old man with a ...	917	on january 22 2020 a 65yearold man with a hist...
3	COVID-19	On January 22, 2020, a 65-year-old man with a ...	644	on january 22 2020 a 65yearold man with a hist...
4	COVID-19	diffuse infiltrates in the bilateral lower lungs	48	diffuse infiltrates in the bilateral lower lungs
5	COVID-19	progressive diffuse interstitial opacities and...	115	progressive diffuse interstitial opacities and...
6	ARDS	Severe ARDS. Person is intubated with an OG in...	53	severe ards person is intubated with an og in ...

```
#Lemmatisation (lemmatisation is not working properly)
import nltk
nltk.download('wordnet')
nltk.download('punkt')     #for word_tokenize function
w_tokenizer = nltk.tokenize.WhitespaceTokenizer()
lemmatizer = nltk.stem.WordNetLemmatizer()

def lemmatize_text(text):
  word_list=nltk.word_tokenize(text)
  txt=' '.join([lemmatizer.lemmatize(w,pos='v') for w in word_list])  #noun is not working
  #s=[lemmatizer.lemmatize(w) for w in w_tokenizer.tokenize(text)]
  #txt=' '.join(s)
  return txt

data_extracted['lemmatisation'] = data_extracted.punctuation.apply(lemmatize_text)
data_extracted.head(10)
```

```
[nltk_data] Downloading package wordnet to /root/nltk_data...
[nltk_data]   Unzipping corpora/wordnet.zip.
[nltk_data] Downloading package punkt to /root/nltk_data...
[nltk_data]   Unzipping tokenizers/punkt.zip.
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:15: SettingWithCopyWarni
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
  from ipykernel import kernelapp as app
```

	finding	clinical_notes	report_length	punctuation	lemmatisation
0	COVID-19	On January 22, 2020, a 65-year-old man with a ...	699	on january 22 2020 a 65yearold man with a hist...	on january 22 2020 a 65yearold man with a hist...
1	COVID-19	On January 22, 2020, a 65-year-old man with a ...	917	on january 22 2020 a 65yearold man with a hist...	on january 22 2020 a 65yearold man with a hist...
2	COVID-19	On January 22, 2020, a 65-year-old man with a ...	917	on january 22 2020 a 65yearold man with a hist...	on january 22 2020 a 65yearold man with a hist...
3	COVID-19	On January 22, 2020, a 65-year-old man with a ...	644	on january 22 2020 a 65yearold man with a hist...	on january 22 2020 a 65yearold man with a hist...
4	COVID-19	diffuse infiltrates in the bilateral lower lungs	48	diffuse infiltrates in the bilateral lower	diffuse infiltrate in the bilateral lower

```
#Stopword removal
nltk.download('stopwords')
from nltk.corpus import stopwords
stop = stopwords.words('english')

def stop_removal(text):
  t=[x for x in text.split() if x not in stop]
  s=' '.join(t)
  return s

data_extracted['stopwords']=data_extracted.lemmatisation.apply(stop_removal)
data_extracted.head(10)
```

```
[nltk_data] Downloading package stopwords to /root/nltk_data...
[nltk_data]   Unzipping corpora/stopwords.zip.
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:11: SettingWithCopyWarni
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
  # This is added back by InteractiveShellApp.init_path()
```

	finding	clinical_notes	report_length	punctuation	lemmatisation	stopwords
0	COVID-19	On January 22, 2020, a 65-year-old man with a ...	699	on january 22 2020 a 65yearold man with a hist...	on january 22 2020 a 65yearold man with a hist...	january 22 2020 65yearold man history hyperten...
1	COVID-19	On January 22, 2020, a 65-year-old man with a ...	917	on january 22 2020 a 65yearold man with a hist...	on january 22 2020 a 65yearold man with a hist...	january 22 2020 65yearold man history hyperten...

```
#Construct TFIDF matrix
from sklearn.feature_extraction.text import TfidfVectorizer
#both unigrams and bigrams are extracted. Change ngram_range=(1,1) only for unigrams
tfidf = TfidfVectorizer(stop_words='english',ngram_range=(1,2))
data_extracted['number_removed']=data_extracted['stopwords'].str.replace('\d+', '')
tfidf_matrix = tfidf.fit_transform(data_extracted['number_removed'])
print('Shape of tfidf matrix: ',tfidf_matrix.shape)
print('Feature names: ',tfidf.get_feature_names()[400:410])

feature_names = tfidf.get_feature_names()
corpus_index = [n for n in range(1,tfidf_matrix.shape[0]+1)]
values=tfidf_matrix.T.todense()
transpose_values=np.array(values).transpose()
tfidf_matrix_display = pd.DataFrame(transpose_values, index=corpus_index, columns=feature_
print(tfidf_matrix_display[['chest', 'patient', 'multiple', 'peripheral','bilateral','lowe
```

```
Shape of tfidf matrix:  (584, 12935)
Feature names:  ['allow', 'allow cpap', 'alongside', 'alongside scatter', 'alpha', 'a
        chest   patient  multiple  ...       air  pneumonia   history
1    0.030577  0.000000       0.0  ...  0.000000   0.000000  0.042129
2    0.026471  0.000000       0.0  ...  0.047673   0.000000  0.036472
3    0.026471  0.000000       0.0  ...  0.047673   0.000000  0.036472
4    0.000000  0.000000       0.0  ...  0.000000   0.000000  0.043610
5    0.000000  0.000000       0.0  ...  0.000000   0.000000  0.000000
..        ...       ...       ...  ...       ...        ...       ...
