Covid-19 Tweet Analysis Using NLP

Project Goal

For this project, I shall be combining 2 datasets including covid tweets and noncovid tweets. This will be able to help the Twitter team to identify the covid related tweets and allow them to connect their users with covid-19 resources developed by official health organizations.

To achieve this goal, we shall be using natural language processing (NLP).

Data Understanding

Covid-19 related dataset was collected from Kaggle, which consists of columns including information such as:

- COLUMN NAMES: Location, date of tweet, original tweet, sentiment (positive, negative, neutral), etc.
- total number of tweets: 44955 https://www.kaggle.com/datatattle/covid-19-nlp-text-classification (https://www.kaggle.com/datatattle/covid-19-nlp-text-classification)
- We shall look specifically at the original tweet text, and develop a column with a “target” of 1 showing it is related to covid-19.

The non-covid 19 dataset was also collected from Kaggle, consisting of columns including:

- COLUMN NAMES: Target (negative, positive, neutral), ids, date, flag, user, and tweet
- total number of tweets: 1.6 million https://www.kaggle.com/kazanova/sentiment140 (https://www.kaggle.com/kazanova/sentiment140)
- The tweet column shall be used and a “target” column of 0 shall represent that the tweets are unrelated to covid.

Metrics

Our project will answer following question: Can we predict tweets related to covid?

Hypothesis:

```
H0 - The tweet is related to covid.

HA - There is statisticaly significant proof that the tweet isn't r
elated to covid.
```

TP, TN, FP, FN definition

TP - we predicted covid tweet and it actually exist.

TN - we predicted that tweet isn't covid related and the tweet actually isn't related to covid.

FP - We predicted covid tweet but it was not a covid tweet.

FN - We predicted that there is no covid tweet but it actually existed.

Metrics used

To compare models we will focus on 2 major metrics:

Recall - We will be focused to minimize FN.

Accuracy - how good we can predict TP and TN. General metrics that will show model performance.

In [1]:

```
#import required modules

from sklearn.pipeline import Pipel
import pandas as pd
import numpy as np
import re

from sklearn.model_selection import train_test_split
from sklearn.preprocessing import LabelEncoderine
from sklearn.feature_extraction.text import TfidfVectorizer, CountVecto
from sklearn.ensemble import RandomForestClassifier
from sklearn.naive_bayes import MultinomialNB
from sklearn.linear_model import LogisticRegression
from sklearn.svm import LinearSVC
from sklearn.model_selection import cross_val_score
from sklearn.metrics import accuracy_score, precision_score, confusion_
from sklearn.tree import DecisionTreeClassifier

import nltk
from nltk.tokenize import regexp_tokenize, word_tokenize, RegexpTokeniz
from nltk.corpus import stopwords, wordnet
from nltk import pos_tag
from nltk.stem import WordNetLemmatizer
from nltk.probability import FreqDist

import matplotlib.pyplot as plt
%matplotlib inline

```

Data Preparation

1) Covid-19 dataset

- Remove unrelated columns
- Train/test sets already separated
- Ended up with 44955 tweets

2) Noncovid-19 dataset

- Create sample of 44955
- Remove unrelated columns

3) Data Preprocessing

- Remove unnecessary numbers, punctuations, etc.
- Tokenization.
- Lower casing.
- Stop words removal.
- Stemming.
- Lemmatization.

4) Create dataset with both

- Concat test/train split
- Train for both covid & non-covid dataset
- Test for both covid & non-covid dataset

5) Vectorizer

- Count Vectorizer
- TF-IDF Vectorizer

These vectorizers were selected to look further into training, validation, and ultimately our test set. Parameters were altered including min_df, max_features, etc. to increase performance of our models.

Let's Organize Our Covid-19 Dataset!

In [2]:

```python
#train_df = pd.read_csv('Documents/Flatiron/Projects/Phase 5/COVID-19-T
train_df = pd.read_csv('data/Corona_NLP_train.csv',encoding='latin1')
test_df = pd.read_csv('data/Corona_NLP_test.csv',encoding='latin1')
train_df
```

Out[2]:

	UserName	ScreenName	Location	TweetAt	OriginalTweet	Sentiment
0	3799	48751	London	16-03-2020	@MeNyrbie @Phil_Gahan @Chrisitv https://t.co/i...	Neutral
1	3800	48752	UK	16-03-2020	advice Talk to your neighbours family to excha...	Positive
2	3801	48753	Vagabonds	16-03-2020	Coronavirus Australia: Woolworths to give elde...	Positive
3	3802	48754	NaN	16-03-2020	My food stock is not the only one which is emp...	Positive
4	3803	48755	NaN	16-03-2020	Me, ready to go at supermarket during the #COV...	Extremely Negative
...	...	...	...	...	...	...
41152	44951	89903	Wellington City, New Zealand	14-04-2020	Airline pilots offering to stock supermarket s...	Neutral
41153	44952	89904	NaN	14-04-2020	Response to complaint not provided citing COVI...	Extremely Negative
41154	44953	89905	NaN	14-04-2020	You know itÂ s getting tough when @KameronWild...	Positive
41155	44954	89906	NaN	14-04-2020	Is it wrong that the smell of hand sanitizer i...	Neutral
41156	44955	89907	i love you so much || he/him	14-04-2020	@TartiiCat Well new/used Rift S are going for ...	Negative

41157 rows × 6 columns

In [3]:

```python
#we shall be using the "OriginalTweet" column using NLP
train_df.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 41157 entries, 0 to 41156
Data columns (total 6 columns):
 #   Column         Non-Null Count  Dtype 
---  ------         --------------  ----- 
 0   UserName       41157 non-null  int64 
 1   ScreenName     41157 non-null  int64 
 2   Location       32567 non-null  object
 3   TweetAt        41157 non-null  object
 4   OriginalTweet  41157 non-null  object
 5   Sentiment      41157 non-null  object
dtypes: int64(2), object(4)
memory usage: 1.9+ MB
```

