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

```
C:\Users\Prave\anaconda3\lib\site-packages\pandas\core\arrays\masked.py:60: UserWarning: Pandas requires version '1.3.
6' or newer of 'bottleneck' (version '1.3.5' currently installed).
  from pandas.core import (
```

In [2]:
```
df = pd.read_csv("C://Users//Prave//Downloads//spam.csv", encoding='ISO-8859-1')
```

In [3]:
```
#df
```

In [4]:
```
#1 . data clearning
#2. EDA
#3. text prepossesing
#4. model building
#5. evaluation
#6. improvement
# apply to out data set.
```

1 . data clearning

In [5]:
```
# Remove the unwanted columns
df.drop(columns=['Unnamed: 2', 'Unnamed: 3', 'Unnamed: 4'], inplace=True)
```

In [6]:
```
#df.head()
```

In [7]:
```
df.rename(columns={"v1":'target','v2':'text'},inplace=True)
```

In [8]:
```
#df.head()
```

In [9]:
```
df.shape
```

Out[9]:
```
(5572, 2)
```

In [10]:
```
from sklearn.preprocessing import LabelEncoder
encoder = LabelEncoder()
```

In [11]:
```
df['target'] = encoder.fit_transform(df['target'])
```

In [12]:
```
#df.head()
```

In [13]:
```
# missing values
df.isnull().sum()
```

Out[13]:
```
target    0
text      0
dtype: int64
```

In [14]:
```
# check for duplicate
df.duplicated().sum()
```

Out[14]:
```
403
```

In [15]:
```
# remvoe duplicates
df = df.drop_duplicates(keep='first')
```

In [16]:
```
df.duplicated().sum()
```

Out[16]:
```
0
```

In [17]:
```
df.shape
```

Out[17]:
```
(5169, 2)
```

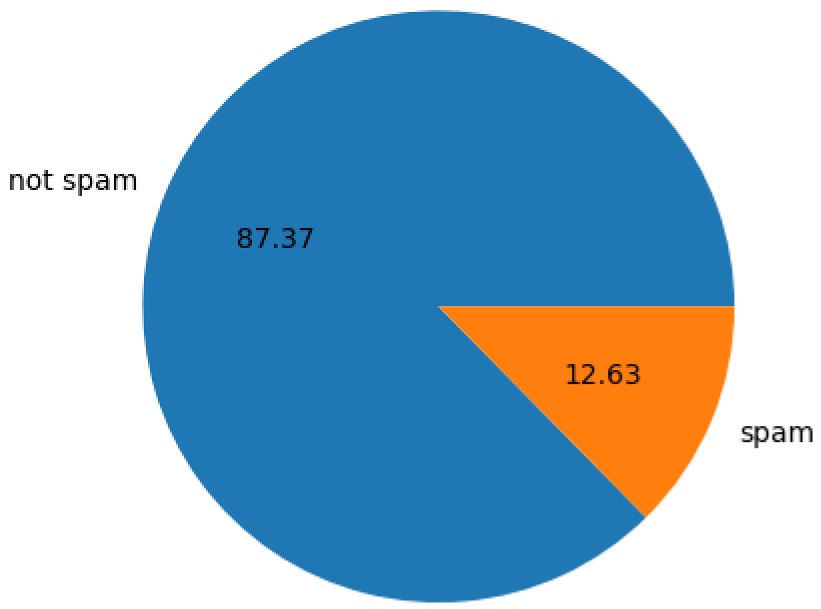
2 EDA

In [18]:
```
df['target'].value_counts()
```

Out[18]:
```
target
0    4516
1     653
Name: count, dtype: int64
```

In [19]:
```
import matplotlib.pyplot as plt
```

In [20]:
```
plt.pie(df['target'].value_counts(),labels=['not spam','spam'],autopct="%0.2f")
plt.show()
```



In [21]:
```
# data is imbalanced
```

In [22]:
```
!pip install nltk
import nltk
```

```
Requirement already satisfied: nltk in c:\users\prave\anaconda3\lib\site-packages (3.7)
Requirement already satisfied: tqdm in c:\users\prave\anaconda3\lib\site-packages (from nltk) (4.64.1)
Requirement already satisfied: joblib in c:\users\prave\anaconda3\lib\site-packages (from nltk) (1.1.1)
Requirement already satisfied: regex>=2021.8.3 in c:\users\prave\anaconda3\lib\site-packages (from nltk) (2022.7.9)
Requirement already satisfied: click in c:\users\prave\anaconda3\lib\site-packages (from nltk) (8.0.4)
Requirement already satisfied: colorama in c:\users\prave\anaconda3\lib\site-packages (from click->nltk) (0.4.6)
```

In [23]:
```
nltk.download('punkt')
```

```
[nltk_data] Downloading package punkt to
[nltk_data]     C:\Users\Prave\AppData\Roaming\nltk_data...
[nltk_data]   Package punkt is already up-to-date!
```

Out[23]:
```
True
```

In [24]:
```
df['num_characters'] = df['text'].apply(len)
```

In [25]:
```
#df.head()
```

In [26]:
```
# num of words
df['num_words'] = df['text'].apply(lambda x:len(nltk.word_tokenize(x)))
```

In [27]:
```
#df.head()
```

In [28]:
```
df['num_sentences'] = df['text'].apply(lambda x:len(nltk.sent_tokenize(x)))
```

In [29]:
```
#df.head()
```

In [30]:
```
#summary stats
df[['num_characters','num_words','num_sentences']].describe()
```

Out[30]:

	num_characters	num_words	num_sentences
count	5169.000000	5169.000000	5169.000000
mean	78.977945	18.453279	1.947185
std	58.236293	13.324793	1.362406
min	2.000000	1.000000	1.000000
25%	36.000000	9.000000	1.000000
50%	60.000000	15.000000	1.000000
75%	117.000000	26.000000	2.000000
max	910.000000	220.000000	28.000000

In [31]:
```
#only not spam
df[df['target']==0][['num_characters','num_words','num_sentences']].describe()
```

Out[31]:

	num_characters	num_words	num_sentences
count	4516.000000	4516.000000	4516.000000
mean	70.459256	17.120903	1.799601
std	56.358207	13.493725	1.278465
min	2.000000	1.000000	1.000000
25%	34.000000	8.000000	1.000000
50%	52.000000	13.000000	1.000000
75%	90.000000	22.000000	2.000000
max	910.000000	220.000000	28.000000

In [32]:
```
#only not spam
df[df['target']==1][['num_characters','num_words','num_sentences']].describe()
```

Out[32]:

	num_characters	num_words	num_sentences
count	653.000000	653.000000	653.000000
mean	137.891271	27.667688	2.967841
std	30.137753	7.008418	1.483201
min	13.000000	2.000000	1.000000
25%	132.000000	25.000000	2.000000
50%	149.000000	29.000000	3.000000
75%	157.000000	32.000000	4.000000
max	224.000000	46.000000	8.000000