580  0.000000  0.000000       0.0  ...  0.000000   0.000000  0.000000
581  0.000000  0.000000       0.0  ...  0.000000   0.000000  0.000000
582  0.034917  0.000000       0.0  ...  0.000000   0.000000  0.000000
583  0.091897  0.049302       0.0  ...  0.000000   0.035382  0.031654
584  0.091634  0.049161       0.0  ...  0.000000   0.035281  0.031564

[584 rows x 15 columns]
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:5: SettingWithCopyWarnir
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead
```

```
        See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
          """



    #Word collection and their frequencies

    wordfreq = {}
    for sentence in data_extracted['number_removed']:
        tokens = nltk.word_tokenize(sentence)
        for token in tokens:
            if token not in wordfreq.keys():
                wordfreq[token] = 1
            else:
                wordfreq[token] += 1
    print('Bag of words and their frequencies:',wordfreq)

    #Gets the 200 most frequent words with their frequency of occurrence
    import heapq
    most_freq = heapq.nlargest(200, wordfreq, key=wordfreq.get)

    #Bag of word model as a 2D matrix
    sentence_vectors = []
    for sentence in data_extracted['number_removed']:
        sentence_tokens = nltk.word_tokenize(sentence)
        sent_vec = []
        for token in most_freq:
            if token in sentence_tokens:
                sent_vec.append(1)
            else:
                sent_vec.append(0)
        sentence_vectors.append(sent_vec)
    sentence_vectors = np.asarray(sentence_vectors)
    bow_model = pd.DataFrame(sentence_vectors, columns=most_freq)
    bow_model.head(10)
```

```
Bag of words and their frequencies: {'january': 92, 'yearold': 152, 'man': 54, 'histo
```

	patient	chest	fever	show	bilateral	right	lung	cough	day	lower	leave	con

```
#feature_names has list of all the words in the tf-idf vocabulary
def top_tfidf_feats(row, feature_names, top_n=40):
    ''' Get top n tfidf values in row and return them with their corresponding feature nam
    '''argsort returns the indices that would sort the row by its tf-idf value and reverse
    '''A pandas DataFrame is returned with the words themselves (feature names) and their
    topn_ids = np.argsort(row)[::-1][:top_n]
    top_feats = [(feature_names[i], row[i]) for i in topn_ids]
    df = pd.DataFrame(top_feats)
    df.columns = ['feature', 'tfidf']
    return df
```

```
#Extracting the 100 most relevant features from tfidf matrix
tfidf = TfidfVectorizer(max_features=100,stop_words='english',ngram_range=(1,2))
data_extracted['number_removed']=data_extracted['stopwords'].str.replace('\d+', '')
tfidf_matrix = tfidf.fit_transform(data_extracted['number_removed'])
print('Shape of tfidf matrix: ',tfidf_matrix.shape)
print('Feature names: ',tfidf.get_feature_names())
feature_names = tfidf.get_feature_names()
corpus_index = [n for n in range(1,tfidf_matrix.shape[0]+1)]
values=tfidf_matrix.T.todense()
transpose_values=np.array(values).transpose()
tfidf_matrix_display = pd.DataFrame(transpose_values, index=corpus_index, columns=feature_
print(tfidf_matrix_display)
```

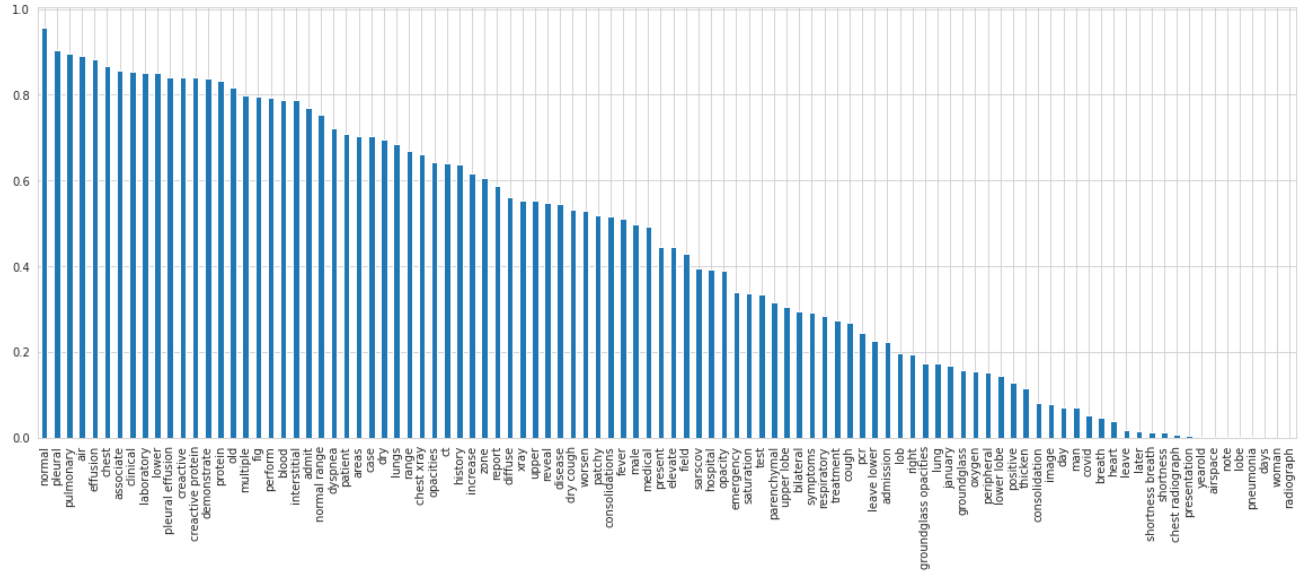
```
Shape of tfidf matrix:  (584, 100)
Feature names:  ['admission', 'admit', 'air', 'airspace', 'areas', 'associate', 'bila
     admission     admit       air  airspace  ...  worsen  xray   yearold      zone
1     0.175126  0.213755  0.000000       0.0  ...     0.0   0.0  0.147130  0.000000
2     0.000000  0.186078  0.173254       0.0  ...     0.0   0.0  0.128080  0.000000
3     0.000000  0.186078  0.173254       0.0  ...     0.0   0.0  0.128080  0.000000
4     0.000000  0.241397  0.000000       0.0  ...     0.0   0.0  0.166157  0.000000
5     0.000000  0.000000  0.000000       0.0  ...     0.0   0.0  0.000000  0.000000
..         ...       ...       ...       ...  ...     ...   ...       ...       ...
580   0.000000  0.000000  0.000000       0.0  ...     0.0   0.0  0.000000  0.327097
581   0.000000  0.000000  0.000000       0.0  ...     0.0   0.0  0.000000  0.000000
582   0.000000  0.325683  0.000000       0.0  ...     0.0   0.0  0.000000  0.000000
583   0.078761  0.096134  0.000000       0.0  ...     0.0   0.0  0.000000  0.000000
584   0.078927  0.096337  0.000000       0.0  ...     0.0   0.0  0.000000  0.000000

[584 rows x 100 columns]
/usr/local/lib/python3.7/dist-packages/ipykernel_launcher.py:3: SettingWithCopyWarnir