In [4]:

```python
train_df['OriginalTweet'].value_counts().sum()
```

Out[4]:

```
41157
```

In [5]:

```python
train_df.isna().sum()
```

Out[5]:

```
UserName            0
ScreenName          0
Location         8590
TweetAt             0
OriginalTweet       0
Sentiment           0
dtype: int64
```

In [6]:

```python
test_df.isna().sum()
```

Out[6]:

```
UserName           0
ScreenName         0
Location         834
TweetAt            0
OriginalTweet      0
Sentiment          0
dtype: int64
```

In [7]:

```python
test_df['OriginalTweet'].value_counts().sum()
```

Out[7]:

```
3798
```

In [8]:

```python
train_df_2 = pd.DataFrame(train_df['OriginalTweet'].astype(str))
test_df_2 = pd.DataFrame(test_df['OriginalTweet'].astype(str))
```

In [9]:

```python
#let's change the target to 1 for train covid df
train_df_2["target"]=1
train_df_2
```

0	@MeNyrbie @Phil_Gahan @Chrisitv https://t.co/i...	1
1	advice Talk to your neighbours family to excha...	1
2	Coronavirus Australia: Woolworths to give elde...	1
3	My food stock is not the only one which is emp...	1
4	Me, ready to go at supermarket during the #COV...	1
...	...	...
41152	Airline pilots offering to stock supermarket s...	1
41153	Response to complaint not provided citing COVI...	1
41154	You know itÂ s getting tough when @KameronWild...	1
41155	Is it wrong that the smell of hand sanitizer i...	1
41156	@TartiiCat Well new/used Rift S are going for ...	1

41157 rows × 2 columns

In [10]:

```python
#let's change the target to 1 for test covid df

test_df_2['target']=1
test_df_2
```

Out[10]:

	OriginalTweet	target
0	TRENDING: New Yorkers encounter empty supermar...	1
1	When I couldn't find hand sanitizer at Fred Me...	1
2	Find out how you can protect yourself and love...	1
3	#Panic buying hits #NewYork City as anxious sh...	1
4	#toiletpaper #dunnypaper #coronavirus #coronav...	1
...	...	...
3793	Meanwhile In A Supermarket in Israel -- People...	1
3794	Did you panic buy a lot of non-perishable item...	1
3795	Asst Prof of Economics @cconces was on @NBCPhi...	1
3796	Gov need to do somethings instead of biar je r...	1
3797	I and @ForestandPaper members are committed to...	1

3798 rows × 2 columns

*As you can see our train & test covid-19 dataset has been cut down to include our index and tweet. Next, we shall add the target column to both.

In [11]:

```python
train_df_2["tweet"] = train_df_2['OriginalTweet']
train_df_2 = train_df_2.drop(["OriginalTweet"], axis=1)
train_df_2
```

0	1	@MeNyrbie @Phil_Gahan @Chrisitv https://t.co/i...
1	1	advice Talk to your neighbours family to excha...
2	1	Coronavirus Australia: Woolworths to give elde...
3	1	My food stock is not the only one which is emp...
4	1	Me, ready to go at supermarket during the #COV...
...	...	...
41152	1	Airline pilots offering to stock supermarket s...
41153	1	Response to complaint not provided citing COVI...
41154	1	You know itÂ s getting tough when @KameronWild...
41155	1	Is it wrong that the smell of hand sanitizer i...
41156	1	@TartiiCat Well new/used Rift S are going for ...

In [12]:

```python
test_df_2["tweet"] = test_df_2['OriginalTweet']
test_df_2 = test_df_2.drop(["OriginalTweet"], axis=1)
test_df_2
```

Out[12]:

	target	tweet
0	1	TRENDING: New Yorkers encounter empty supermar...
1	1	When I couldn't find hand sanitizer at Fred Me...
2	1	Find out how you can protect yourself and love...
3	1	#Panic buying hits #NewYork City as anxious sh...
4	1	#toiletpaper #dunnypaper #coronavirus #coronav...
...	...	...
3793	1	Meanwhile In A Supermarket in Israel -- People...
3794	1	Did you panic buy a lot of non-perishable item...
3795	1	Asst Prof of Economics @cconces was on @NBCPhi...
3796	1	Gov need to do somethings instead of biar je r...
3797	1	I and @ForestandPaper members are committed to...

3798 rows × 2 columns

Let's Organize Our Non-Covid-19 Dataset!

In [13]:

```python
noncovid_df = pd.read_csv('data/non_covid_tweets.csv', encoding='latin1
noncovid_df.shape
```

Out[13]:

```
(44955, 6)
```

In [14]:

```python
#We dropped the irrelevant columns for the non-covid-19 tweets
noncovid_df2 = pd.DataFrame(noncovid_df['tweet'].astype(str))
noncovid_df2.head()
```

Out[14]:

	tweet
1534203	@JPcashcash fun fun! say hi to mercy mercedes ...
1436035	@comfykitty Thanks
1012124	I'ma try and get 700 tweets today
330807	WHOO-HOO! So excited 4 new phone (sorry sideki...
422674	@xoticbeauty no one

In [15]:
```
# Add a "target" column to noncovid_df where each row is set to 0
noncovid_df2['target']=0
noncovid_df2
```

Out[15]:

	tweet	target
1534203	@JPcashcash fun fun! say hi to mercy mercedes ...	0
1436035	@comfykitty Thanks	0
1012124	I'ma try and get 700 tweets today	0
330807	WHOO-HOO! So excited 4 new phone (sorry sideki...	0
422674	@xoticbeauty no one	0
...	...	...
1278613	Jennii00what is yourfavoritecobra starshipsong?	0
1141699	@bignatewoods Well Leigh was @leighmathews bu...	0
195875	@PaulmMcC why am I not s good wife	0
649399	Also watched 'Analyze That' and disappointed ...	0
342154	I have to go wash my hair as it stinks from bu...	0

44955 rows × 2 columns

In [16]:
```
# Reset the index of the noncovid_df
noncovid_df2.reset_index(drop=True)
noncovid_df2
```

	tweet	target
1534203	@JPcashcash fun fun! say hi to mercy mercedes ...	0
1436035	@comfykitty Thanks	0
1012124	I'ma try and get 700 tweets today	0
330807	WHOO-HOO! So excited 4 new phone (sorry sideki...	0
422674	@xoticbeauty no one	0
...	...	...
1278613	Jennii00what is yourfavoritecobra starshipsong?	0
1141699	@bignatewoods Well Leigh was @leighmathews bu...	0
195875	@PaulmMcC why am I not s good wife	0
649399	Also watched 'Analyze That' and disappointed ...	0
342154	I have to go wash my hair as it stinks from bu...	0

44955 rows × 2 columns

In [17]:
```
noncovid_df2.isna().sum()
```

Out[17]:
```
tweet     0
target    0
dtype: int64
```

Let's combine datasets and complete preprocessing for NLP!