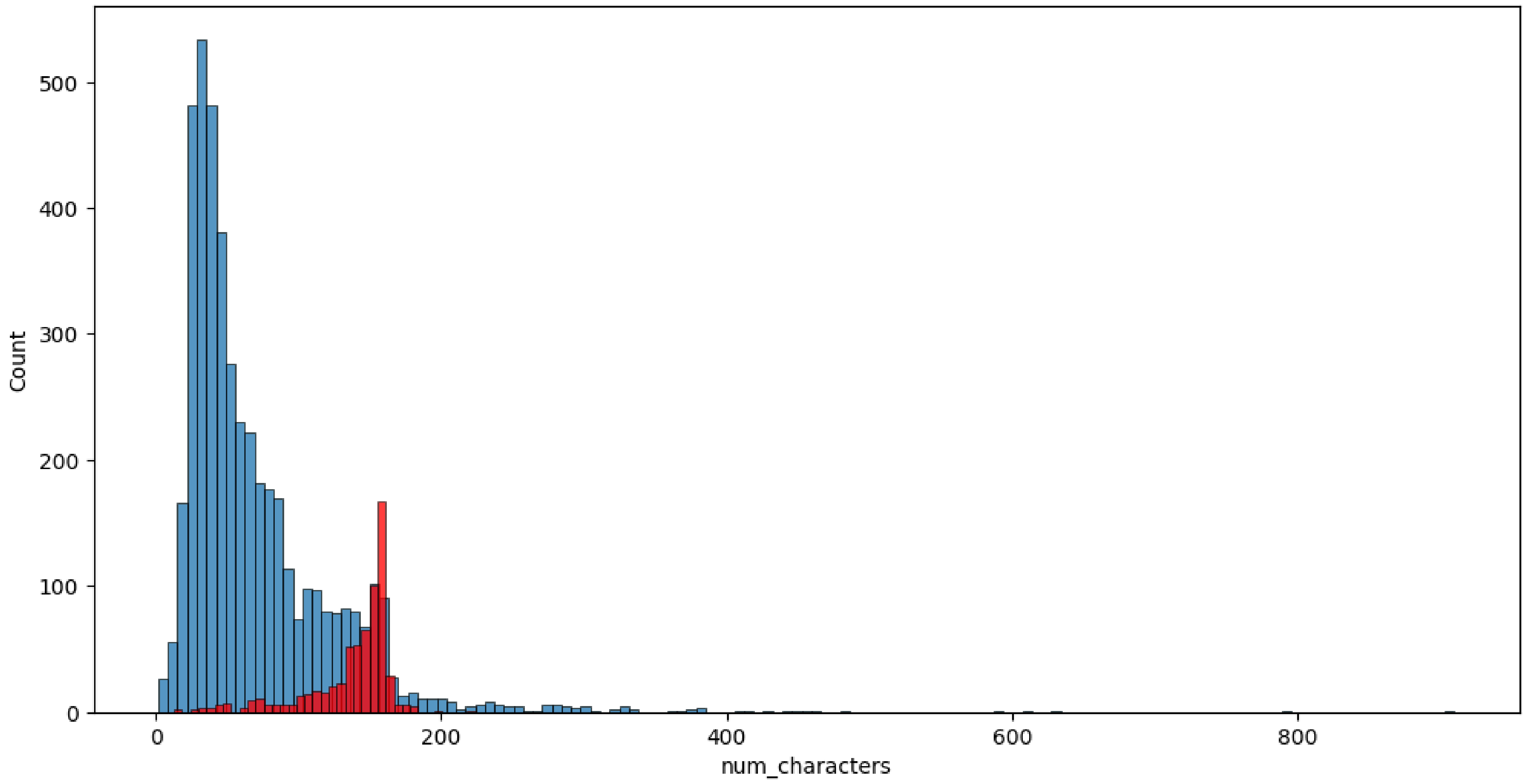
In [33]:
```
# histogram
import seaborn as sns
```

In [34]:
```
plt.figure(figsize=(12,6))
sns.histplot(df[df['target']==0]['num_characters'])
sns.histplot(df[df['target']==1]['num_characters'],color='red')
```

```
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated
and will be removed in a future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated
and will be removed in a future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
```

Out[34]:

```
<Axes: xlabel='num_characters', ylabel='Count'>
```



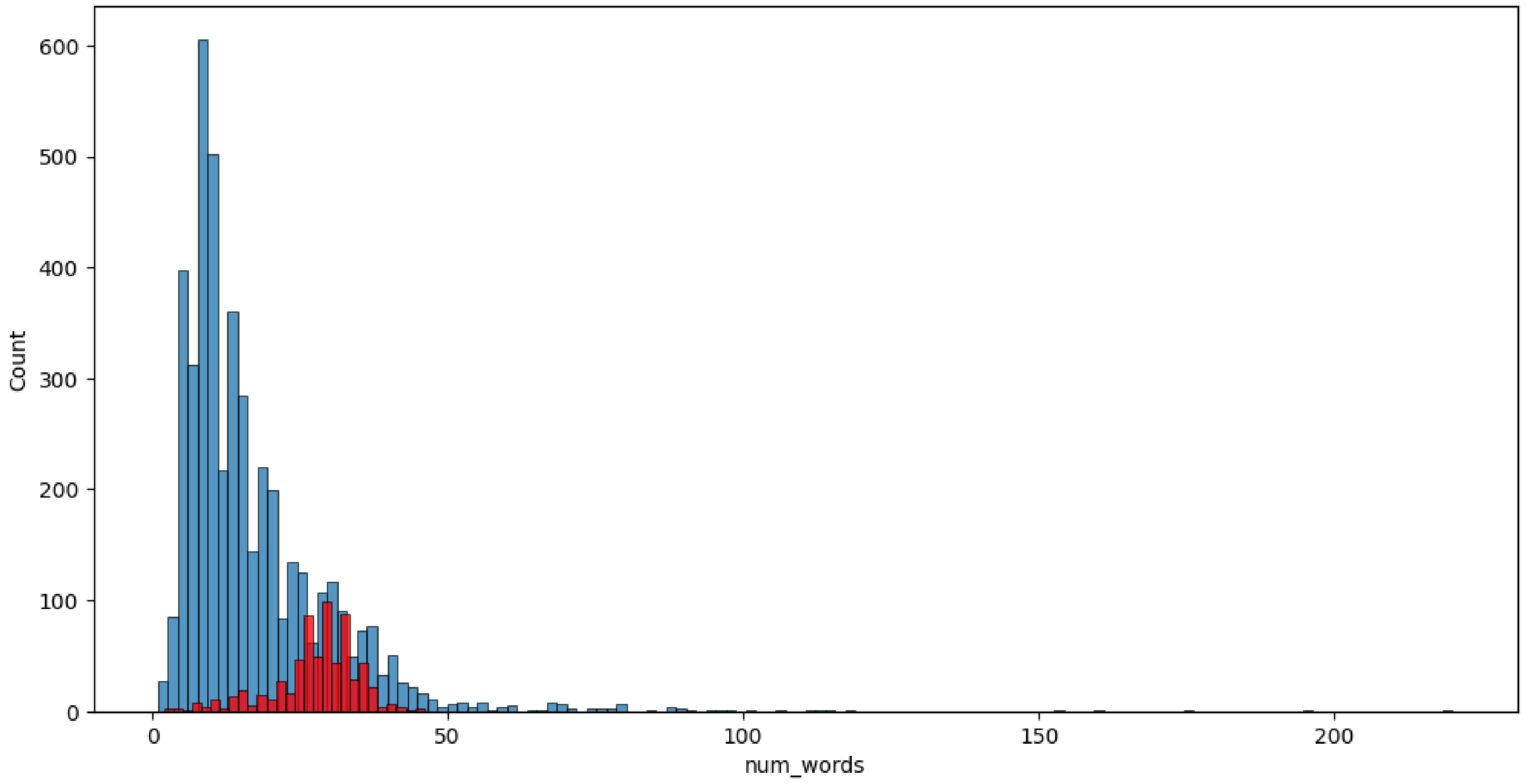
In [35]:

```python
plt.figure(figsize=(12,6))
sns.histplot(df[df['target']==0]['num_words'])
sns.histplot(df[df['target']==1]['num_words'],color='red')
```

```
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated
and will be removed in a future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated
and will be removed in a future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
```