A value is trying to be set on a copy of a slice from a DataFrame.
Try using .loc[row_indexer,col_indexer] = value instead

See the caveats in the documentation: https://pandas.pydata.org/pandas-docs/stable/us
  This is separate from the ipykernel package so we can avoid doing imports until
```

```
X = tfidf_matrix.toarray()
y = data_extracted['finding']
```

```
#chi scores for features
```

```
from sklearn.feature_selection import SelectFromModel
from sklearn.feature_selection import SelectKBest, chi2, f_classif
chi_scores = chi2(X,y)
p_values = pd.Series(chi_scores[1],tfidf.get_feature_names())
p_values.sort_values(ascending = False , inplace = True)
p_values.plot.bar(figsize=(20, 7))
```

```
<matplotlib.axes._subplots.AxesSubplot at 0x7fa4210efa10>
```




```
#Chi square test for feature selection
test = SelectKBest(score_func=chi2, k=50)
fit = test.fit(X, y)
X_new=test.fit_transform(X, y)
fit.scores_
```

```
array([ 3.00903424,  0.52168862,  0.23142465, 13.54610406,  0.70031645,
        0.31136558,  2.45299131,  0.4744574 ,  6.15950531,  0.70343436,
        0.28394214,  9.67488731,  0.82327806,  0.31764241,  5.05775375,
        1.32657491,  2.64257343,  5.96200526,  0.34922085,  0.34922085,
        0.89113045,  5.28780964, 19.80396012,  0.35261272,  1.15654451,
        1.21653033,  0.72453003,  1.26154851,  0.65132146,  0.25143997,
        1.6234104 ,  2.16533599,  1.3420368 ,  1.68907851,  0.45775617,
        3.70143291,  3.51397764,  6.56956577,  0.90380448,  1.87085233,
        5.08293825,  0.96539723,  0.47671587,  3.58338634,  0.31934997,
        8.32683169,  8.00027359,  2.97829759,  3.25729584, 15.54399215,
        0.31935841,  3.8598245 ,  3.52186045,  0.75803731,  1.39535695,
        5.31352971,  1.41242189,  0.45051429,  0.08883733,  0.56341373,
       15.0093119 ,  0.40622286,  0.87984551,  1.8840332 ,  3.73511746,
        2.31251918,  1.31258098,  0.68886153,  2.82926096,  0.4627694 ,
```

```
       3.76761726,  0.20044368,  0.34592624, 16.59401643,  4.12823524,
       1.61761403, 11.64772689,  0.36872711,  0.22079907, 35.99803083,
       0.80353281,  1.06847132,  2.5117913 ,  1.20698448,  3.27377262,
       1.85952614,  2.16986047,  8.79688166,  8.79688166,  2.46256483,
       2.19312578,  4.30551565,  2.58770705,  1.18243681,  2.37759229,
      28.1105965 ,  1.2705133 ,  1.18195461, 12.87205657,  1.00274725])
```

```
from sklearn.model_selection import train_test_split
from numpy import mean
from numpy import std
from sklearn.naive_bayes import MultinomialNB
from sklearn.model_selection import KFold
from sklearn.model_selection import RepeatedKFold
from sklearn.model_selection import cross_val_score
from sklearn.metrics import accuracy_score, precision_score, recall_score, f1_score
from sklearn.metrics import confusion_matrix,classification_report
from sklearn import metrics
from sklearn.model_selection import GridSearchCV

X = X_new
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.2, random_state=0)


#Multinomial Naive Bayes
#Model and metrics evaluation
print('-------------------------Multinomial Naive Bayes-------------------------')
NaiveBayes = MultinomialNB()
NaiveBayes.fit(X_train,y_train)
y_predict = NaiveBayes.predict(X_test)
print('Accuracy: ',accuracy_score(y_test,y_predict))
print('Confusion matrix: \n ',confusion_matrix(y_test, y_predict))
print('Classification report: ',classification_report(y_test,y_predict))

#Using Cross validation (CV) and evaluating accuracy after CV
#10 fold cross validation repreated twice
rkf = RepeatedKFold(n_splits=10, n_repeats=2, random_state=1)
scores = cross_val_score(NaiveBayes, X_train, y_train, scoring='accuracy', cv=rkf, n_jobs=
# report performance
print("%0.4f accuracy with a standard deviation of %0.2f for Multinomial Naive Bayes after

#GridSearch and evaluating accuracy after performing gridsearch
parameters = {
'alpha': (1, 0.1, 0.01, 0.001, 0.0001, 0.00001)
}
grid_search = GridSearchCV(estimator = NaiveBayes, param_grid = parameters,scoring = 'accu
grid_search = grid_search.fit(X_train, y_train)
best_parameters = grid_search.best_params_
best_accuracy = grid_search.best_score_

print('*******************BEFORE TUNING:************************')
print('Accuracy:',accuracy_score(y_test,y_predict)*100)
print('Precision:', precision_score(y_test,y_predict,average='weighted')*100)
print('Recall:', recall_score(y_test,y_predict,average='weighted')*100)