In [18]:

```
#Concat test/train split
#Train for both covid & non-covid dataset
#Test for both covid & non-covid dataset

covid_tweets =  pd.concat([train_df_2, test_df_2], axis=0)
all_tweets = pd.concat([covid_tweets, noncovid_df2], axis = 0)
all_tweets

# set variables
X = all_tweets.drop("target", axis=1)
y = all_tweets['target']

# test/train split
X_train, X_test, y_train, y_test = train_test_split(X, y, test_size=0.1

# test/train split for validatiion set
X_train, X_val, y_train, y_val = train_test_split(X_test, y_test, test_

#Back into DF, not running these causes an error for preprocessing func
X_train = pd.DataFrame(X_train)
X_test = pd.DataFrame(X_test)
X_val = pd.DataFrame(X_val)
```

In [19]:

```
all_tweets.describe()
```

Out[19]:

	target
count	89910.000000
mean	0.500000
std	0.500003
min	0.000000
25%	0.000000
50%	0.500000
75%	1.000000
max	1.000000

In [20]:

```
print("Total tweets in this data: {}".format(all_tweets.shape[0]))
```

```
Total tweets in this data: 89910
```

Baseline Values:

In [21]:

```
print(all_tweets['target'].unique())
print(all_tweets['target'].value_counts(normalize=True))
```

```
[1 0]
1    0.5
0    0.5
Name: target, dtype: float64
```

In [22]:

```
all_tweets.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Int64Index: 89910 entries, 0 to 342154
Data columns (total 2 columns):
 #   Column  Non-Null Count  Dtype 
---  ------  --------------  ----- 
 0   target  89910 non-null  int64 
 1   tweet   89910 non-null  object
dtypes: int64(1), object(1)
memory usage: 2.1+ MB
```

In [23]:

```
# Let's begin the various text preprocessing steps:
#Tokenization.
#Lower casing.
#Stop words removal.
#Stemming.
#Lemmatization.
```

Data Preprocessing

For data preprocessing, I needed to find additional preprocessing steps and found this resource (https://www.kaggle.com/datatattle/battle-of-ml-classification-models).

In [24]:

```
#initialize stopwords for removal
sw = stopwords.words('english')
```

In [25]:

```
# Number removal
def remove_num(text):
    remove= re.sub(r'\d+', '', text)
    return remove
X_train['tweet']=X_train['tweet'].apply(lambda x:remove_num(x))
X_test['tweet']=X_test['tweet'].apply(lambda x:remove_num(x))
```

In [26]:

```
# remove punctuations

def punct_remove(text):
    punct = re.sub(r"[^\w\s\d]","", text)
    return punct
X_train['tweet']=X_train['tweet'].apply(lambda x:punct_remove(x))
X_test['tweet']=X_test['tweet'].apply(lambda x:punct_remove(x))

```

In [27]:

```python
#Remove mentions and hashtags

def remove_mention(x):
    text=re.sub(r'@\w+','',x)
    return text
X_train['tweet']=X_train['tweet'].apply(lambda x:remove_mention(x))
X_test['tweet']=X_test['tweet'].apply(lambda x:remove_mention(x))

def remove_hash(x):
    text=re.sub(r'#\w+','',x)
    return text
X_train['tweet']=X_train['tweet'].apply(lambda x:remove_hash(x))
X_test['tweet']=X_test['tweet'].apply(lambda x:remove_hash(x))

#Remove extra white space left while removing stuff
def remove_space(text):
    space_remove = re.sub(r"\s+"," ",text).strip()
    return space_remove
X_train['tweet']=X_train['tweet'].apply(lambda x:remove_space(x))
X_test['tweet']=X_test['tweet'].apply(lambda x:remove_space(x))

```

In [28]:

```python
#Remove Urls and HTML links
def remove_urls(text):
    url_remove = re.compile(r'https?://\S+|www\.\S+')
    return url_remove.sub(r'', text)
X_train['tweet']=X_train['tweet'].apply(lambda x:remove_urls(x))
X_test['tweet']=X_test['tweet'].apply(lambda x:remove_urls(x))

def remove_html(text):
    html=re.compile(r'<.*?>')
    return html.sub(r'',text)
X_train['tweet']=X_train['tweet'].apply(lambda x:remove_html(x))
X_test['tweet']=X_test['tweet'].apply(lambda x:remove_html(x))
```

In [29]:

```python
#identify POS tags
def get_pos(treebank_tag):
    if treebank_tag.startswith('J'):
        return wordnet.ADJ
    elif treebank_tag.startswith('V'):
        return wordnet.VERB
    elif treebank_tag.startswith('N'):
        return wordnet.NOUN
    elif treebank_tag.startswith('R'):
        return wordnet.ADV
    else:
        return wordnet.NOUN
```

In [30]:

```python
#preprocess text function - has been modified to suit our needs

def tweet_preparer(tweet_text, stopwords=sw):
    regex_token = RegexpTokenizer(r'([a-zA-Z]+)')
    tweet_text = regex_token.tokenize(tweet_text)
    tweet_text = [word.lower() for word in tweet_text]
    tweet_text = [word for word in tweet_text if word not in sw]
    tweet_text = pos_tag(tweet_text)
    tweet_text = [(word[0], get_pos(word[1])) for word in tweet_text]
    lemmatizer = WordNetLemmatizer()
    tweet_text = [lemmatizer.lemmatize(word[0], word[1]) for word in tw
    return tweet_text
```