Out[35]:

```
<Axes: xlabel='num_words', ylabel='Count'>
```



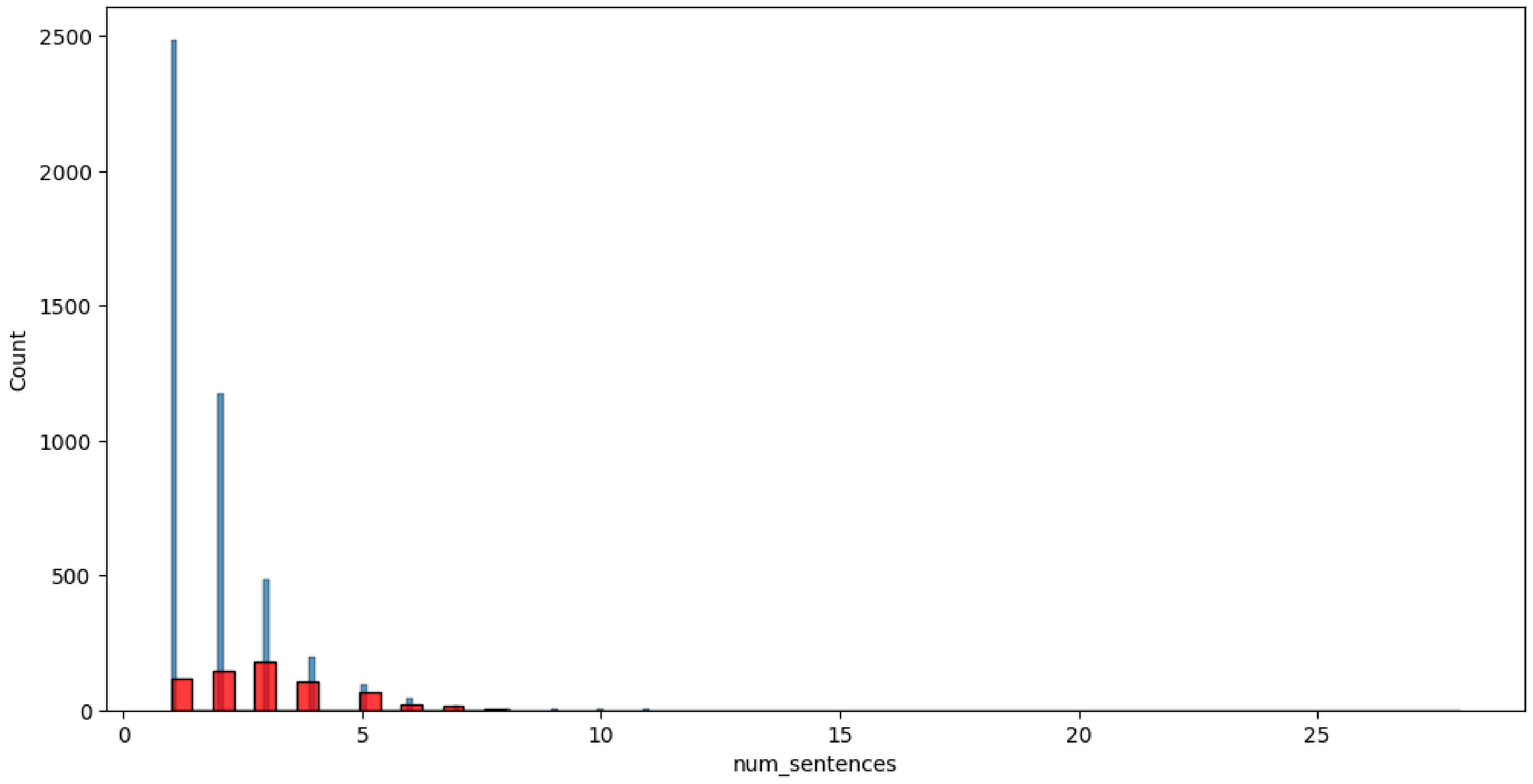
In [36]:

```python
plt.figure(figsize=(12,6))
sns.histplot(df[df['target']==0]['num_sentences'])
sns.histplot(df[df['target']==1]['num_sentences'],color='red')
```

```
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated
and will be removed in a future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated
and will be removed in a future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
```

Out[36]:

```
<Axes: xlabel='num_sentences', ylabel='Count'>
```

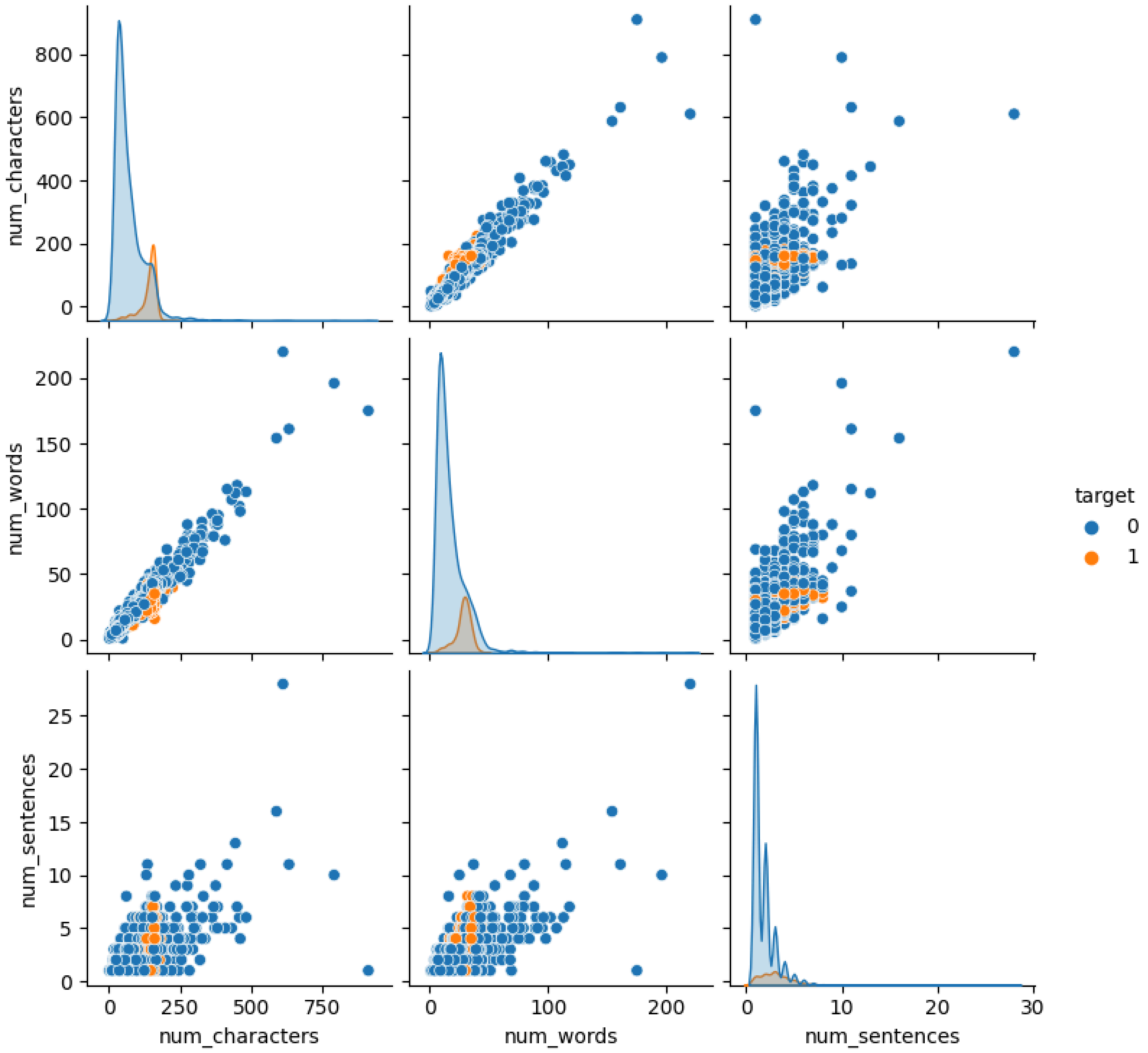


In [37]:

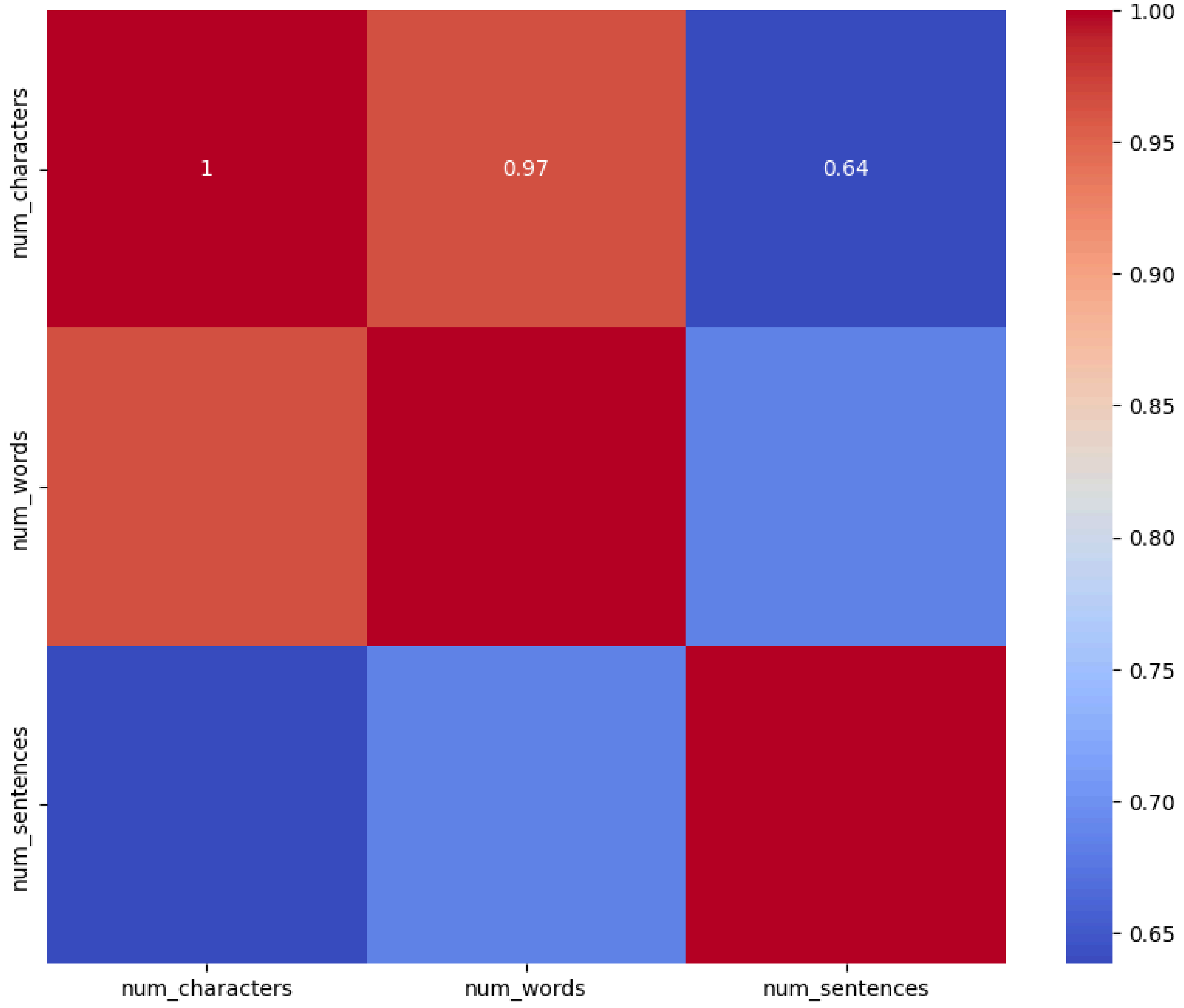
```python
# relation
sns.pairplot(df,hue='target')
```

```
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated
and will be removed in a future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-
like, you will need to pass a length-1 tuple to get_group in a future version of pandas. Pass `(name,)` instead of `nam
e` to silence this warning.
  data_subset = grouped_data.get_group(pd_key)
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated
and will be removed in a future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-
like, you will need to pass a length-1 tuple to get_group in a future version of pandas. Pass `(name,)` instead of `nam
e` to silence this warning.
  data_subset = grouped_data.get_group(pd_key)
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1119: FutureWarning: use_inf_as_na option is deprecated
and will be removed in a future version. Convert inf values to NaN before operating instead.
  with pd.option_context('mode.use_inf_as_na', True):
C:\Users\Prave\anaconda3\lib\site-packages\seaborn\_oldcore.py:1075: FutureWarning: When grouping with a length-1 list-
like, you will need to pass a length-1 tuple to get_group in a future version of pandas. Pass `(name,)` instead of `nam
e` to silence this warning.
  data_subset = grouped_data.get_group(pd_key)
```

```
Out[37]: <seaborn.axisgrid.PairGrid at 0x1e59891d720>
```


num_characters
num_words
num_sentences
target
0
1

In [38]:
```
# Compute the correlation matrix, specifying numeric_only
#!pip install --upgrade pandas
df_numeric = df.select_dtypes(include=['float64', 'int64'])
plt.figure(figsize=(10,8))
sns.heatmap(df_numeric.corr(), annot=True, cmap='coolwarm')
plt.show()
```


num_characters
num_words
num_sentences
1
0.97
0.64
num_characters
num_words
num_sentences
1.00
0.95
0.90
0.85
0.80
0.75
0.70
0.65

text preprocessing

```
In [39]: #lower case
         #Tokenization
         #Removing special characters
         #removing stop words and punctuations
         # stemming
```

```
In [40]: # Download the stopwords resource
         nltk.download('stopwords')
         from nltk.corpus import stopwords
         import string
         stopwords.words('english')
         from nltk.stem.porter import PorterStemmer

         ps = PorterStemmer()
```

```
[nltk_data] Downloading package stopwords to
[nltk_data]     C:\Users\Prave\AppData\Roaming\nltk_data...
[nltk_data]   Package stopwords is already up-to-date!
```

```
In [41]: def transform_text(text):
             # Convert text to lowercase and tokenize
             text = text.lower()
             text = nltk.word_tokenize(text)

             # Use list comprehension to filter out non-alphanumeric words and stopwords
             return [ps.stem(i) for i in text if i.isalnum() and i not in stopwords.words('english') and i not in string.punctua
```

```
In [42]: transform_text('do your like dancing and singing ?')
```

```
Out[42]: ['like', 'danc', 'sing']
```

```
In [43]: df['transformed_text'] = df['text'].apply(transform_text)
```

```
In [96]: # Save the transformed dataset using pickle
         with open('transformed_data.pkl', 'wb') as file:
             pickle.dump(df, file)
```

```
In [44]: df.head()
```