print('F1 score:', f1_score(y_test,y_predict,average='weighted')*100)
```

```
print()
print('******************AFTER TUNING:**********************')
weighted_prediction=grid_search.predict(X_test)
print('Best Parameters after tuning: {}'.format(best_parameters))
print('Best Accuracy after tuning: {}'.format(best_accuracy))
print('Precision:', precision_score(y_test, weighted_prediction,average='weighted')*100)
print('Recall:', recall_score(y_test, weighted_prediction,average='weighted')*100)
print('F1 score:', f1_score(y_test, weighted_prediction,average='weighted')*100)
```

```
------------------------Multinomial Naive Bayes------------------------
Accuracy:  0.811965811965812
Confusion matrix:
  [[ 3 16  0]
 [ 0 92  0]
 [ 0  6  0]]
Classification report:                precision    recall  f1-score   support

          ARDS       1.00      0.16      0.27        19
      COVID-19       0.81      1.00      0.89        92
          SARS       0.00      0.00      0.00         6

      accuracy                           0.81       117
     macro avg       0.60      0.39      0.39       117
  weighted avg       0.80      0.81      0.75       117

/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1272: Undef
  _warn_prf(average, modifier, msg_start, len(result))
0.8543 accuracy with a standard deviation of 0.04 for Multinomial Naive Bayes after 1
******************BEFORE TUNING:**********************
Accuracy: 81.19658119658119
Precision: 79.69710601289547
Recall: 81.19658119658119
F1 score: 74.6637397122834

******************AFTER TUNING:**********************
Best Parameters after tuning: {'alpha': 0.001}
Best Accuracy after tuning: 0.8756706753006476
Precision: 81.41218141218141
Recall: 83.76068376068376
F1 score: 79.06766030903962
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1272: Undef
  _warn_prf(average, modifier, msg_start, len(result))
/usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1272: Undef
  _warn_prf(average, modifier, msg_start, len(result))
```

```
#Logistic Regression
#Model and metrics evaluation
from sklearn.linear_model import LogisticRegression
print('------------------------Logistic Regression------------------------')
logres = LogisticRegression(random_state = 0)
logres.fit(X_train,y_train)
y_predict = logres.predict(X_test)
print('Accuracy: ',accuracy_score(y_test,y_predict))
print('Confusion matrix: \n ',confusion_matrix(y_test, y_predict))
print('Classification report: ',classification_report(y_test,y_predict))

#Using Cross validation (CV) and evaluating accuracy after CV
#10 fold cross validation repreated twice
```

```
#10 fold cross validation repeated twice
rkf = RepeatedKFold(n_splits=10, n_repeats=2, random_state=1)
scores = cross_val_score(logres, X_train, y_train, scoring='accuracy', cv=rkf, n_jobs=-1)
# report performance
print("%0.2f accuracy with a standard deviation of %0.2f for Logistic Regression after 10

#GridSearch and evaluating accuracy after performing gridsearch
parameters = {"solver":['newton-cg', 'lbfgs', 'liblinear'],"C":[100, 10, 1.0, 0.1, 0.01],
grid_search = GridSearchCV(estimator = logres, param_grid = parameters,scoring = 'accuracy
grid_search = grid_search.fit(X_train, y_train)
best_parameters = grid_search.best_params_
best_accuracy = grid_search.best_score_

print('******************BEFORE TUNING:**********************')
print('Accuracy:',accuracy_score(y_test,y_predict)*100)
print('Precision:', precision_score(y_test,y_predict,average='weighted')*100)
print('Recall:', recall_score(y_test,y_predict,average='weighted')*100)
print('F1 score:', f1_score(y_test,y_predict,average='weighted')*100)

print()
print('******************AFTER TUNING:**********************')
weighted_prediction=grid_search.predict(X_test)
print('Best Parameters after tuning: {}'.format(best_parameters))
print('Best Accuracy after tuning: {}'.format(best_accuracy))
print('Precision:', precision_score(y_test, weighted_prediction,average='weighted')*100)
print('Recall:', recall_score(y_test, weighted_prediction,average='weighted')*100)
print('F1 score:', f1_score(y_test, weighted_prediction,average='weighted')*100)
```

```
          accuracy                           0.88       117
         macro avg       0.62      0.53      0.55       117
      weighted avg       0.84      0.88      0.85       117

      /usr/local/lib/python3.7/dist-packages/sklearn/metrics/_classification.py:1272: Un