In [31]:

```python
#Process Training data
X_train['Tweet_tokens'] = [tweet_preparer(tweet_text, sw) for tweet_tex
```

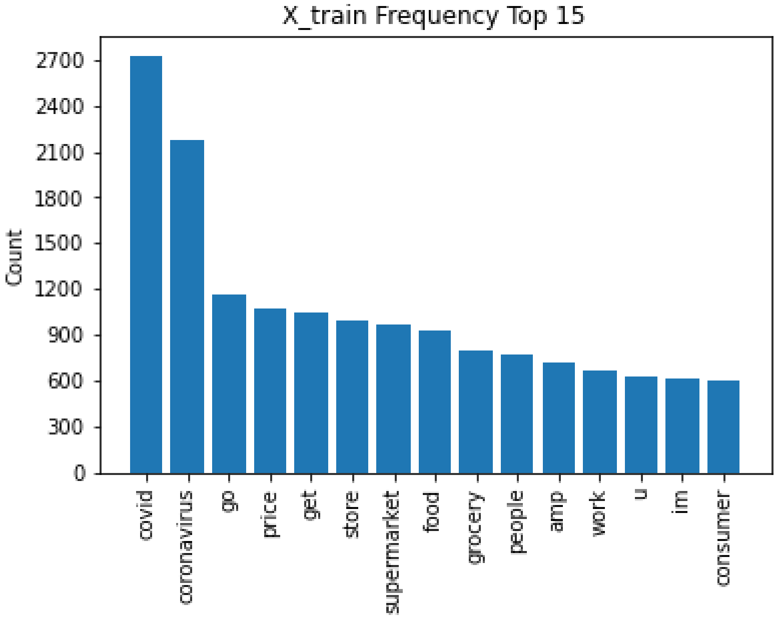
In [32]:

```python
#process test data
X_test['Tweet_tokens'] = [tweet_preparer(tweet_text, sw) for tweet_text

```

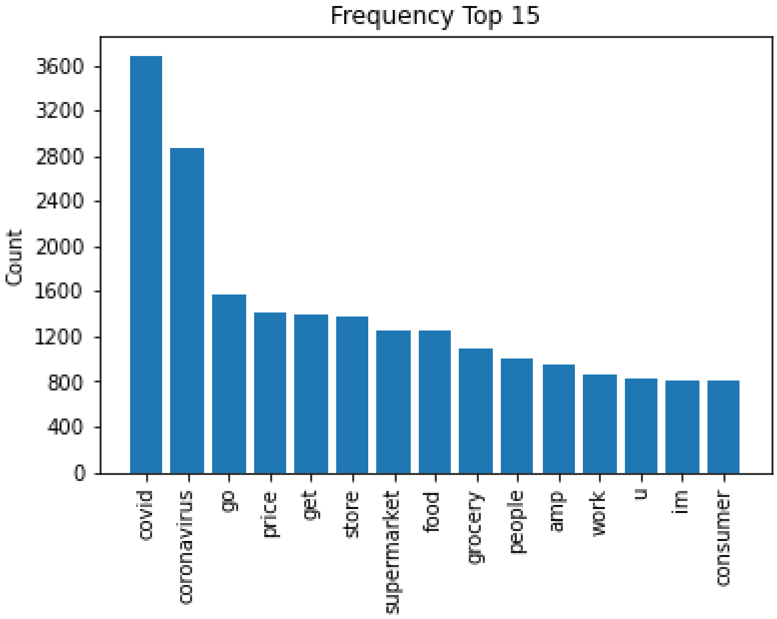
In [33]:

```python
#for plotting frequency distribution
from matplotlib.ticker import MaxNLocator
def plot_frequency(freq_dist, title):
    top_15 = list(zip(*freq_dist.most_common(15)))
    tokens = top_15[0]
    counts = top_15[1]
    fig, ax = plt.subplots()
    ax.bar(tokens, counts)
    ax.set_title(title)
    ax.set_ylabel("Count")
    ax.yaxis.set_major_locator(MaxNLocator(integer=True))
    ax.tick_params(axis="x", rotation=90)
```

In [34]:
```
# plotting frequency distribution - plot of Training tokens top 15
train_freq_dist = FreqDist(X_train['Tweet_tokens'].explode())
plot_frequency(train_freq_dist, "X_train Frequency Top 15")
```



In [35]:
```
#plotting test freqdist words - similar results
X_testfreq_dist = FreqDist(X_test['Tweet_tokens'].explode())
plot_frequency(X_testfreq_dist, "Frequency Top 15")
```



Among the top 3 words that are seen in the `X_train` & `X_test` are words that relate to covid/coronavirus.

CountVectorizer

In [36]:

```
#CountVectorizer - no limit to how many words to check performance with
#fit transform train data
cvec = CountVectorizer(stop_words=sw, min_df=.000026, max_features = 27
X_t_vec = cvec.fit_transform(X_train['tweet'])
X_t_vec  = pd.DataFrame.sparse.from_spmatrix(X_t_vec)
X_t_vec.columns = sorted(cvec.vocabulary_)
X_t_vec.set_index(y_train.index, inplace=True)
X_t_vec
```

Out[36]:

	__	___	____	_______	__________	__anthony	_anujsinghal	_bcla	_claragh__b_	_crc_	...
459681	0	0	0	0	0	0	0	0	0	0	...
7207	0	0	0	0	0	0	0	0	0	0	...
1077990	0	0	0	0	0	0	0	0	0	0	...
32218	0	0	0	0	0	0	0	0	0	0	...
38172	0	0	0	0	0	0	0	0	0	0	...
...	...	...	...	...	...	...	...	...	...	...	...
2430	0	0	0	0	0	0	0	0	0	0	...
576114	0	0	0	0	0	0	0	0	0	0	...
329972	0	0	0	0	0	0	0	0	0	0	...
409019	0	0	0	0	0	0	0	0	0	0	...
40788	0	0	0	0	0	0	0	0	0	0	...