Out[44]:

	target	text	num_characters	num_words	num_sentences	transformed_text
0	0	Go until jurong point, crazy.. Available only ...	111	24	2	[go, jurong, point, crazi, avail, bugi, n, gre...
1	0	Ok lar... Joking wif u oni...	29	8	2	[ok, lar, joke, wif, u, oni]
2	1	Free entry in 2 a wkly comp to win FA Cup fina...	155	37	2	[free, entri, 2, wkli, comp, win, fa, cup, fin...
3	0	U dun say so early hor... U c already then say...	49	13	1	[u, dun, say, earli, hor, u, c, alreadi, say]
4	0	Nah I don't think he goes to usf, he lives aro...	61	15	1	[nah, think, goe, usf, live, around, though]

In [45]:

```
!pip install wordcloud
```

```
Requirement already satisfied: wordcloud in c:\users\prave\anaconda3\lib\site-packages (1.9.3)
Requirement already satisfied: pillow in c:\users\prave\anaconda3\lib\site-packages (from wordcloud) (9.4.0)
Requirement already satisfied: numpy>=1.6.1 in c:\users\prave\anaconda3\lib\site-packages (from wordcloud) (1.23.5)
Requirement already satisfied: matplotlib in c:\users\prave\anaconda3\lib\site-packages (from wordcloud) (3.9.1)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib->wordclo
ud) (1.0.5)
Requirement already satisfied: packaging>=20.0 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib->wordclou
d) (22.0)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib->wordclo
ud) (3.0.9)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib->wordcl
oud) (4.25.0)
Requirement already satisfied: cycler>=0.10 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib->wordcloud)
(0.11.0)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib->wor
dcloud) (2.8.2)
Requirement already satisfied: kiwisolver>=1.3.1 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib->wordcl
oud) (1.4.4)
Requirement already satisfied: six>=1.5 in c:\users\prave\anaconda3\lib\site-packages (from python-dateutil>=2.7->matpl
otlib->wordcloud) (1.16.0)
```

In [46]:

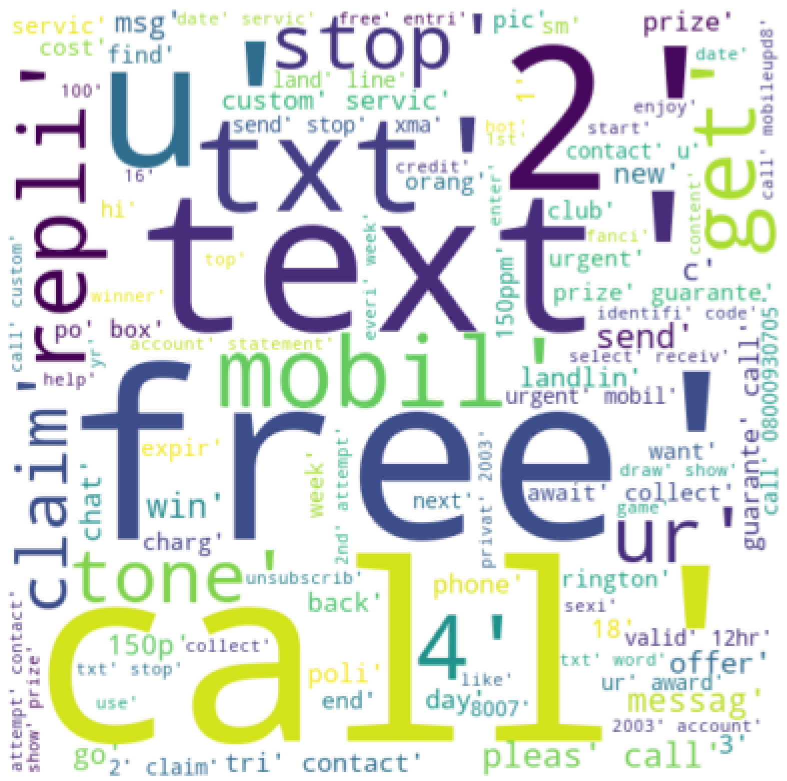
```
!pip install wordcloud matplotlib
from wordcloud import WordCloud
wc = WordCloud(width=500,height=500,min_font_size=10,background_color='white')
```

```
Requirement already satisfied: wordcloud in c:\users\prave\anaconda3\lib\site-packages (1.9.3)
Requirement already satisfied: matplotlib in c:\users\prave\anaconda3\lib\site-packages (3.9.1)
Requirement already satisfied: numpy>=1.6.1 in c:\users\prave\anaconda3\lib\site-packages (from wordcloud) (1.23.5)
Requirement already satisfied: pillow in c:\users\prave\anaconda3\lib\site-packages (from wordcloud) (9.4.0)
Requirement already satisfied: pyparsing>=2.3.1 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib) (3.0.9)
Requirement already satisfied: fonttools>=4.22.0 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib) (4.25.
0)
Requirement already satisfied: contourpy>=1.0.1 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib) (1.0.5)
Requirement already satisfied: packaging>=20.0 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib) (22.0)
Requirement already satisfied: kiwisolver>=1.3.1 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib) (1.4.
4)
Requirement already satisfied: cycler>=0.10 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib) (0.11.0)
Requirement already satisfied: python-dateutil>=2.7 in c:\users\prave\anaconda3\lib\site-packages (from matplotlib) (2.
8.2)
Requirement already satisfied: six>=1.5 in c:\users\prave\anaconda3\lib\site-packages (from python-dateutil>=2.7->matpl
otlib) (1.16.0)
```

In [47]:
```
# Ensure the 'transformed_text' column has only strings by converting non-string data
#df['transformed_text'] = df['transformed_text'].astype(str)
```

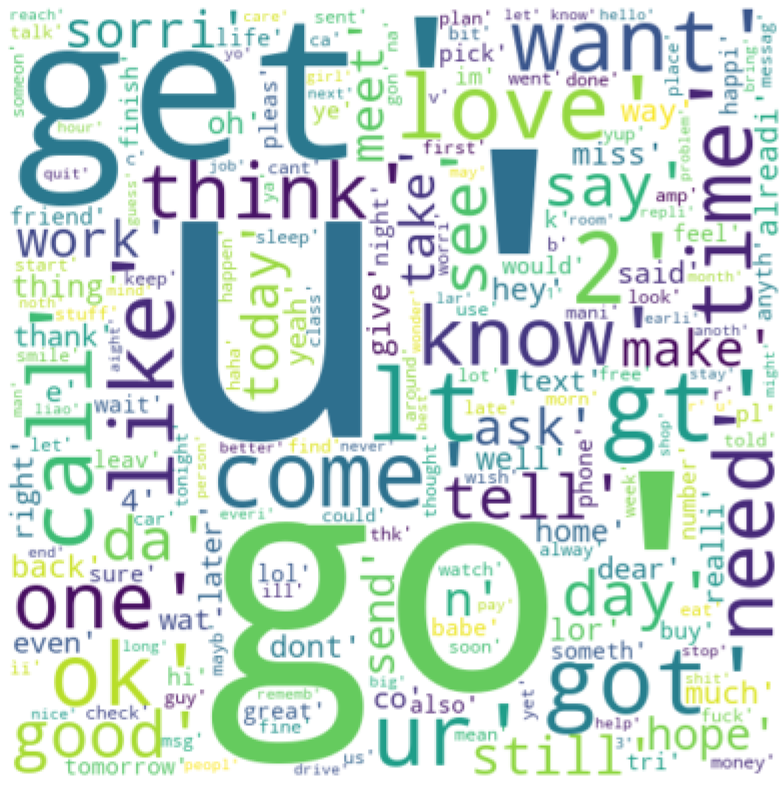
In [48]:
```
df.loc[:, 'transformed_text'] = df['transformed_text'].astype(str)
spam_wc = wc.generate(df[df['target']==1]['transformed_text'].str.cat(sep=" "))
```