        _warn_prf(average, modifier, msg_start, len(result))
      0.90 accuracy with a standard deviation of 0.04 for Logistic Regression after 10 f
      /usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_logistic.py:940: Conv
      STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

      Increase the number of iterations (max_iter) or scale the data as shown in:
          https://scikit-learn.org/stable/modules/preprocessing.html
      Please also refer to the documentation for alternative solver options:
          https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
        extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
      /usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_logistic.py:940: Conv
      STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.


      Increase the number of iterations (max_iter) or scale the data as shown in:
          https://scikit-learn.org/stable/modules/preprocessing.html
      Please also refer to the documentation for alternative solver options:
          https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
        extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
      /usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_logistic.py:940: Conv
      STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

      Increase the number of iterations (max_iter) or scale the data as shown in:
          https://scikit-learn.org/stable/modules/preprocessing.html
      Please also refer to the documentation for alternative solver options:
          https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
        extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
```

```
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
/usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_logistic.py:940: Conv
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
/usr/local/lib/python3.7/dist-packages/sklearn/linear_model/_logistic.py:940: Conv
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regression
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
**********BEFORE TUNING:**********
Accuracy: 88.03418803418803
Precision: 84.48637316561846
Recall: 88.03418803418803
F1 score: 84.98143831477165

**********AFTER TUNING:**********
Best Parameters after tuning: {'C': 100, 'penalty': 'l2', 'solver': 'liblinear'}
Best Accuracy after tuning: 0.9582793709528215
Precision: 95.73711312841749
Recall: 94.87179487179486
```

```
#Support Vector Machines
#Model and metrics evaluation
from sklearn import svm
print('-------------------------Support Vector Machines-------------------------')
classifier = svm.SVC()
classifier.fit(X_train,y_train)
y_predict = classifier.predict(X_test)
print('Accuracy: ',accuracy_score(y_test,y_predict))
print('Confusion matrix: \n ',confusion_matrix(y_test, y_predict))
print('Classification report: ',classification_report(y_test,y_predict))

#Using Cross validation (CV) and evaluating accuracy after CV
#10 fold cross validation repreated twice
rkf = RepeatedKFold(n_splits=10, n_repeats=2, random_state=1)
scores = cross_val_score(classifier, X_train, y_train, scoring='accuracy', cv=rkf, n_jobs=
# report performance
print("%0.2f accuracy with a standard deviation of %0.2f for Support Vector Machines after

#GridSearch and evaluating accuracy after performing gridsearch
parameters = {'C': [0.1, 1, 10, 100, 1000],
              'gamma': [1, 0.1, 0.01, 0.001, 0.0001],
              'kernel': ['rbf','linear','poly','sigmoid']}
grid_search = GridSearchCV(estimator = classifier, param_grid = parameters,scoring = 'accu
grid_search = grid_search.fit(X_train, y_train)
best_parameters = grid_search.best_params_
best_accuracy = grid_search.best_score_
```

```
print('******************BEFORE TUNING:************************')
print('Accuracy:',accuracy_score(y_test,y_predict)*100)
print('Precision:', precision_score(y_test,y_predict,average='weighted')*100)
print('Recall:', recall_score(y_test,y_predict,average='weighted')*100)
print('F1 score:', f1_score(y_test,y_predict,average='weighted')*100)

print()
print('******************AFTER TUNING:************************')
weighted_prediction=grid_search.predict(X_test)
print('Best Parameters after tuning: {}'.format(best_parameters))
print('Best Accuracy after tuning: {}'.format(best_accuracy))
print('Precision:', precision_score(y_test, weighted_prediction,average='weighted')*100)