10115 rows × 27133 columns

In [37]:

```
#CountVectorizer
# transform val data

X_val_vec = cvec.transform(X_val['tweet'])
X_val_vec  = pd.DataFrame.sparse.from_spmatrix(X_val_vec)
X_val_vec.columns = sorted(cvec.vocabulary_)
X_val_vec.set_index(y_val.index, inplace=True)
X_val_vec
```

Out[37]:

	__	___	____	_______	__________	__anthony	_anujsinghal	_bcla	_claragh__b_	_crc_	...
3395	0	0	0	0	0	0	0	0	0	0	...
15269	0	0	0	0	0	0	0	0	0	0	...
18341	0	0	0	0	0	0	0	0	0	0	...
9078	0	0	0	0	0	0	0	0	0	0	...
473511	0	0	0	0	0	0	0	0	0	0	...
...	...	...	...	...	...	...	...	...	...	...	...
4504	0	0	0	0	0	0	0	0	0	0	...
615549	0	0	0	0	0	0	0	0	0	0	...
1049654	0	0	0	0	0	0	0	0	0	0	...
28105	0	0	0	0	0	0	0	0	0	0	...
2194	0	0	0	0	0	0	0	0	0	0	...

3372 rows × 27133 columns

In [38]:

```
#CountVectorizer - no limit to how many words to check performance with
#fit transform test data
X_test_vec = cvec.transform(X_test['tweet'])
X_test_vec  = pd.DataFrame.sparse.from_spmatrix(X_test_vec)
X_test_vec.columns = sorted(cvec.vocabulary_)
X_test_vec.set_index(y_test.index, inplace=True)
X_test_vec
```

Out[38]:

	__	___	____	_______	__________	__anthony	_anujsinghal	_bcla	_claragh__b_	_crc_	...
37944	0	0	0	0	0	0	0	0	0	0	...
3961	0	0	0	0	0	0	0	0	0	0	...
22311	0	0	0	0	0	0	0	0	0	0	...
414855	0	0	0	0	0	0	0	0	0	0	...
7872	0	0	0	0	0	0	0	0	0	0	...
...	...	...	...	...	...	...	...	...	...	...	...
32434	0	0	0	0	0	0	0	0	0	0	...
11713	0	0	0	0	0	0	0	0	0	0	...
36535	0	0	0	0	0	0	0	0	0	0	...
139852	0	0	0	0	0	0	0	0	0	0	...
1308211	0	0	0	0	0	0	0	0	0	0	...

13487 rows × 27133 columns

TF-IDF Vectorizer

1st TF-IDF Vectorizer

In [39]:

```
#1st TD-IDF vectorizer
# max_features & token_pattern are different for both
#Fit transform training data

tfidf = TfidfVectorizer(stop_words=sw, lowercase=True, max_features=271

X_t_tf = tfidf.fit_transform(X_train['tweet'])
X_t_tf  = pd.DataFrame.sparse.from_spmatrix(X_t_tf)
X_t_tf.columns = sorted(tfidf.vocabulary_)
X_t_tf.set_index(y_train.index, inplace=True)
X_t_tf
```

Out[39]:

	aaa	aaaaa	aaaaaaaaaahhhhhhhhhhyou	aaaaaahh	aaaaache	aaaaalll	aaaaarrrrgggghhhl
459681	0.0	0.0	0.0	0.0	0.0	0.0	0.
7207	0.0	0.0	0.0	0.0	0.0	0.0	0.
1077990	0.0	0.0	0.0	0.0	0.0	0.0	0.
32218	0.0	0.0	0.0	0.0	0.0	0.0	0.
38172	0.0	0.0	0.0	0.0	0.0	0.0	0.
...	...	...	...	...	...	...	..
2430	0.0	0.0	0.0	0.0	0.0	0.0	0.
576114	0.0	0.0	0.0	0.0	0.0	0.0	0.
329972	0.0	0.0	0.0	0.0	0.0	0.0	0.
409019	0.0	0.0	0.0	0.0	0.0	0.0	0.
40788	0.0	0.0	0.0	0.0	0.0	0.0	0.

10115 rows × 26899 columns

In [40]:

```python
# transform val data

X_val_tf = tfidf.transform(X_val['tweet'])
X_val_tf  = pd.DataFrame.sparse.from_spmatrix(X_val_tf)
X_val_tf.columns = sorted(tfidf.vocabulary_)
X_val_tf.set_index(y_val.index, inplace=True)
X_val_tf
```

Out[40]:

	aaa	aaaaa	aaaaaaaaaahhhhhhhhhhyou	aaaaaahh	aaaaache	aaaaalll	aaaaarrrrggghhhl
3395	0.0	0.0	0.0	0.0	0.0	0.0	0.
15269	0.0	0.0	0.0	0.0	0.0	0.0	0.
18341	0.0	0.0	0.0	0.0	0.0	0.0	0.
9078	0.0	0.0	0.0	0.0	0.0	0.0	0.
473511	0.0	0.0	0.0	0.0	0.0	0.0	0.
...	...	...	...	...	...	...	..
4504	0.0	0.0	0.0	0.0	0.0	0.0	0.
615549	0.0	0.0	0.0	0.0	0.0	0.0	0.
1049654	0.0	0.0	0.0	0.0	0.0	0.0	0.
28105	0.0	0.0	0.0	0.0	0.0	0.0	0.
2194	0.0	0.0	0.0	0.0	0.0	0.0	0.