In [49]:
```
# Plot the word cloud
# Plot the WordCloud
plt.figure(figsize=(10, 5))
plt.imshow(spam_wc, interpolation='bilinear')
plt.axis('off')
plt.show()
```



```
In [50]: ham_wc = wc.generate(df[df['target']==0]['transformed_text'].str.cat(sep=" "))
```

```
In [51]: # Plot the word cloud
         # Plot the WordCloud
         plt.figure(figsize=(10, 5))
         plt.imshow(ham_wc, interpolation='bilinear')
         plt.axis('off')
         plt.show()
```



```
In [52]: df.head()
```

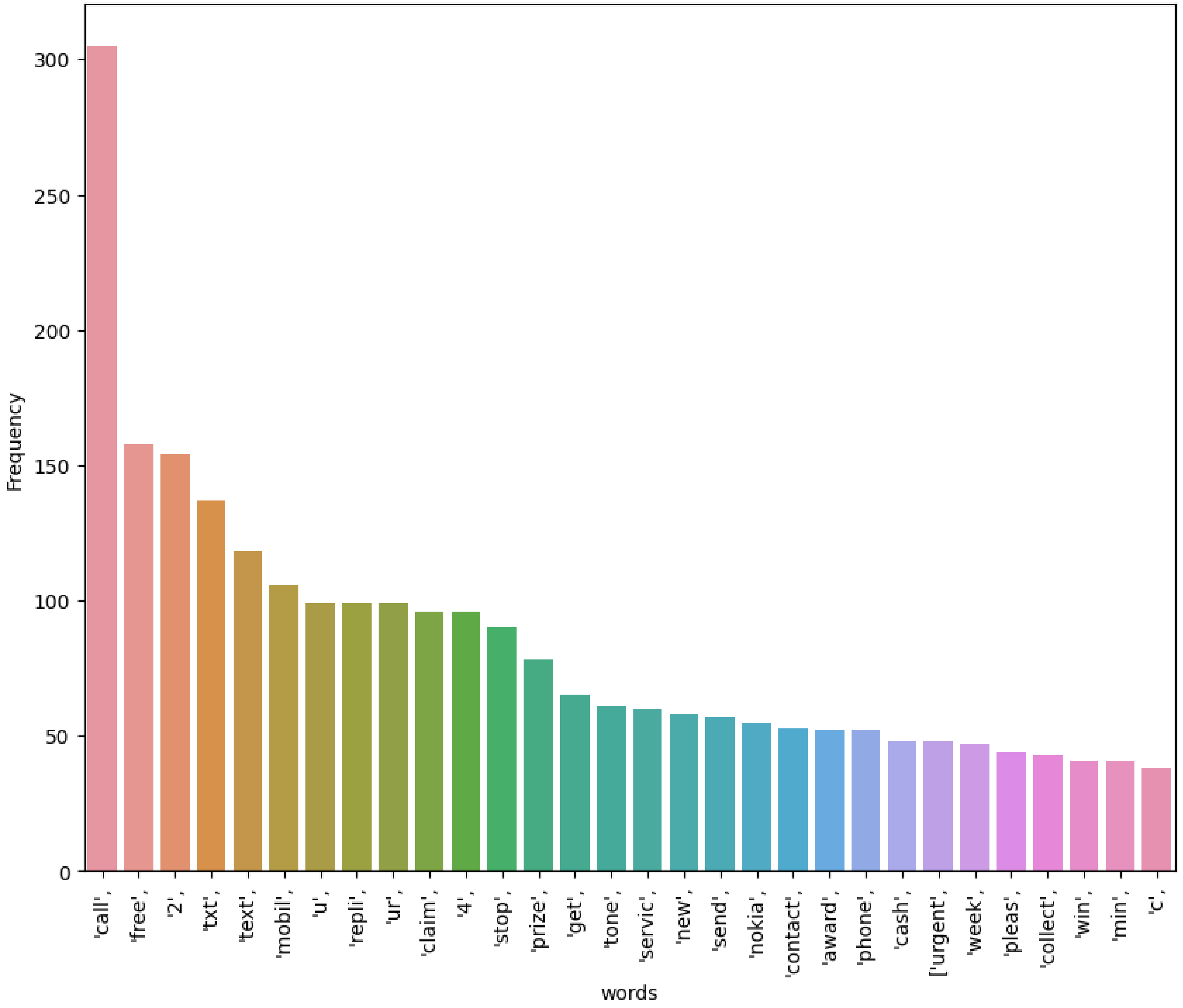
Out[52]:

	target	text	num_characters	num_words	num_sentences	transformed_text
0	0	Go until jurong point, crazy.. Available only ...	111	24	2	['go', 'jurong', 'point', 'crazi', 'avail', 'b...
1	0	Ok lar... Joking wif u oni...	29	8	2	['ok', 'lar', 'joke', 'wif', 'u', 'oni']
2	1	Free entry in 2 a wkly comp to win FA Cup fina...	155	37	2	['free', 'entri', '2', 'wkli', 'comp', 'win', ...
3	0	U dun say so early hor... U c already then say...	49	13	1	['u', 'dun', 'say', 'earli', 'hor', 'u', 'c', ...
4	0	Nah I don't think he goes to usf, he lives aro...	61	15	1	['nah', 'think', 'goe', 'usf', 'live', 'around...

```
In [53]: spam_corpus = []
         for msg in df[df['target']==1]['transformed_text'].tolist():
             for word in msg.split():
                 spam_corpus.append(word)
```

In [54]:
```
from collections import Counter
common_words_df = pd.DataFrame(Counter(spam_corpus).most_common(30),columns=['words','Frequency'])
```

In [55]:
```
# Plot the barplot using Seaborn
plt.figure(figsize=(10,8))
sns.barplot(x='words', y='Frequency', data=common_words_df)
plt.xticks(rotation=90)  # Rotate x-axis labels for better readability
plt.show()
```



Frequency
0
50
100
150
200
250
300
words
'call',
'free',
'2',
'txt',
'text',
'mobil',
'u',
'repli',
'ur',
'claim',
'4',
'stop',
'prize',
'get',
'tone',
'servic',
'new',
'send',
'nokia',
'contact',
'award',
'phone',
'cash',
['urgent',
'week',
'pleas',
'collect',
'win',
'min',
'c',

In [56]:
```
df.head(5)
```

Out[56]:

	target	text	num_characters	num_words	num_sentences	transformed_text
0	0	Go until jurong point, crazy.. Available only ...	111	24	2	['go', 'jurong', 'point', 'crazi', 'avail', 'b...
1	0	Ok lar... Joking wif u oni...	29	8	2	['ok', 'lar', 'joke', 'wif', 'u', 'oni']
2	1	Free entry in 2 a wkly comp to win FA Cup fina...	155	37	2	['free', 'entri', '2', 'wkli', 'comp', 'win', ...
3	0	U dun say so early hor... U c already then say...	49	13	1	['u', 'dun', 'say', 'earli', 'hor', 'u', 'c', ...
4	0	Nah I don't think he goes to usf, he lives aro...	61	15	1	['nah', 'think', 'goe', 'usf', 'live', 'around...