print('Recall:', recall_score(y_test, weighted_prediction,average='weighted')*100)
print('F1 score:', f1_score(y_test, weighted_prediction,average='weighted')*100)
```

```
------------------------Support Vector Machines------------------------
Accuracy:  0.9487179487179487
Confusion matrix:
  [[17  2  0]
 [ 0 92  0]
 [ 0  4  2]]
Classification report:                precision    recall  f1-score   support

          ARDS       1.00      0.89      0.94        19
      COVID-19       0.94      1.00      0.97        92
          SARS       1.00      0.33      0.50         6

      accuracy                           0.95       117
     macro avg       0.98      0.74      0.80       117
  weighted avg       0.95      0.95      0.94       117

0.93 accuracy with a standard deviation of 0.03 for Support Vector Machines after 10
******************BEFORE TUNING:************************
Accuracy: 94.87179487179486
Precision: 95.18576661433804
Recall: 94.87179487179486
F1 score: 94.05058229619632

******************AFTER TUNING:************************
Best Parameters after tuning: {'C': 10, 'gamma': 1, 'kernel': 'rbf'}
Best Accuracy after tuning: 0.9582562442183165
Precision: 97.45427809943939
Recall: 97.43589743589743
F1 score: 97.40397740397741
```

```
#Decision Tree
#Model and metrics evaluation
from sklearn.tree import DecisionTreeClassifier
print('------------------------Decision Tree------------------------')
dt = DecisionTreeClassifier()
dt.fit(X_train,y_train)
y_predict = dt.predict(X_test)
print('Accuracy: ',accuracy_score(y_test,y_predict))
print('Confusion matrix: \n ',confusion_matrix(y_test, y_predict))
print('Classification report: ',classification_report(y_test,y_predict))

#Using Cross validation (CV) and evaluating accuracy after CV
```

```
#10 fold cross validation repreated twice
rkf = RepeatedKFold(n_splits=10, n_repeats=2, random_state=1)
scores = cross_val_score(dt, X_train, y_train, scoring='accuracy', cv=rkf, n_jobs=-1)
# report performance
print("%0.2f accuracy with a standard deviation of %0.2f for Decision Tree after 10 fold C

#GridSearch and evaluating accuracy after performing gridsearch
parameters = {'criterion': ['gini','entropy'],
              'max_depth': range(1,10),
              'min_samples_split': range(2,10),
              'min_samples_leaf': range(1,5)}
grid_search = GridSearchCV(estimator = dt, param_grid = parameters,scoring = 'accuracy', c
grid_search = grid_search.fit(X_train, y_train)
best_parameters = grid_search.best_params_
best_accuracy = grid_search.best_score_

print('********************BEFORE TUNING:************************')
print('Accuracy:',accuracy_score(y_test,y_predict)*100)
print('Precision:', precision_score(y_test,y_predict,average='weighted')*100)
print('Recall:', recall_score(y_test,y_predict,average='weighted')*100)
print('F1 score:', f1_score(y_test,y_predict,average='weighted')*100)

print()
print('********************AFTER TUNING:************************')
weighted_prediction=grid_search.predict(X_test)
print('Best Parameters after tuning: {}'.format(best_parameters))
print('Best Accuracy after tuning: {}'.format(best_accuracy))
print('Precision:', precision_score(y_test, weighted_prediction,average='weighted')*100)
print('Recall:', recall_score(y_test, weighted_prediction,average='weighted')*100)
print('F1 score:', f1_score(y_test, weighted_prediction,average='weighted')*100)
```

```
-------------------------Decision Tree-------------------------
Accuracy:  0.9487179487179487
Confusion matrix:
  [[15  4  0]
 [ 1 90  1]
 [ 0  0  6]]
Classification report:                precision    recall  f1-score   support

          ARDS       0.94      0.79      0.86        19
      COVID-19       0.96      0.98      0.97        92
          SARS       0.86      1.00      0.92         6

      accuracy                           0.95       117
     macro avg       0.92      0.92      0.92       117
  weighted avg       0.95      0.95      0.95       117

0.89 accuracy with a standard deviation of 0.03 for Decision Tree after 10 fold Cross
********************BEFORE TUNING:************************
Accuracy: 94.87179487179486
Precision: 94.906379081911
Recall: 94.87179487179486
F1 score: 94.74908879375381

********************AFTER TUNING:************************
Best Parameters after tuning: {'criterion': 'entropy', 'max_depth': 9, 'min_samples_l
Best Accuracy after tuning: 0.9077474560592045
```

```