3372 rows × 26899 columns

In [41]:

```
#For test set of 1st TD-IDF vectorizer

X_test_tf = tfidf.transform(X_test['tweet'])
X_test_tf  = pd.DataFrame.sparse.from_spmatrix(X_test_tf)
X_test_tf.columns = sorted(tfidf.vocabulary_)
X_test_tf.set_index(y_test.index, inplace=True)
X_test_tf
```

Out[41]:

	aaa	aaaaa	aaaaaaaaaahhhhhhhhhhyou	aaaaaahh	aaaaache	aaaaalll	aaaaarrrrgggghhhl
37944	0.0	0.0	0.0	0.0	0.0	0.0	0.
3961	0.0	0.0	0.0	0.0	0.0	0.0	0.
22311	0.0	0.0	0.0	0.0	0.0	0.0	0.
414855	0.0	0.0	0.0	0.0	0.0	0.0	0.
7872	0.0	0.0	0.0	0.0	0.0	0.0	0.
...	...	...	...	...	...	...	..
32434	0.0	0.0	0.0	0.0	0.0	0.0	0.
11713	0.0	0.0	0.0	0.0	0.0	0.0	0.
36535	0.0	0.0	0.0	0.0	0.0	0.0	0.
139852	0.0	0.0	0.0	0.0	0.0	0.0	0.
1308211	0.0	0.0	0.0	0.0	0.0	0.0	0.

13487 rows × 26899 columns

2nd TF-IDF Vectorizer

In [42]:

```
Secondary TF-IDF vectorizer with new params to limit vocab to syntactically
For train set with min_df specified
 min_df = 0.00008

fidf2 = TfidfVectorizer(stop_words=sw, min_df=.000008, max_features=10785, 

_train_tfidf = tfidf2.fit_transform(X_train['tweet'])
_train_tfidf  = pd.DataFrame.sparse.from_spmatrix(X_train_tfidf)
_train_tfidf.columns = sorted(tfidf2.vocabulary_)
_train_tfidf.set_index(y_train.index, inplace=True)
_train_tfidf
```

Out[42]:

	aa	aah	aand	aaron	aarons	aas	aaww	ab	abandoned	abc	...	z	zachary	zamb
459681	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
7207	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
1077990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
32218	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
38172	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
2430	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
576114	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
329972	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
409019	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
40788	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0

10115 rows × 10785 columns

In [43]:

```python
#validation set for
X_val_tf2 = tfidf2.transform(X_val['tweet'])
X_val_tf2 = pd.DataFrame.sparse.from_spmatrix(X_val_tf2)
X_val_tf2.columns = sorted(tfidf2.vocabulary_)
X_val_tf2.set_index(y_val.index, inplace=True)
X_val_tf2
```

Out[43]:

```
          aa   aah  aand  aaron  aarons  aas  aaww   ab  abandoned  abc  ...         z  zachary
3395     0.0   0.0   0.0    0.0     0.0  0.0   0.0  0.0        0.0  0.0  ...  0.282126      0.0
15269    0.0   0.0   0.0    0.0     0.0  0.0   0.0  0.0        0.0  0.0  ...  0.000000      0.0
18341    0.0   0.0   0.0    0.0     0.0  0.0   0.0  0.0        0.0  0.0  ...  0.000000      0.0
9078     0.0   0.0   0.0    0.0     0.0  0.0   0.0  0.0        0.0  0.0  ...  0.000000      0.0
473511   0.0   0.0   0.0    0.0     0.0  0.0   0.0  0.0        0.0  0.0  ...  0.000000      0.0
...      ...   ...   ...    ...     ...  ...   ...  ...        ...  ...  ...       ...      ...
4504     0.0   0.0   0.0    0.0     0.0  0.0   0.0  0.0        0.0  0.0  ...  0.000000      0.0
615549   0.0   0.0   0.0    0.0     0.0  0.0   0.0  0.0        0.0  0.0  ...  0.000000      0.0
1049654  0.0   0.0   0.0    0.0     0.0  0.0   0.0  0.0        0.0  0.0  ...  0.000000      0.0
28105    0.0   0.0   0.0    0.0     0.0  0.0   0.0  0.0        0.0  0.0  ...  0.000000      0.0
2194     0.0   0.0   0.0    0.0     0.0  0.0   0.0  0.0        0.0  0.0  ...  0.000000      0.0

3372 rows × 10785 columns
```

In [44]:

```
## 2nd TF-IDF vectorizer with new params to limit vocab to syntacticall
#For test set with max features of 10785 to match train

X_test_tfidf2 = tfidf2.transform(X_test['tweet'])
X_test_tfidf2  = pd.DataFrame.sparse.from_spmatrix(X_test_tfidf2)
X_test_tfidf2.columns = sorted(tfidf2.vocabulary_)
X_test_tfidf2.set_index(y_test.index, inplace=True)
X_test_tfidf2
```

Out[44]:

	aa	aah	aand	aaron	aarons	aas	aaww	ab	abandoned	abc	...	z	zachary	zamb
37944	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
3961	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
22311	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
414855	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
7872	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
...	...	...	...	...	...	...	...	...	...	...	...	...	...	
32434	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
11713	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
36535	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
139852	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0
1308211	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0

13487 rows × 10785 columns

In [45]:

```
#Sum weight of the 2nd TF-IDF Vectorized Matrix Features
tfidf_test = X_train_tfidf.sum()
type(tfidf_test)
```

Out[45]:

```
pandas.core.series.Series
```

In [46]:

```
#To a DF
tf_df = pd.DataFrame(tfidf_test)
tf_df.rename(columns={0: 'Value'}, inplace=True)
tf_df
```

Out[46]:

	Value
aa	1.693972
aah	0.655926
aand	0.851539
aaron	0.622174
aarons	0.798210
...	...
zmartbit	0.561984
zombie	2.538501
zombies	1.324632
zoom	0.704087
zoos	0.603126

10785 rows × 1 columns

In [47]:

```
#sorted
tf_df.sort_values('Value', ascending=False)
```

Out[47]:

	Value
covid	259.596054
coronavirus	229.897891
im	129.972588
supermarket	124.448046
store	123.275909
...	...
bestiptv	0.176764
resonable	0.176764
orourke	0.175827
bbqs	0.168062
ballot	0.133536

Modeling

Models using Count Vectorizer

- For this part of modeling, we shall use the training set & validation set.