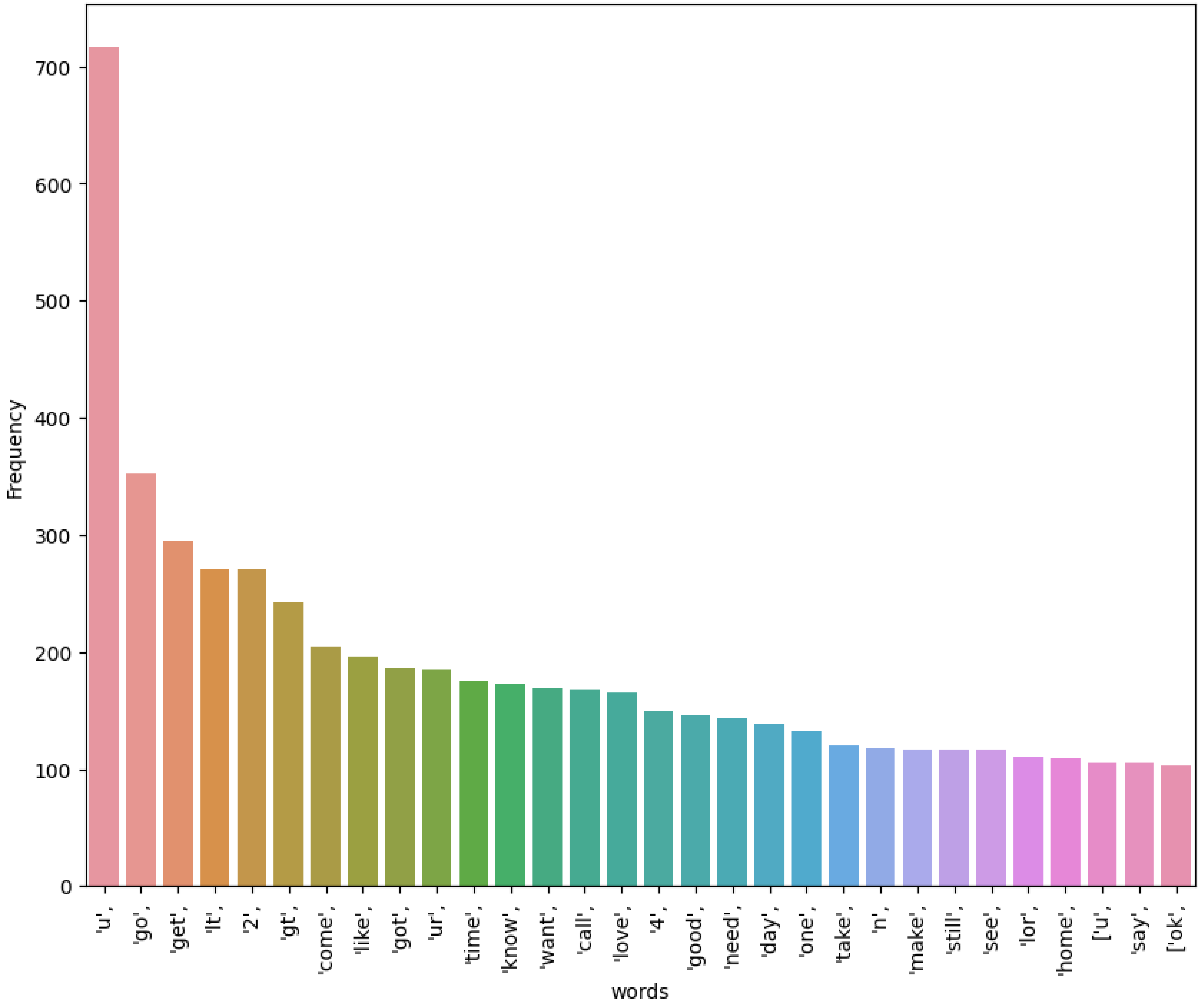
In [57]:
```
#ham_corpus = []
#ham_corpus = df[df['target'] == 0]['transformed_text'].apply(lambda x: ' '.join(x)).tolist()
ham_corpus = [word for msg in df[df['target'] == 0]['transformed_text'].tolist() for word in msg.split()]
```

In [58]:
```
print(len(ham_corpus))
```

```
35403
```

In [59]:
```
from collections import Counter
common_words_df = pd.DataFrame(Counter(ham_corpus).most_common(30),columns=['words','Frequency'])
```

In [60]:
```
# Plot the barplot using Seaborn
plt.figure(figsize=(10,8))
sns.barplot(x='words', y='Frequency', data=common_words_df)
plt.xticks(rotation=90)  # Rotate x-axis labels for better readability
plt.show()
```


Frequency
0
100
200
300
400
500
600
700
'u',
'go',
'get',
'lt',
'2',
'gt',
'come',
'like',
'got',
'ur',
'time',
'know',
'want',
'call',
'love',
'4',
'good',
'need',
'day',
'one',
'take',
'n',
'make',
'still',
'see',
'lor',
'home',
['u',
'say',
['ok',
words

Model Building

In [61]:
```
df.head()
```

Out[61]:

	target	text	num_characters	num_words	num_sentences	transformed_text
0	0	Go until jurong point, crazy.. Available only ...	111	24	2	['go', 'jurong', 'point', 'crazi', 'avail', 'b...
1	0	Ok lar... Joking wif u oni...	29	8	2	['ok', 'lar', 'joke', 'wif', 'u', 'oni']
2	1	Free entry in 2 a wkly comp to win FA Cup fina...	155	37	2	['free', 'entri', '2', 'wkli', 'comp', 'win', ...
3	0	U dun say so early hor... U c already then say...	49	13	1	['u', 'dun', 'say', 'earli', 'hor', 'u', 'c', ...
4	0	Nah I don't think he goes to usf, he lives aro...	61	15	1	['nah', 'think', 'goe', 'usf', 'live', 'around...

In [62]:
```
from sklearn.feature_extraction.text import CountVectorizer,TfidfVectorizer
cv = CountVectorizer()
tfidf = TfidfVectorizer(max_features=3000)
```

In [63]:
```
X = cv.fit_transform(df['transformed_text']).toarray()
```

In [64]:
```
#from sklearn.preprocessing import MinMaxScaler
#scaler = MinMaxScaler()
#X = scaler.fit_transform(X)
```

In [65]:
```
# appending the num of charc col to X
#X = np.hstack((X,df['num_characters'].values.reshape(-1,1)))
```

In [66]:
```
X.shape
```

Out[66]:
```
(5169, 6708)
```

In [67]:
```
y = df['target'].values
```

In [68]:
```
y
```

Out[68]:
```
array([0, 0, 1, ..., 0, 0, 0])
```

In [69]:
```
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score,confusion_matrix,precision_score
```

In [70]:
```
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.2,random_state=2)
```

In [71]:
```
from sklearn.naive_bayes import GaussianNB,MultinomialNB,BernoulliNB
```