Precision: 92.25949489107383
Recall: 92.3076923076923
F1 score: 91.89503307150366
```

```
#Bagging
#Model and metrics evaluation
from sklearn.ensemble import BaggingClassifier
print('-------------------------Bagging-------------------------')
bag = BaggingClassifier()
bag.fit(X_train,y_train)
y_predict = bag.predict(X_test)
print('Accuracy: ',accuracy_score(y_test,y_predict))
print('Confusion matrix: \n ',confusion_matrix(y_test, y_predict))
print('Classification report: ',classification_report(y_test,y_predict))

#Using Cross validation (CV) and evaluating accuracy after CV
#10 fold cross validation repreated twice
rkf = RepeatedKFold(n_splits=10, n_repeats=2, random_state=1)
scores = cross_val_score(bag, X_train, y_train, scoring='accuracy', cv=rkf, n_jobs=-1)
# report performance
print("%0.2f accuracy with a standard deviation of %0.2f for Bagging after 10 fold Cross V

#GridSearch and evaluating accuracy after performing gridsearch
parameters = {
    'max_samples' : [0.05, 0.1, 0.2, 0.5],
    'n_estimators': [10, 100, 1000]}
grid_search = GridSearchCV(estimator = bag, param_grid = parameters,scoring = 'accuracy',
grid_search = grid_search.fit(X_train, y_train)
best_parameters = grid_search.best_params_
best_accuracy = grid_search.best_score_

print('********************BEFORE TUNING:************************')
print('Accuracy:',accuracy_score(y_test,y_predict)*100)
print('Precision:', precision_score(y_test,y_predict,average='weighted')*100)
print('Recall:', recall_score(y_test,y_predict,average='weighted')*100)
print('F1 score:', f1_score(y_test,y_predict,average='weighted')*100)

print()
print('********************AFTER TUNING:************************')
weighted_prediction=grid_search.predict(X_test)
print('Best Parameters after tuning: {}'.format(best_parameters))
print('Best Accuracy after tuning: {}'.format(best_accuracy))
print('Precision:', precision_score(y_test, weighted_prediction,average='weighted')*100)
print('Recall:', recall_score(y_test, weighted_prediction,average='weighted')*100)
print('F1 score:', f1_score(y_test, weighted_prediction,average='weighted')*100)
```

```
-------------------------Bagging-------------------------
Accuracy:  0.9316239316239316
Confusion matrix:
  [[17  1  1]
 [ 2 90  0]
 [ 0  4  2]]
Classification report:               precision    recall  f1-score   support
```

```
              ARDS       0.89      0.89      0.89        19
          COVID-19       0.95      0.98      0.96        92
              SARS       0.67      0.33      0.44         6

          accuracy                           0.93       117
         macro avg       0.84      0.74      0.77       117
      weighted avg       0.92      0.93      0.92       117

      0.89 accuracy with a standard deviation of 0.04 for Bagging after 10 fold Cross Valic
      ********************BEFORE TUNING:************************
      Accuracy: 93.16239316239316
      Precision: 92.44264507422402
      Recall: 93.16239316239316
      F1 score: 92.49813367460428

      ********************AFTER TUNING:************************
      Best Parameters after tuning: {'max_samples': 0.5, 'n_estimators': 1000}
      Best Accuracy after tuning: 0.90127197039778
      Precision: 88.4573487514664
      Recall: 88.88888888888889
      F1 score: 87.5724922948069
```

```
#Random forest classifier
#Model and metrics evaluation
from sklearn.ensemble import RandomForestClassifier
print('------------------------Random Forest-------------------------')
rf = RandomForestClassifier()
rf.fit(X_train,y_train)
y_predict = rf.predict(X_test)
print('Accuracy: ',accuracy_score(y_test,y_predict))
print('Confusion matrix: \n ',confusion_matrix(y_test, y_predict))
print('Classification report: ',classification_report(y_test,y_predict))

#Using Cross validation (CV) and evaluating accuracy after CV
#10 fold cross validation repreated twice
rkf = RepeatedKFold(n_splits=10, n_repeats=2, random_state=1)
scores = cross_val_score(rf, X_train, y_train, scoring='accuracy', cv=rkf, n_jobs=-1)
# report performance
print("%0.2f accuracy with a standard deviation of %0.2f for Random forest classifier afte

#GridSearch and evaluating accuracy after performing gridsearch
parameters = {
    'n_estimators': [10, 100, 1000],
               'max_features': ['auto', 'sqrt'],
               'min_samples_split': [2, 5, 10],
               'min_samples_leaf': [1, 2, 4],
               'bootstrap': [True, False]}
grid_search = GridSearchCV(estimator = rf, param_grid = parameters,scoring = 'accuracy', c
grid_search = grid_search.fit(X_train, y_train)
best_parameters = grid_search.best_params_
best_accuracy = grid_search.best_score_


print('********************BEFORE TUNING:************************')
print('Accuracy:',accuracy_score(y_test,y_predict)*100)
```

```
print('Precision:', precision_score(y_test,y_predict,average='weighted')*100)
print('Recall:', recall_score(y_test,y_predict,average='weighted')*100)
print('F1 score:', f1_score(y_test,y_predict,average='weighted')*100)

print()
print('******************AFTER TUNING:**********************')
weighted_prediction=grid_search.predict(X_test)
print('Best Parameters after tuning: {}'.format(best_parameters))
print('Best Accuracy after tuning: {}'.format(best_accuracy))
print('Precision:', precision_score(y_test, weighted_prediction,average='weighted')*100)
print('Recall:', recall_score(y_test, weighted_prediction,average='weighted')*100)
print('F1 score:', f1_score(y_test, weighted_prediction,average='weighted')*100)
```

```
-------------------------Random Forest-------------------------
Accuracy:  0.9316239316239316
Confusion matrix:
  [[15  3  1]
 [ 0 92  0]
 [ 1  3  2]]
Classification report:               precision    recall  f1-score   support

        ARDS       0.94      0.79      0.86        19
    COVID-19       0.94      1.00      0.97        92
        SARS       0.67      0.33      0.44         6

    accuracy                           0.93       117
   macro avg       0.85      0.71      0.76       117
weighted avg       0.92      0.93      0.92       117

0.92 accuracy with a standard deviation of 0.04 for Random forest classifier after 10
******************BEFORE TUNING:**********************
Accuracy: 93.16239316239316
Precision: 92.46140763997907
Recall: 93.16239316239316
F1 score: 92.3479639269113

******************AFTER TUNING:**********************
Best Parameters after tuning: {'bootstrap': False, 'max_features': 'auto', 'min_samp
Best Accuracy after tuning: 0.9228723404255319
Precision: 91.8241695303551
Recall: 92.3076923076923
F1 score: 91.78854067742955
```

```
#Gradient Boosting
#Model and metrics evaluation
from sklearn.ensemble import GradientBoostingClassifier
print('-------------------------Gradient Boosting-------------------------')
gb_clf = GradientBoostingClassifier()
gb_clf.fit(X_train,y_train)
y_predict = gb_clf.predict(X_test)
print('Accuracy: ',accuracy_score(y_test,y_predict))
print('Confusion matrix: \n ',confusion_matrix(y_test, y_predict))
print('Classification report: ',classification_report(y_test,y_predict))

#Using Cross validation (CV) and evaluating accuracy after CV
#10 fold cross validation repreated twice
```

```
rkf = RepeatedKFold(n_splits=10, n_repeats=2, random_state=1)
scores = cross_val_score(gb_clf, X_train, y_train, scoring='accuracy', cv=rkf, n_jobs=-1)
# report performance
print("%0.2f accuracy with a standard deviation of %0.2f for Gradient Boosting after 10 fo

#GridSearch and evaluating accuracy after performing gridsearch
parameters = {
    'n_estimators': [10, 100, 1000],
               'max_features': ['auto', 'sqrt'],
               'min_samples_split': [2, 5, 10],
               'min_samples_leaf': [1, 2, 4],
              'learning_rate': [0.05, 0.075, 0.1, 0.25, 0.5, 0.75, 1]}
grid_search = GridSearchCV(estimator = gb_clf, param_grid = parameters,scoring = 'accuracy
grid_search = grid_search.fit(X_train, y_train)
best_parameters = grid_search.best_params_
best_accuracy = grid_search.best_score_


print('******************BEFORE TUNING:**********************')
print('Accuracy:',accuracy_score(y_test,y_predict)*100)
print('Precision:', precision_score(y_test,y_predict,average='weighted')*100)
print('Recall:', recall_score(y_test,y_predict,average='weighted')*100)
print('F1 score:', f1_score(y_test,y_predict,average='weighted')*100)

print()
print('******************AFTER TUNING:**********************')
weighted_prediction=grid_search.predict(X_test)
print('Best Parameters after tuning: {}'.format(best_parameters))
print('Best Accuracy after tuning: {}'.format(best_accuracy))
print('Precision:', precision_score(y_test, weighted_prediction,average='weighted')*100)
print('Recall:', recall_score(y_test, weighted_prediction,average='weighted')*100)
print('F1 score:', f1_score(y_test, weighted_prediction,average='weighted')*100)
```