In [48]:

```
lsvc = LinearSVC()
mnb = MultinomialNB()
dt = DecisionTreeClassifier()
rf = RandomForestClassifier()


```

In [49]:

```
# MODELS using Count Vec
# Using training set
from sklearn.metrics import recall_score

models = [lsvc, mnb, dt, rf]
scores = {}

for model in models:
    model.fit(X_t_vec, y_train)
    y_pred= model.predict(X_test_vec)
    Accuracy = accuracy_score(y_test, y_pred)
    Recall = recall_score(y_test, y_pred)

    scores[model] = ('Accuracy:', Accuracy), ('Recall:', Recall)
```

In [50]:

```
for key, value in scores.items():
    print(f"Model name - {key}, accuracy - {round(value[0][1],5)}, reca

```

```
Model name - LinearSVC(), accuracy - 0.9954, recall 0.99134
Model name - MultinomialNB(), accuracy - 0.98354, recall 0.99462
Model name - DecisionTreeClassifier(), accuracy - 0.99333, recall 0.99238
Model name - RandomForestClassifier(), accuracy - 0.99652, recall 0.99388
```

In [51]:

```
# MODELS using Count Vec
# Using valditation set
from sklearn.metrics import recall_score

models = [lsvc, mnb, dt, rf]
scores = {}

for model in models:
    model.fit(X_t_vec, y_train)
    y_pred= model.predict(X_val_vec)
    Accuracy = accuracy_score(y_val, y_pred)
    Recall = recall_score(y_val, y_pred)

    scores[model] = ('Accuracy:', Accuracy), ('Recall:', Recall)
```

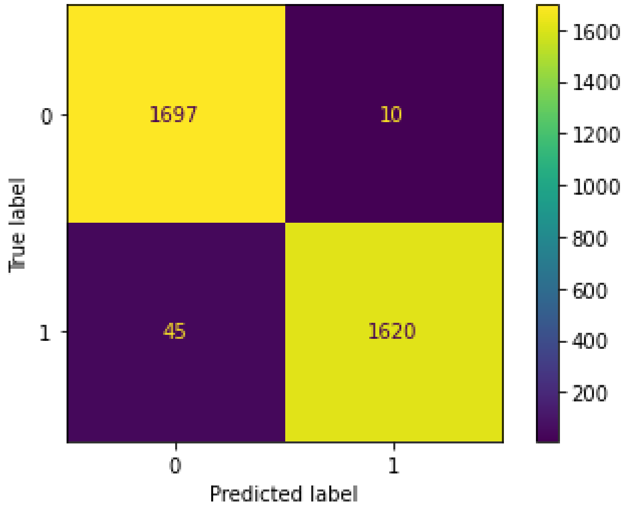
In [52]:

```
for key, value in scores.items():
    print(f"Model name - {key}, accuracy - {round(value[0][1],5)}, reca

```

```
Model name - LinearSVC(), accuracy - 0.97954, recall 0.96216
Model name - MultinomialNB(), accuracy - 0.95848, recall 0.9958
Model name - DecisionTreeClassifier(), accuracy - 0.97064, recall 0.96456
Model name - RandomForestClassifier(), accuracy - 0.98369, recall 0.97297
```

In [53]:

```
from sklearn.metrics import accuracy_score, precision_score, plot_confu

#confusion matrix on validation set
plot_confusion_matrix(rf, X_val_vec, y_val);
```



Models using TF-IDF Vectorizer

- training set
- validation set

I needed to research ways to run effective vectorizers and found this resource (https://github.com/smashley-eakland/tweet-nlp-analysis/blob/main/NLP.ipynb).

In [54]:

```python
# MODELS using 2nd TF-IDF Vectorizer
# Using training set

from sklearn.metrics import recall_score

models = [lsvc, mnb, dt, rf]
scores = {}

for model in models:
    model.fit(X_train_tfidf, y_train)
    y_pred= model.predict(X_test_tfidf2)
    Accuracy = accuracy_score(y_test, y_pred)
    Recall = recall_score(y_test, y_pred)

    scores[model] = ('Accuracy:', Accuracy), ('Recall:', Recall)

```

In [55]:

```python
for key, value in scores.items():
    print(f"Model name - {key}, accuracy - {round(value[0][1],5)}, reca
```

```
Model name - LinearSVC(), accuracy - 0.99385, recall 0.98985
Model name - MultinomialNB(), accuracy - 0.97865, recall 0.98656
Model name - DecisionTreeClassifier(), accuracy - 0.99177, recall 0.99089
Model name - RandomForestClassifier(), accuracy - 0.99577, recall 0.99298
```

In [56]:

```python
# MODELS using 2nd TF-IDF Vectorizer.
# The 2nd TF-IDF vectorizer included 10785 columns compared to 26975 col
# Using validation set

from sklearn.metrics import recall_score

models = [lsvc, mnb, dt, rf]
scores = {}

for model in models:
    model.fit(X_train_tfidf, y_train)
    y_pred= model.predict(X_val_tf2)
    Accuracy = accuracy_score(y_val, y_pred)
    Recall = recall_score(y_val, y_pred)

    scores[model] = ('Accuracy:', Accuracy), ('Recall:', Recall)

```

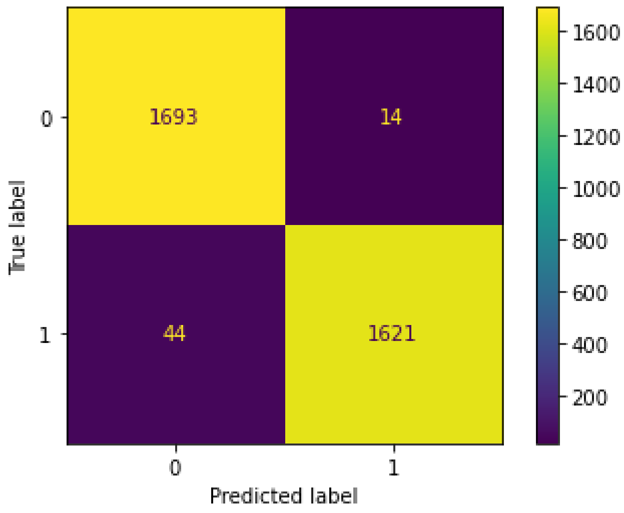
In [57]:

```python
for key, value in scores.items():
    print(f"Model name - {key}, accuracy - {round(value[0][1],5)}, reca

```

```
Model name - LinearSVC(), accuracy - 0.98161, recall 0.96997
Model name - MultinomialNB(), accuracy - 0.96234, recall 0.98619
Model name - DecisionTreeClassifier(), accuracy - 0.97005, recall 0.96577
Model name - RandomForestClassifier(), accuracy - 0.9828, recall 0.97357
```

In [58]:

```
#confusion matrix on validation set
plot_confusion_matrix(rf, X_val_tf2, y_val);
```



MODEL Continued

- The random forest classifer did the best compared to the other 3 models while using the count vectorizer & 2nd TF-IDF.
- Moving forward we shall use the TF-IDF since the results were better for this one.

In [59]:

```
# MODELS using 2nd TF-IDF
# Using Cross-Validation

models = [lsvc, mnb, dt, rf]
from sklearn.model_selection import cross_validate
# 5 Cross-validation
CV = 5
cv_df = pd.DataFrame(index=range(CV * len(models)))

scores = []

for model in models:
    model_name = model.__class__.__name__
    accuracies = cross_validate(model, X_train_tfidf, y_train, scoring=
#     model.fit(X_t_vec, y_train)
#     y_pred= model.predict(X_test_vec)
#     Accuracy = accuracy_score(y_val, y_pred)
#     Recall = recall_score(y_val, y_pred)
    for fold_idx, recall in enumerate(accuracies["test_recall"]):
        Recall = recall
        Accuracy = accuracies["test_accuracy"][fold_idx]
        scores.append((model_name, Accuracy, Recall))

cv_df = pd.DataFrame(scores, columns=['Model Name', 'Accuracy', 'Recall
```

In [60]:

```
cv_df
```

Out[60]:

	Model Name	Accuracy	Recall
0	LinearSVC	0.974296	0.953280
1	LinearSVC	0.974790	0.957256
2	LinearSVC	0.977756	0.963221
3	LinearSVC	0.976767	0.959285
4	LinearSVC	0.977756	0.966236
5	MultinomialNB	0.959466	0.973161
6	MultinomialNB	0.967870	0.983101
7	MultinomialNB	0.969847	0.980119
8	MultinomialNB	0.965398	0.978153
9	MultinomialNB	0.966387	0.977160
10	DecisionTreeClassifier	0.964904	0.958250
11	DecisionTreeClassifier	0.966387	0.957256
12	DecisionTreeClassifier	0.969352	0.958250
13	DecisionTreeClassifier	0.969352	0.961271
14	DecisionTreeClassifier	0.968858	0.963257
15	RandomForestClassifier	0.977261	0.965209
16	RandomForestClassifier	0.982699	0.970179
17	RandomForestClassifier	0.983193	0.970179
18	RandomForestClassifier	0.983193	0.971202
19	RandomForestClassifier	0.984676	0.973188

`RandomForestClassifer` seems to be the best performing model.

In [61]:

```
#Let's test on best model w/o CV
# on validation set

model = [rf]
scores = {}

for model in model:
    model.fit(X_train_tfidf, y_train)
    y_pred= model.predict(X_val_tf2)
    Accuracy = accuracy_score(y_val, y_pred)
    Recall = recall_score(y_val, y_pred)

    scores[model] = ('Accuracy:', Accuracy), ('Recall:', Recall)
```

In [62]:

```python
for key, value in scores.items():
    print(f"Model name - {key}, accuracy - {round(value[0][1],5)}, reca
```

```
Model name - RandomForestClassifier(), accuracy - 0.98488, recall 0.97778
```

Evaluation for Best Model

In [63]:

```python
# using test set

model = [rf]
scores = {}

for model in model:
    rf_hat = model.predict(X_test_tfidf2)
    Accuracy = accuracy_score(y_test, rf_hat)
    Recall = recall_score(y_test, rf_hat)

    scores[model] = ('Accuracy:', Accuracy), ('Recall:', Recall)
```

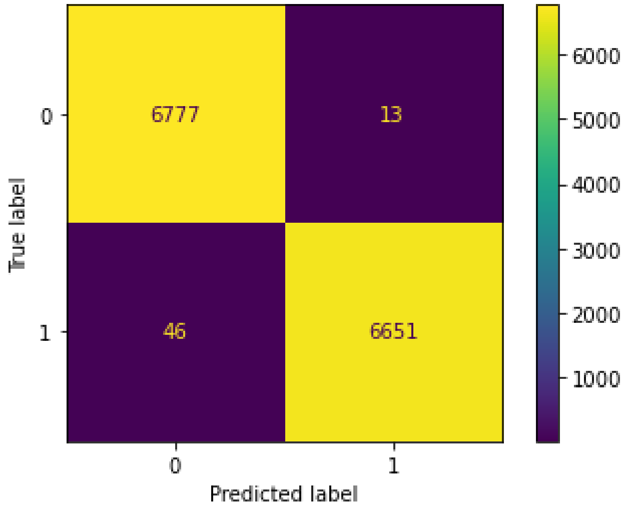
In [64]:

```python
for key, value in scores.items():
    print(f"Model name - {key}, accuracy - {round(value[0][1],5)}, reca
```

```
Model name - RandomForestClassifier(), accuracy - 0.99563, recall 0.99313
```

In [65]:

```python
#confusion matrix on validation set
plot_confusion_matrix(rf, X_test_tfidf2, y_test);
```



Conclusions

Based on results our final model will be: "Random Forest Classifier using TF-IDF"

With the following parameters after tuning:

Accuracy: 0.99577

Recall: 0.99242

Because of the following reasons:

1) It has high accuracy and recall.

In a future project, additional preprocessing steps & token patterns can be used for count vectorizer + tf-idf to attempt to get better metrics.

In conclusion, this data tells us that twitter can use NLP to predict whether if a tweet is related to covid and be able to provide resources to those positing about it.