In [72]:
```
gnb = GaussianNB()
mnb = MultinomialNB()
bnb = BernoulliNB()
```

In [73]:
```
gnb.fit(X_train,y_train)
y_pred_gnb = gnb.predict(X_test)
print(accuracy_score(y_test,y_pred_gnb))
print(confusion_matrix(y_test,y_pred_gnb))
print(precision_score(y_test,y_pred_gnb))
```

```
0.8800773694390716
[[792 104]
 [ 20 118]]
0.5315315315315315
```

In [74]:
```
mnb.fit(X_train,y_train)
y_pred_mnb = mnb.predict(X_test)
print(accuracy_score(y_test,y_pred_mnb))
print(confusion_matrix(y_test,y_pred_mnb))
print(precision_score(y_test,y_pred_mnb))
```

```
0.9642166344294004
[[871  25]
 [ 12 126]]
0.8344370860927153
```

In [75]:
```
bnb.fit(X_train,y_train)
y_pred_bnb = bnb.predict(X_test)
print(accuracy_score(y_test,y_pred_bnb))
print(confusion_matrix(y_test,y_pred_bnb))
print(precision_score(y_test,y_pred_bnb))
```

```
0.9700193423597679
[[893   3]
 [ 28 110]]
0.9734513274336283
```

In [76]:
```
# bernouli in performing well
```

In [77]:
```
# Tfidf
```

In [78]:
```
X = tfidf.fit_transform(df['transformed_text']).toarray()
```

In [79]:
```
# appending the num of charc col to X
#X = np.hstack((X,df['num_characters'].values.reshape(-1,1)))
```

In [98]:
```
# Save the TfidfVectorizer and X_tfidf using pickle
with open('tfidf_vectorizer.pkl', 'wb') as file:
    pickle.dump(tfidf, file)
with open('X_tfidf.pkl', 'wb') as file:
    pickle.dump(X, file)
```

In [80]:
```
y = df['target'].values
```

In [99]:
```
# Save the target variable
with open('target.pkl', 'wb') as file:
    pickle.dump(y, file)
```

In [81]:
```
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.2,random_state=2)
```

In [82]:
```
gnb.fit(X_train,y_train)
y_pred_gnb = gnb.predict(X_test)
print(accuracy_score(y_test,y_pred_gnb))
print(confusion_matrix(y_test,y_pred_gnb))
print(precision_score(y_test,y_pred_gnb))
```

```
0.8694390715667312
[[788 108]
 [ 27 111]]
0.5068493150684932
```

In [83]:
```
mnb.fit(X_train,y_train)
y_pred_mnb = mnb.predict(X_test)
print(accuracy_score(y_test,y_pred_mnb))
print(confusion_matrix(y_test,y_pred_mnb))
print(precision_score(y_test,y_pred_mnb))
```

```
0.9709864603481625
[[896   0]
 [ 30 108]]
1.0
```

In [84]:
```
bnb.fit(X_train,y_train)
y_pred_bnb = bnb.predict(X_test)
print(accuracy_score(y_test,y_pred_bnb))
print(confusion_matrix(y_test,y_pred_bnb))
print(precision_score(y_test,y_pred_bnb))
```

```
0.9835589941972921
[[895   1]
 [ 16 122]]
0.991869918699187
```

In [100…
```
# Save models using pickle
with open('gaussian_nb_model.pkl', 'wb') as file:
    pickle.dump(gnb, file)
with open('multinomial_nb_model.pkl', 'wb') as file:
    pickle.dump(mnb, file)
with open('bernoulli_nb_model.pkl', 'wb') as file:
    pickle.dump(bnb, file)
```

In [101…
```
# Save predictions
with open('y_pred_gnb.pkl', 'wb') as file:
    pickle.dump(y_pred_gnb, file)
with open('y_pred_mnb.pkl', 'wb') as file:
    pickle.dump(y_pred_mnb, file)
with open('y_pred_bnb.pkl', 'wb') as file:
    pickle.dump(y_pred_bnb, file)
```

In [85]:
```
# mnb peforming well interms of precision with TfIdf
```

In [86]:
```
# pipeline creation
```

In [87]:
```
# Calculate accuracy scores
accuracy_gnb = accuracy_score(y_test, y_pred_gnb)
accuracy_mnb = accuracy_score(y_test, y_pred_mnb)
accuracy_bnb = accuracy_score(y_test, y_pred_bnb)
```

In [88]:
```
# Calculate precision scores (set average to 'weighted' for multi-class classification)
precision_gnb = precision_score(y_test, y_pred_gnb, average='weighted')
```

```
precision_mnb = precision_score(y_test, y_pred_mnb, average='weighted')
precision_bnb = precision_score(y_test, y_pred_bnb, average='weighted')
```

In [89]:
```
# Store models with their accuracy and precision
model_results = [
    ("GaussianNB", gnb, accuracy_gnb, precision_gnb),
    ("MultinomialNB", mnb, accuracy_mnb, precision_mnb),
    ("BernoulliNB", bnb, accuracy_bnb, precision_bnb)
]
```

In [90]:
```
# Sort models by accuracy and precision
sorted_by_accuracy = sorted(model_results, key=lambda x: x[2], reverse=True)  # Sort by accuracy
sorted_by_precision = sorted(model_results, key=lambda x: x[3], reverse=True)  # Sort by precision
```

In [91]:
```
# Get the best model by accuracy and precision
best_model_accuracy = sorted_by_accuracy[0]
best_model_precision = sorted_by_precision[0]
```

In [92]:
```
# Print sorted results
print("Models sorted by Accuracy:")
for name, model, accuracy, precision in sorted_by_accuracy:
    print(f"Model: {name}, Accuracy: {accuracy}, Precision: {precision}")
```

```
Models sorted by Accuracy:
Model: BernoulliNB, Accuracy: 0.9835589941972921, Precision: 0.9836958370815164
Model: MultinomialNB, Accuracy: 0.9709864603481625, Precision: 0.971926423835803
Model: GaussianNB, Accuracy: 0.8694390715667312, Precision: 0.9054755995131818
```

In [93]:
```
print("\nModels sorted by Precision:")
for name, model, accuracy, precision in sorted_by_precision:
    print(f"Model: {name}, Precision: {precision}, Accuracy: {accuracy}")
```

```
Models sorted by Precision:
Model: BernoulliNB, Precision: 0.9836958370815164, Accuracy: 0.9835589941972921
Model: MultinomialNB, Precision: 0.971926423835803, Accuracy: 0.9709864603481625
Model: GaussianNB, Precision: 0.9054755995131818, Accuracy: 0.8694390715667312
```

In [94]:
```
# Print the best models
print(f"\nBest model by Accuracy: {best_model_accuracy[0]} with Accuracy: {best_model_accuracy[2]}")
print(f"Best model by Precision: {best_model_precision[0]} with Precision: {best_model_precision[3]}")
```

```
Best model by Accuracy: BernoulliNB with Accuracy: 0.9835589941972921
Best model by Precision: BernoulliNB with Precision: 0.9836958370815164
```

In [102…

```
# Save model results using pickle
with open('model_results.pkl', 'wb') as file:
    pickle.dump(model_results, file)

# Save sorted results by accuracy
with open('sorted_by_accuracy.pkl', 'wb') as file:
    pickle.dump(sorted_by_accuracy, file)

# Save sorted results by precision
with open('sorted_by_precision.pkl', 'wb') as file:
    pickle.dump(sorted_by_precision, file)

# Save best model by accuracy
with open('best_model_accuracy.pkl', 'wb') as file:
    pickle.dump(best_model_accuracy, file)

# Save best model by precision
with open('best_model_precision.pkl', 'wb') as file:
    pickle.dump(best_model_precision, file)
```

In [ ]: