In [1]:
```
pip install tabulate
```

```
Requirement already satisfied: tabulate in c:\users\kariu\anaconda3\lib\site-packages
(0.8.10)
Note: you may need to restart the kernel to use updated packages.
```

In [2]:
```
pip install xgboost
```

```
Requirement already satisfied: xgboost in c:\users\kariu\anaconda3\lib\site-packages (2.
0.2)
Requirement already satisfied: numpy in c:\users\kariu\anaconda3\lib\site-packages (from
xgboost) (1.24.3)
Requirement already satisfied: scipy in c:\users\kariu\anaconda3\lib\site-packages (from
xgboost) (1.11.1)
Note: you may need to restart the kernel to use updated packages.
```

In [3]:
```
pip install lightgbm
```

```
Requirement already satisfied: lightgbm in c:\users\kariu\anaconda3\lib\site-packages
(4.1.0)
Requirement already satisfied: numpy in c:\users\kariu\anaconda3\lib\site-packages (from
lightgbm) (1.24.3)
Requirement already satisfied: scipy in c:\users\kariu\anaconda3\lib\site-packages (from
lightgbm) (1.11.1)
Note: you may need to restart the kernel to use updated packages.
```

In [4]:
```
pip install tensorflow
```

```
Requirement already satisfied: tensorflow in c:\users\kariu\anaconda3\lib\site-packages
(2.15.0)
Requirement already satisfied: tensorflow-intel==2.15.0 in c:\users\kariu\anaconda3\lib
\site-packages (from tensorflow) (2.15.0)
Requirement already satisfied: absl-py>=1.0.0 in c:\users\kariu\anaconda3\lib\site-packa
ges (from tensorflow-intel==2.15.0->tensorflow) (2.0.0)
Requirement already satisfied: astunparse>=1.6.0 in c:\users\kariu\anaconda3\lib\site-pa
ckages (from tensorflow-intel==2.15.0->tensorflow) (1.6.3)
Requirement already satisfied: flatbuffers>=23.5.26 in c:\users\kariu\anaconda3\lib\site
-packages (from tensorflow-intel==2.15.0->tensorflow) (23.5.26)
Requirement already satisfied: gast!=0.5.0,!=0.5.1,!=0.5.2,>=0.2.1 in c:\users\kariu\ana
conda3\lib\site-packages (from tensorflow-intel==2.15.0->tensorflow) (0.5.4)
Requirement already satisfied: google-pasta>=0.1.1 in c:\users\kariu\anaconda3\lib\site-
packages (from tensorflow-intel==2.15.0->tensorflow) (0.2.0)
Requirement already satisfied: h5py>=2.9.0 in c:\users\kariu\anaconda3\lib\site-packages
(from tensorflow-intel==2.15.0->tensorflow) (3.9.0)
Requirement already satisfied: libclang>=13.0.0 in c:\users\kariu\anaconda3\lib\site-pac
kages (from tensorflow-intel==2.15.0->tensorflow) (16.0.6)
Requirement already satisfied: ml-dtypes~=0.2.0 in c:\users\kariu\anaconda3\lib\site-pac
kages (from tensorflow-intel==2.15.0->tensorflow) (0.2.0)
Requirement already satisfied: numpy<2.0.0,>=1.23.5 in c:\users\kariu\anaconda3\lib\site
-packages (from tensorflow-intel==2.15.0->tensorflow) (1.24.3)
Requirement already satisfied: opt-einsum>=2.3.2 in c:\users\kariu\anaconda3\lib\site-pa
ckages (from tensorflow-intel==2.15.0->tensorflow) (3.3.0)
Requirement already satisfied: packaging in c:\users\kariu\anaconda3\lib\site-packages
(from tensorflow-intel==2.15.0->tensorflow) (23.1)
Requirement already satisfied: protobuf!=4.21.0,!=4.21.1,!=4.21.2,!=4.21.3,!=4.21.4,!=4.
21.5,<5.0.0dev,>=3.20.3 in c:\users\kariu\anaconda3\lib\site-packages (from tensorflow-i
ntel==2.15.0->tensorflow) (4.23.4)
Requirement already satisfied: setuptools in c:\users\kariu\anaconda3\lib\site-packages
(from tensorflow-intel==2.15.0->tensorflow) (68.0.0)
Requirement already satisfied: six>=1.12.0 in c:\users\kariu\anaconda3\lib\site-packages
(from tensorflow-intel==2.15.0->tensorflow) (1.16.0)
Requirement already satisfied: termcolor>=1.1.0 in c:\users\kariu\anaconda3\lib\site-pac
kages (from tensorflow-intel==2.15.0->tensorflow) (2.4.0)
Requirement already satisfied: typing-extensions>=3.6.6 in c:\users\kariu\anaconda3\lib
\site-packages (from tensorflow-intel==2.15.0->tensorflow) (4.7.1)
```

```
Requirement already satisfied: wrapt<1.15,>=1.11.0 in c:\users\kariu\anaconda3\lib\site-packages (from tensorflow-intel==2.15.0->tensorflow) (1.14.1)
Requirement already satisfied: tensorflow-io-gcs-filesystem>=0.23.1 in c:\users\kariu\anaconda3\lib\site-packages (from tensorflow-intel==2.15.0->tensorflow) (0.31.0)
Requirement already satisfied: grpcio<2.0,>=1.24.3 in c:\users\kariu\anaconda3\lib\site-packages (from tensorflow-intel==2.15.0->tensorflow) (1.60.0)
Requirement already satisfied: tensorboard<2.16,>=2.15 in c:\users\kariu\anaconda3\lib\site-packages (from tensorflow-intel==2.15.0->tensorflow) (2.15.1)
Requirement already satisfied: tensorflow-estimator<2.16,>=2.15.0 in c:\users\kariu\anaconda3\lib\site-packages (from tensorflow-intel==2.15.0->tensorflow) (2.15.0)
Requirement already satisfied: keras<2.16,>=2.15.0 in c:\users\kariu\anaconda3\lib\site-packages (from tensorflow-intel==2.15.0->tensorflow) (2.15.0)
Requirement already satisfied: wheel<1.0,>=0.23.0 in c:\users\kariu\anaconda3\lib\site-packages (from astunparse>=1.6.0->tensorflow-intel==2.15.0->tensorflow) (0.38.4)
Requirement already satisfied: google-auth<3,>=1.6.3 in c:\users\kariu\anaconda3\lib\site-packages (from tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (2.25.2)
Requirement already satisfied: google-auth-oauthlib<2,>=0.5 in c:\users\kariu\anaconda3\lib\site-packages (from tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (1.2.0)
Requirement already satisfied: markdown>=2.6.8 in c:\users\kariu\anaconda3\lib\site-packages (from tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (3.4.1)
Requirement already satisfied: requests<3,>=2.21.0 in c:\users\kariu\anaconda3\lib\site-packages (from tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (2.31.0)
Requirement already satisfied: tensorboard-data-server<0.8.0,>=0.7.0 in c:\users\kariu\anaconda3\lib\site-packages (from tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (0.7.2)
Requirement already satisfied: werkzeug>=1.0.1 in c:\users\kariu\anaconda3\lib\site-packages (from tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (2.2.3)
Requirement already satisfied: cachetools<6.0,>=2.0.0 in c:\users\kariu\anaconda3\lib\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (5.3.2)
Requirement already satisfied: pyasn1-modules>=0.2.1 in c:\users\kariu\anaconda3\lib\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (0.2.8)
Requirement already satisfied: rsa<5,>=3.1.4 in c:\users\kariu\anaconda3\lib\site-packages (from google-auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (4.9)
Requirement already satisfied: requests-oauthlib>=0.7.0 in c:\users\kariu\anaconda3\lib\site-packages (from google-auth-oauthlib<2,>=0.5->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (1.3.1)
Requirement already satisfied: charset-normalizer<4,>=2 in c:\users\kariu\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (2.0.4)
Requirement already satisfied: idna<4,>=2.5 in c:\users\kariu\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (3.4)
Requirement already satisfied: urllib3<3,>=1.21.1 in c:\users\kariu\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (1.26.16)
Requirement already satisfied: certifi>=2017.4.17 in c:\users\kariu\anaconda3\lib\site-packages (from requests<3,>=2.21.0->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (2023.7.22)
Requirement already satisfied: MarkupSafe>=2.1.1 in c:\users\kariu\anaconda3\lib\site-packages (from werkzeug>=1.0.1->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (2.1.1)
Requirement already satisfied: pyasn1<0.5.0,>=0.4.6 in c:\users\kariu\anaconda3\lib\site-packages (from pyasn1-modules>=0.2.1->google-auth<3,>=1.6.3->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (0.4.8)
Requirement already satisfied: oauthlib>=3.0.0 in c:\users\kariu\anaconda3\lib\site-packages (from requests-oauthlib>=0.7.0->google-auth-oauthlib<2,>=0.5->tensorboard<2.16,>=2.15->tensorflow-intel==2.15.0->tensorflow) (3.2.2)
Note: you may need to restart the kernel to use updated packages.
```

In [222…

```python
import pandas as pd
import numpy as np
```

```
from tqdm.auto import tqdm
import matplotlib.pyplot as plt
import seaborn as sns


from sklearn.preprocessing import LabelEncoder
from scipy.stats import chi2_contingency
from sklearn.model_selection import train_test_split, GridSearchCV
from sklearn.ensemble import RandomForestClassifier
from sklearn.neighbors import KNeighborsClassifier
from sklearn.naive_bayes import GaussianNB
from sklearn.ensemble import GradientBoostingClassifier
from xgboost import XGBClassifier
from sklearn.svm import SVC
from lightgbm import LGBMClassifier
from sklearn.ensemble import AdaBoostClassifier
from sklearn.neural_network import MLPClassifier
from sklearn.metrics import confusion_matrix


from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import classification_report, confusion_matrix, accuracy_score
from sklearn.feature_selection import RFE

from tensorflow.keras.models import Sequential
from tensorflow.keras.layers import Dense, Flatten, Reshape, SimpleRNN, Conv2D, MaxPooli
from tensorflow.keras.utils import to_categorical

from tabulate import tabulate
```

In [223…

```
# Load the dataset
file_path = 'H1N1_Flu_Vaccines - Clean.csv'
data = pd.read_csv(file_path)

# Show the head of the dataframe
data_head = data.head()

# Display the head of the dataframe
data_head
```

Out[223]:

	id	respondent_id	h1n1_concern	h1n1_knowledge	behavioral_antiviral_meds	behavioral_avoidance	behavioral_
0	1	0	1	0	0	0	
1	2	1	3	2	0	1	
2	3	2	1	1	0	1	
3	4	3	1	1	0	1	
4	5	4	2	1	0	1	

5 rows × 36 columns

In [224…

```
data.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 26707 entries, 0 to 26706
Data columns (total 36 columns):
 #   Column                       Non-Null Count  Dtype 
---  ------                       --------------  ----- 
 0   id                           26707 non-null  int64 
 1   respondent_id                26707 non-null  int64 
 2   h1n1_concern                 26707 non-null  int64 
 3   h1n1_knowledge               26707 non-null  int64 
 4   behavioral_antiviral_meds    26707 non-null  int64 
 5   behavioral_avoidance         26707 non-null  int64 
 6   behavioral_face_mask         26707 non-null  int64 
 7   behavioral_wash_hands        26707 non-null  int64 
 8   behavioral_large_gatherings  26707 non-null  int64 
 9   behavioral_outside_home      26707 non-null  int64 
 10  behavioral_touch_face        26707 non-null  int64 
 11  doctor_recc_h1n1             26707 non-null  int64 
 12  doctor_recc_seasonal         26707 non-null  int64 
 13  chronic_med_condition        26707 non-null  int64 
 14  child_under_6_months         26707 non-null  int64 
 15  health_worker                26707 non-null  int64 
 16  health_insurance             26707 non-null  int64 
 17  opinion_h1n1_vacc_effective  26707 non-null  int64 
 18  opinion_h1n1_risk            26707 non-null  int64 
 19  opinion_h1n1_sick_from_vacc  26707 non-null  int64 
 20  opinion_seas_vacc_effective  26707 non-null  int64 
 21  opinion_seas_risk            26707 non-null  int64 
 22  opinion_seas_sick_from_vacc  26707 non-null  int64 
 23  age_group                    26707 non-null  object
 24  education                    26707 non-null  object
 25  race                         26707 non-null  object
 26  sex                          26707 non-null  object
 27  income_poverty               26707 non-null  object
 28  marital_status               26707 non-null  object
 29  rent_or_own                  26707 non-null  object
 30  employment_status            26707 non-null  object
 31  census_msa                   26707 non-null  object
 32  household_adults             26707 non-null  int64 
 33  household_children           26707 non-null  int64 
 34  h1n1_vaccine                 26707 non-null  int64 
 35  seasonal_vaccine             26707 non-null  int64 
dtypes: int64(27), object(9)
memory usage: 7.3+ MB
```

In [20]:
```
data.describe()
```

Out[20]:

	id	respondent_id	h1n1_concern	h1n1_knowledge	behavioral_antiviral_meds	behavioral_avoidar
count	26707.000000	26707.000000	26707.000000	26707.000000	26707.000000	26707.0000
mean	13354.000000	13353.000000	1.612910	1.257049	0.048714	0.7199
std	7709.791156	7709.791156	0.913676	0.622368	0.215273	0.4490
min	1.000000	0.000000	0.000000	0.000000	0.000000	0.0000
25%	6677.500000	6676.500000	1.000000	1.000000	0.000000	0.0000
50%	13354.000000	13353.000000	2.000000	1.000000	0.000000	1.0000
75%	20030.500000	20029.500000	2.000000	2.000000	0.000000	1.0000
max	26707.000000	26706.000000	3.000000	2.000000	1.000000	1.0000

8 rows × 27 columns

In [21]:
```
data.isnull().sum()
```

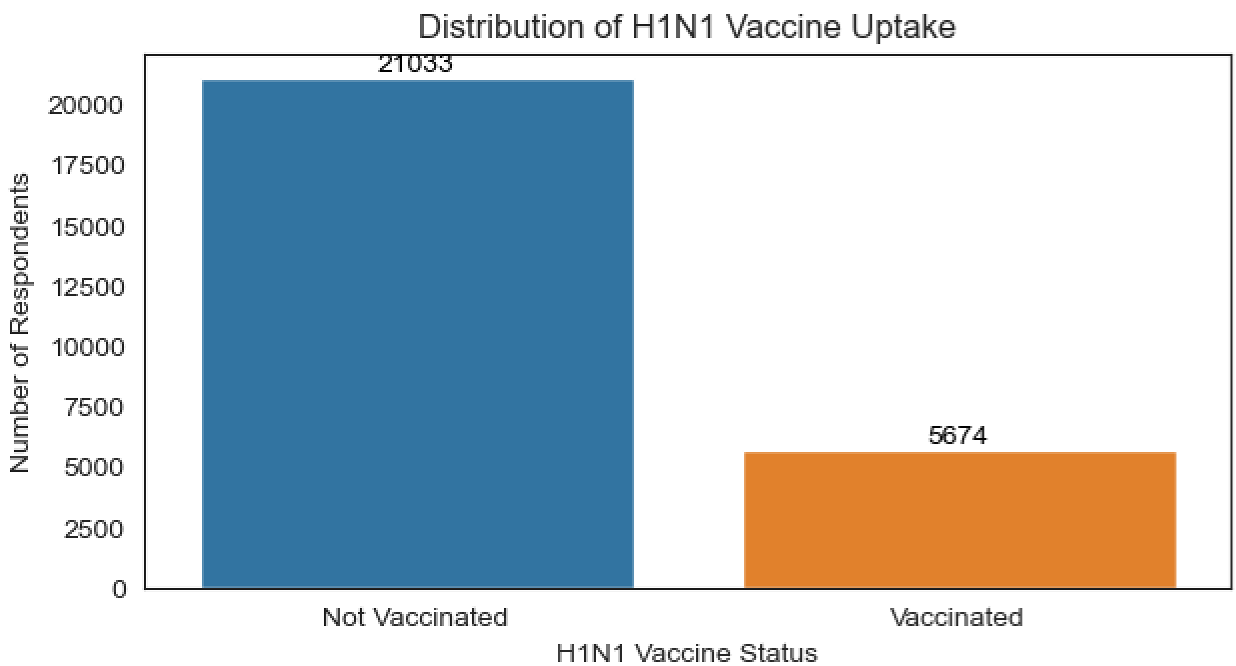
Out[21]:
```
id                             0
respondent_id                  0
h1n1_concern                   0
h1n1_knowledge                 0
behavioral_antiviral_meds      0
behavioral_avoidance           0
behavioral_face_mask           0
behavioral_wash_hands          0
behavioral_large_gatherings    0
behavioral_outside_home        0
behavioral_touch_face          0
doctor_recc_h1n1               0
doctor_recc_seasonal           0
chronic_med_condition          0
child_under_6_months           0
health_worker                  0
health_insurance               0
opinion_h1n1_vacc_effective    0
opinion_h1n1_risk              0
opinion_h1n1_sick_from_vacc    0
opinion_seas_vacc_effective    0
opinion_seas_risk              0
opinion_seas_sick_from_vacc    0
age_group                      0
education                      0
race                           0
sex                            0
income_poverty                 0
marital_status                 0
rent_or_own                    0
employment_status              0
census_msa                     0
household_adults               0
household_children             0
h1n1_vaccine                   0
seasonal_vaccine               0
dtype: int64
```

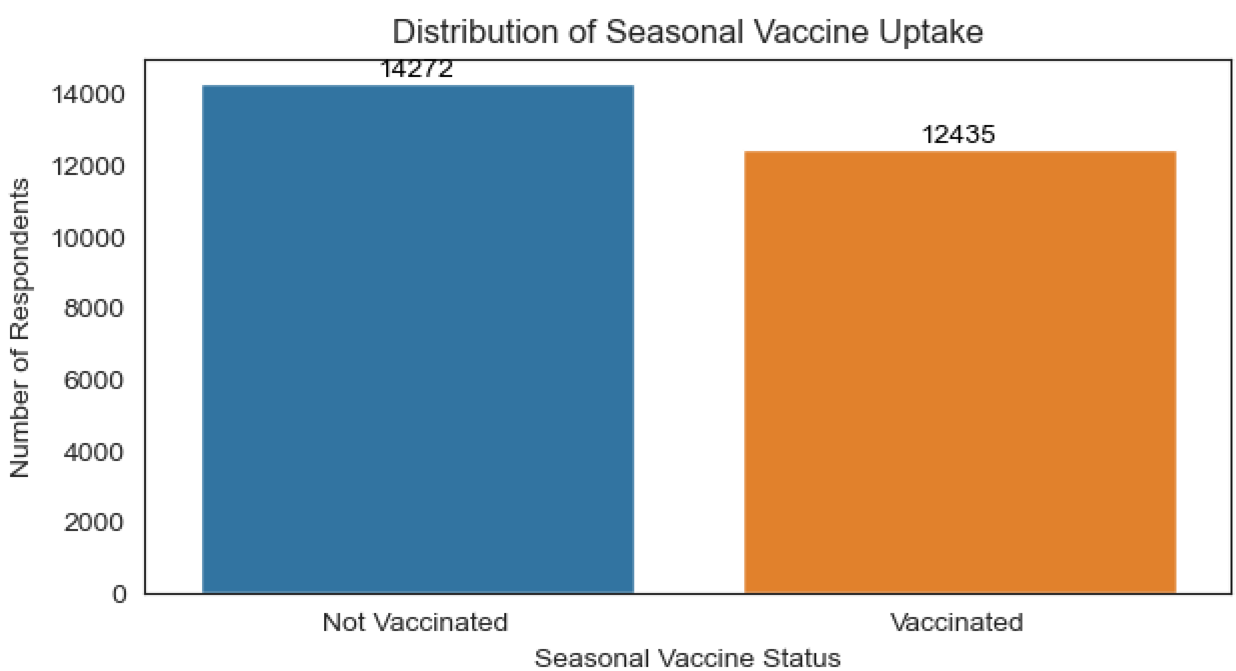
In [22]:
```
data.shape
```

Out[22]:
```
(26707, 36)
```

In [23]:
```
# Set the aesthetic style of the plots
sns.set_style('white')

# Plot the distribution of H1N1 vaccine uptake
plt.figure(figsize=(7, 3))  # Adjusted figsize
h1n1_vaccine_dist = sns.countplot(x='h1n1_vaccine', data=data)

# Add data labels without decimal points
for p in h1n1_vaccine_dist.patches:
    h1n1_vaccine_dist.annotate(f'{int(p.get_height())}', (p.get_x() + p.get_width() / 2.
                                ha='center', va='center', fontsize=10, color='black', xy
                                textcoords='offset points')

plt.title('Distribution of H1N1 Vaccine Uptake')
plt.xlabel('H1N1 Vaccine Status')
plt.ylabel('Number of Respondents')
plt.xticks([0, 1], ['Not Vaccinated', 'Vaccinated'])
plt.subplots_adjust(top=1)
plt.show()

# Plot the distribution of Seasonal vaccine uptake
```

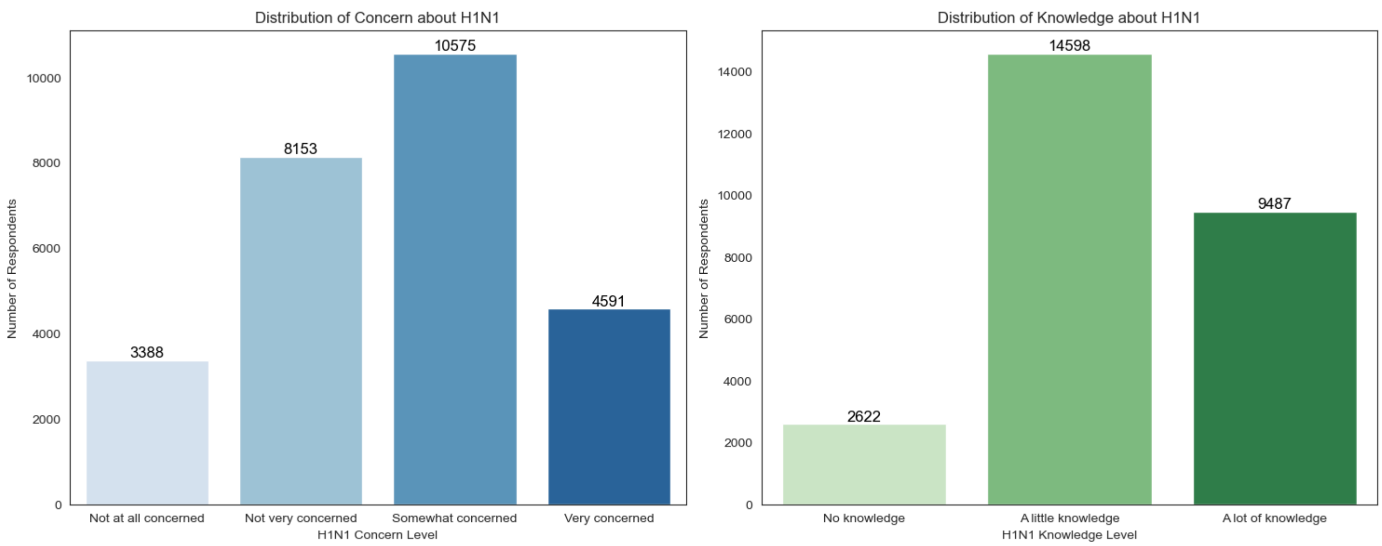
```python
plt.figure(figsize=(7, 3))  # Adjusted figsize
seasonal_vaccine_dist = sns.countplot(x='seasonal_vaccine', data=data)

# Add data labels without decimal points
for p in seasonal_vaccine_dist.patches:
    seasonal_vaccine_dist.annotate(f'{int(p.get_height())}', (p.get_x() + p.get_width()
                                   ha='center', va='center', fontsize=10, color='black',
                                   textcoords='offset points')

plt.title('Distribution of Seasonal Vaccine Uptake')
plt.xlabel('Seasonal Vaccine Status')
plt.ylabel('Number of Respondents')
plt.xticks([0, 1], ['Not Vaccinated', 'Vaccinated'])
plt.subplots_adjust(top=1)
plt.show()
```





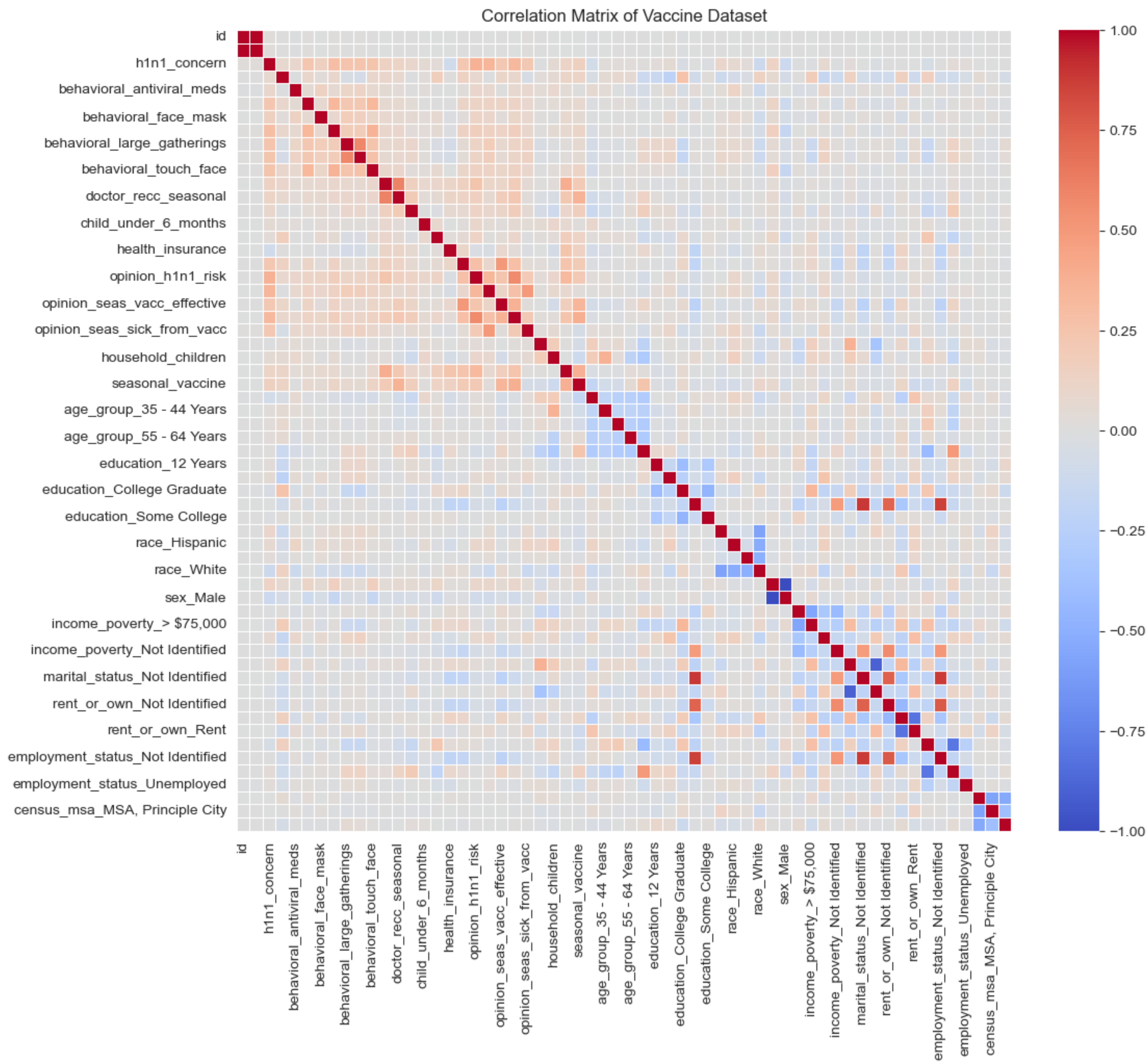
> - The first chart shows the number of respondents who have been vaccinated for H1N1.
> - The second chart displays the number of respondents who have been vaccinated for the Seasonal flu.

In [24]:
```
# Set the aesthetic style of the plots
sns.set_style('white')

# Create subplots
fig, axes = plt.subplots(1, 2, figsize=(15, 6))

# Plot the distribution of concern about H1N1 with color fade and data labels
sns.countplot(x='h1n1_concern', data=data, palette='Blues', ax=axes[0])
for p in axes[0].patches:
    axes[0].annotate(f'{int(p.get_height())}', (p.get_x() + p.get_width() / 2., p.get_he
                     ha='center', va='center', fontsize=12, color='black', xytext=(0, 5)
                     textcoords='offset points')
axes[0].set_title('Distribution of Concern about H1N1')
axes[0].set_xlabel('H1N1 Concern Level')
axes[0].set_ylabel('Number of Respondents')
axes[0].set_xticks([0, 1, 2, 3])
axes[0].set_xticklabels(['Not at all concerned', 'Not very concerned', 'Somewhat concern

# Plot the distribution of knowledge about H1N1 with color fade and data labels
sns.countplot(x='h1n1_knowledge', data=data, palette='Greens', ax=axes[1])
for p in axes[1].patches:
    axes[1].annotate(f'{int(p.get_height())}', (p.get_x() + p.get_width() / 2., p.get_he
                     ha='center', va='center', fontsize=12, color='black', xytext=(0, 5)
                     textcoords='offset points')
axes[1].set_title('Distribution of Knowledge about H1N1')
axes[1].set_xlabel('H1N1 Knowledge Level')
axes[1].set_ylabel('Number of Respondents')
axes[1].set_xticks([0, 1, 2])
axes[1].set_xticklabels(['No knowledge', 'A little knowledge', 'A lot of knowledge'])

# Adjust layout
plt.tight_layout()

# Show the plots
plt.show()
```



In [25]:
```
# I have calculated the correlation matrix for the dataset and visualized it using a hea

label_encoders = {}

# Encode categorical variables using one-hot encoding
for column in data.select_dtypes(include=['object']).columns:
    data = pd.get_dummies(data, columns=[column], prefix=[column])

# Calculate the correlation matrix
correlation_matrix = data.corr()
```

```
# Plot the correlation matrix using a heatmap
plt.figure(figsize=(12, 10))
sns.heatmap(correlation_matrix, cmap='coolwarm', fmt='.2f', linewidths=.5, annot_kws={'s
plt.title('Correlation Matrix of Vaccine Dataset')
plt.show()
```



> - This visualization can help us understand which factors are most strongly associated with the uptake of H1N1 and Seasonal vaccines.

Strong correlations with H1N1 and Seasonal vaccine uptake

In [26]:

```
# Select correlations related to 'h1n1_vaccine' and 'seasonal_vaccine' and sort them
h1n1_corr = correlation_matrix['h1n1_vaccine'].sort_values(ascending=False)
seasonal_corr = correlation_matrix['seasonal_vaccine'].sort_values(ascending=False)

# Filter out strong correlations (greater than 0.1 or less than -0.1)
strong_h1n1_corr = h1n1_corr[np.abs(h1n1_corr) > 0.1]
strong_seasonal_corr = seasonal_corr[np.abs(seasonal_corr) > 0.1]

# Display the strong correlations for H1N1 vaccine
print('Strong correlations with H1N1 vaccine uptake:')
```

```
print(strong_h1n1_corr)

# Display the strong correlations for Seasonal vaccine
print('\nStrong correlations with Seasonal vaccine uptake:')
print(strong_seasonal_corr)
```

```
Strong correlations with H1N1 vaccine uptake:
h1n1_vaccine                   1.000000
doctor_recc_h1n1               0.394086
seasonal_vaccine               0.377143
opinion_h1n1_risk              0.317980
opinion_h1n1_vacc_effective    0.254815
opinion_seas_risk              0.253290
health_insurance               0.244975
doctor_recc_seasonal           0.218976
opinion_seas_vacc_effective    0.168425
health_worker                  0.168056
h1n1_concern                   0.121664
h1n1_knowledge                 0.117153
Name: h1n1_vaccine, dtype: float64

Strong correlations with Seasonal vaccine uptake:
seasonal_vaccine                        1.000000
opinion_seas_risk                       0.384359
h1n1_vaccine                            0.377143
doctor_recc_seasonal                    0.360696
opinion_seas_vacc_effective             0.344458
age_group_65+ Years                     0.244830
opinion_h1n1_risk                       0.216036
opinion_h1n1_vacc_effective             0.199518
doctor_recc_h1n1                        0.198560
chronic_med_condition                   0.169465
h1n1_concern                            0.153838
employment_status_Not in Labor Force    0.145819
health_insurance                        0.138161
health_worker                           0.126977
behavioral_touch_face                   0.119078
h1n1_knowledge                          0.118515
behavioral_wash_hands                   0.112164
rent_or_own_Own                         0.108002
race_White                              0.100314
rent_or_own_Rent                       -0.101796
household_children                     -0.111680
age_group_18 - 34 Years                -0.178786
Name: seasonal_vaccine, dtype: float64
```

I have identified strong correlations with H1N1 and Seasonal vaccine uptake:

- For the H1N1 vaccine, the strongest correlations are with:
- Doctor's recommendation for H1N1 vaccine
- Uptake of the Seasonal vaccine
- Respondent's opinion on the risk of H1N1

For the Seasonal vaccine, the strongest correlations are with:

- Respondent's opinion on the risk of the Seasonal flu
- Uptake of the H1N1 vaccine
- Doctor's recommendation for the Seasonal vaccine

Demographic factors (like age, race, sex, income) that influence vaccine uptake

In [28]:
```
# Load the dataset
```

```
file_path = 'H1N1_Flu_Vaccines - Clean.csv'
data = pd.read_csv(file_path)
```

In [29]:
```
# Investigate demographic factors influencing vaccine uptake

# Calculate the mean vaccine uptake for different demographic groups
# Age group
age_vaccine_uptake = data.groupby('age_group')[['h1n1_vaccine', 'seasonal_vaccine']].mea
# Race
group_race_vaccine_uptake = data.groupby('race')[['h1n1_vaccine', 'seasonal_vaccine']].m
# Sex
group_sex_vaccine_uptake = data.groupby('sex')[['h1n1_vaccine', 'seasonal_vaccine']].mea
# Income
group_income_vaccine_uptake = data.groupby('income_poverty')[['h1n1_vaccine', 'seasonal_

# Convert the results to a DataFrame for better formatting
age_df = pd.DataFrame(age_vaccine_uptake).reset_index()
race_df = pd.DataFrame(group_race_vaccine_uptake).reset_index()
sex_df = pd.DataFrame(group_sex_vaccine_uptake).reset_index()
income_df = pd.DataFrame(group_income_vaccine_uptake).reset_index()

# Display the tables
print('Vaccine uptake by age group:')
print(tabulate(age_df, headers='keys', tablefmt='fancy_grid', showindex=False))

print('\nVaccine uptake by race:')
print(tabulate(race_df, headers='keys', tablefmt='fancy_grid', showindex=False))

print('\nVaccine uptake by sex:')
print(tabulate(sex_df, headers='keys', tablefmt='fancy_grid', showindex=False))

print('\nVaccine uptake by income:')
print(tabulate(income_df, headers='keys', tablefmt='fancy_grid', showindex=False))
```

Vaccine uptake by age group:

age_group	h1n1_vaccine	seasonal_vaccine
18 - 34 Years	0.190029	0.284564
35 - 44 Years	0.197765	0.362526
45 - 54 Years	0.194731	0.401298
55 - 64 Years	0.242855	0.511235
65+ Years	0.226655	0.673681

Vaccine uptake by race:

race	h1n1_vaccine	seasonal_vaccine
Black	0.148725	0.349858
Hispanic	0.207977	0.339601
Other or Multiple	0.216501	0.419975
White	0.218877	0.491047

Vaccine uptake by sex:

sex	h1n1_vaccine	seasonal_vaccine

Female	0.219448	0.497415
Male	0.202231	0.419117

Vaccine uptake by income:

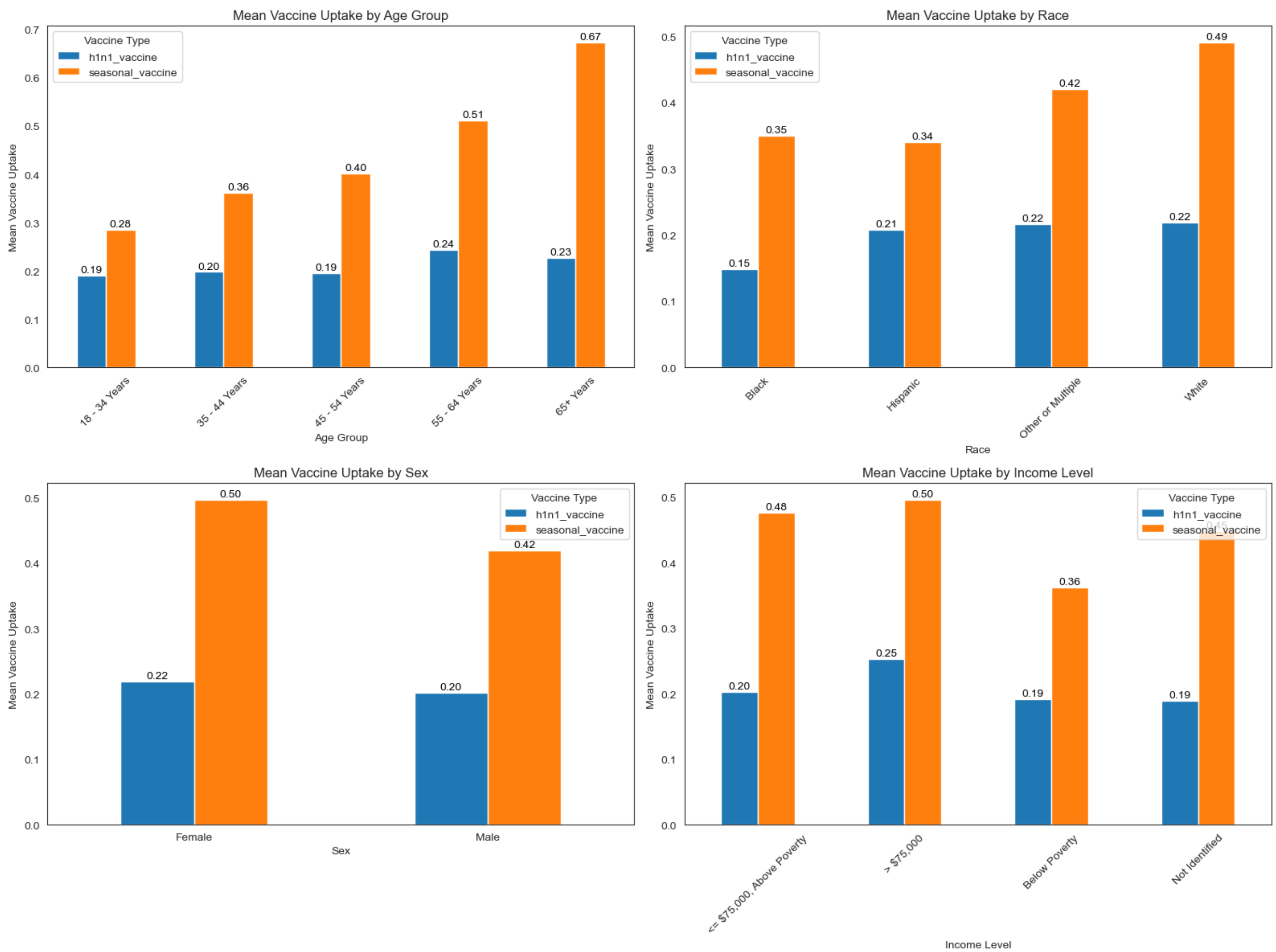
income_poverty	h1n1_vaccine	seasonal_vaccine
<= $75,000, Above Poverty	0.203412	0.476716
> $75,000	0.25301	0.496769
Below Poverty	0.191324	0.362625
Not Identified	0.189012	0.448338

Let's visualize this

In [30]:

```
# Visualize the mean vaccine uptake for different demographic groups using bar plots
fig, axes = plt.subplots(2, 2, figsize=(16, 12))

# Age group
age_vaccine_uptake.plot(kind='bar', ax=axes[0, 0])
axes[0, 0].set_title('Mean Vaccine Uptake by Age Group')
axes[0, 0].set_xlabel('Age Group')
axes[0, 0].set_ylabel('Mean Vaccine Uptake')
axes[0, 0].tick_params(axis='x', rotation=45)
axes[0, 0].legend(title='Vaccine Type')

# Add data labels for Age group
for p in axes[0, 0].patches:
    axes[0, 0].annotate(f'{p.get_height():.2f}', (p.get_x() + p.get_width() / 2., p.get_
                       ha='center', va='center', fontsize=10, color='black', xytext=(0,
                       textcoords='offset points')

# Race
group_race_vaccine_uptake.plot(kind='bar', ax=axes[0, 1])
axes[0, 1].set_title('Mean Vaccine Uptake by Race')
axes[0, 1].set_xlabel('Race')
axes[0, 1].set_ylabel('Mean Vaccine Uptake')
axes[0, 1].tick_params(axis='x', rotation=45)
axes[0, 1].legend(title='Vaccine Type')

# Add data labels for Race
for p in axes[0, 1].patches:
    axes[0, 1].annotate(f'{p.get_height():.2f}', (p.get_x() + p.get_width() / 2., p.get_
                       ha='center', va='center', fontsize=10, color='black', xytext=(0,
                       textcoords='offset points')

# Sex
group_sex_vaccine_uptake.plot(kind='bar', ax=axes[1, 0])
axes[1, 0].set_title('Mean Vaccine Uptake by Sex')
axes[1, 0].set_xlabel('Sex')
axes[1, 0].set_ylabel('Mean Vaccine Uptake')
axes[1, 0].tick_params(axis='x', rotation=0)
axes[1, 0].legend(title='Vaccine Type')

# Add data labels for Sex
for p in axes[1, 0].patches:
    axes[1, 0].annotate(f'{p.get_height():.2f}', (p.get_x() + p.get_width() / 2., p.get_
                       ha='center', va='center', fontsize=10, color='black', xytext=(0,
                       textcoords='offset points')
```

```
# Income
group_income_vaccine_uptake.plot(kind='bar', ax=axes[1, 1])
axes[1, 1].set_title('Mean Vaccine Uptake by Income Level')
axes[1, 1].set_xlabel('Income Level')
axes[1, 1].set_ylabel('Mean Vaccine Uptake')
axes[1, 1].tick_params(axis='x', rotation=45)
axes[1, 1].legend(title='Vaccine Type')

# Add data labels for Income
for p in axes[1, 1].patches:
    axes[1, 1].annotate(f'{p.get_height():.2f}', (p.get_x() + p.get_width() / 2., p.get_
                        ha='center', va='center', fontsize=10, color='black', xytext=(0,
                        textcoords='offset points')

plt.tight_layout()
plt.show()
```



Impact of behavioral factors (like hand washing, avoiding close contact) on the likelihood of getting vaccinated.

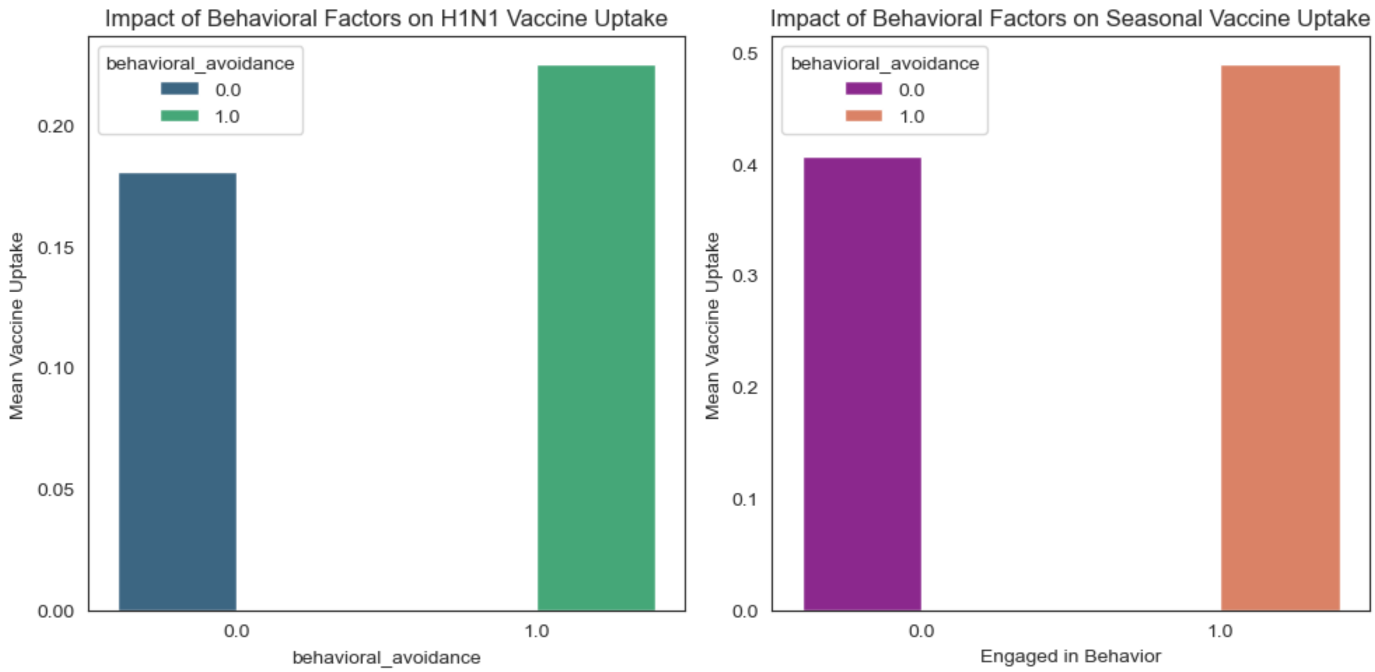
In [36]:
```
# Analyze the impact of behavioral factors on the likelihood of getting vaccinated

# Calculate the mean vaccine uptake for behavioral factors
behavioral_factors = ['behavioral_avoidance', 'behavioral_face_mask', 'behavioral_wash_h
behavior_vaccine_uptake = data[behavioral_factors + ['h1n1_vaccine', 'seasonal_vaccine']

# Display the head of the dataframe to show the impact of behavioral factors
print(behavior_vaccine_uptake.head())
```

```
   behavioral_avoidance  behavioral_face_mask  behavioral_wash_hands  \
```

```
0                      0                      0                       0
1                      0                      0                       0
2                      0                      0                       0
3                      0                      0                       0
4                      0                      0                       0

   behavioral_large_gatherings  behavioral_outside_home  \
0                            0                        0
1                            0                        0
2                            0                        1
3                            0                        1
4                            1                        0

   behavioral_touch_face  h1n1_vaccine  seasonal_vaccine
0                      0      0.120771          0.293233
1                      1      0.176301          0.416185
2                      0      0.156863          0.470588
3                      1      0.171429          0.542857
4                      0      0.162500          0.362500
```

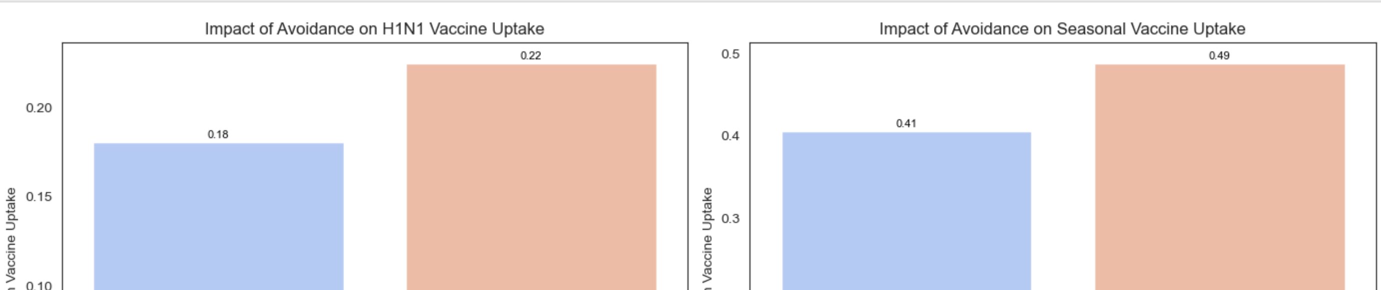
The table above shows the mean vaccine uptake for H1N1 and Seasonal flu across different behavioral factors such as avoidance of certain situations, wearing face masks, hand washing, attending large gatherings, going out of home, and touching one's face. Each row represents a combination of behavioral responses, with the corresponding mean vaccine uptake rates. This data can help understand how individual behaviors may correlate with the likelihood of getting vaccinated.

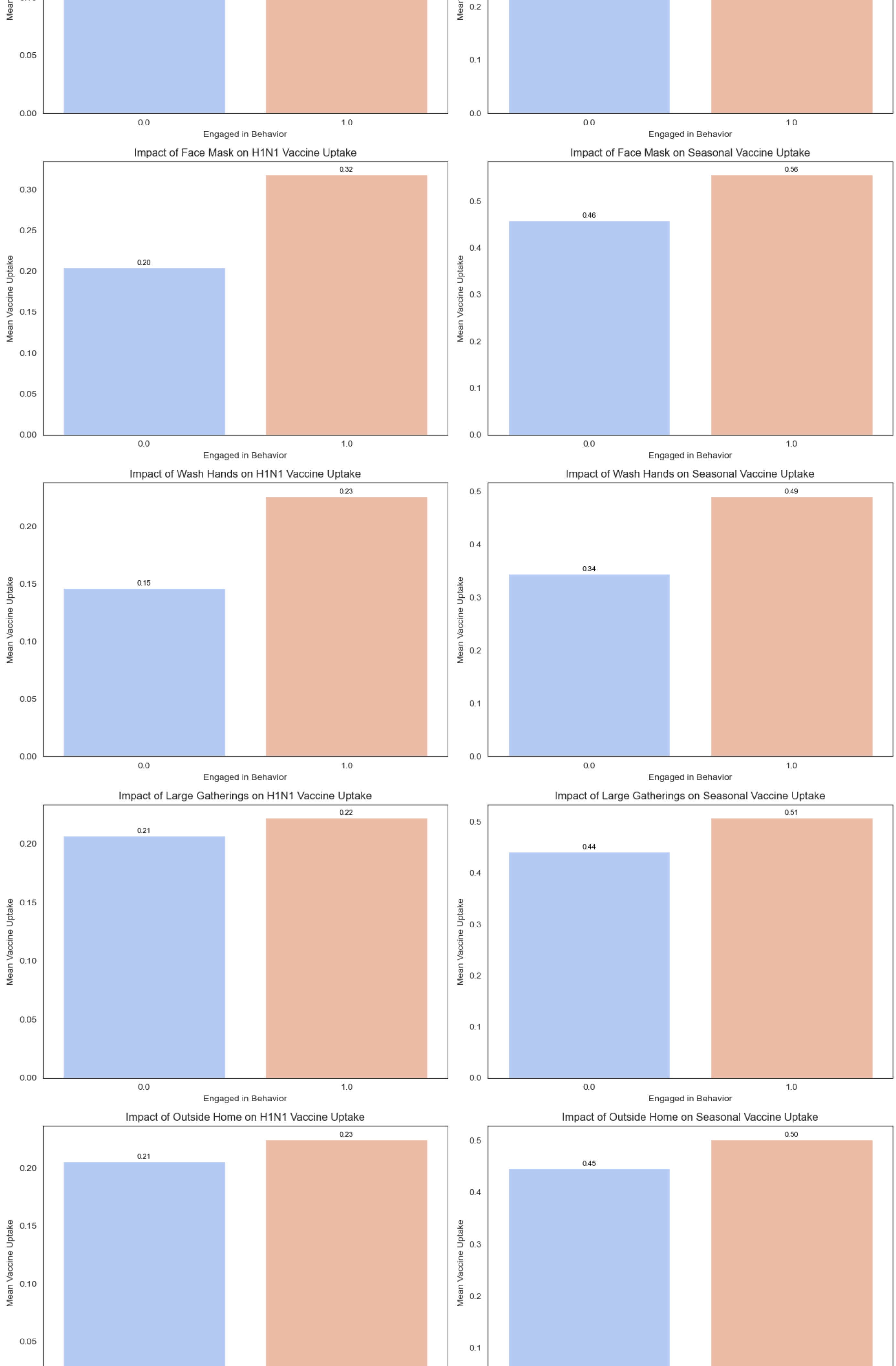
In [37]:
```
# Visualize the impact of behavioral factors on the likelihood of getting vaccinated usi

# Create a new dataframe to store results
behavioral_impact_stacked = pd.DataFrame()

for factor in behavioral_factors:
    # Calculate the vaccine uptake for each behavior
    uptake = data.groupby(factor)[['h1n1_vaccine', 'seasonal_vaccine']].mean().reset_ind
    uptake.rename(columns={'h1n1_vaccine': factor + '_h1n1', 'seasonal_vaccine': factor
    behavioral_impact_stacked = pd.concat([behavioral_impact_stacked, uptake], axis=0)

# Plotting
fig, axes = plt.subplots(nrows=1, ncols=2, figsize=(10, 5), sharex=True)

# Stacked bar plot for H1N1 vaccine
sns.barplot(x=behavioral_impact_stacked[behavioral_impact_stacked.columns[0]], y=behavio
axes[0].set_title('Impact of Behavioral Factors on H1N1 Vaccine Uptake')
axes[0].set_ylabel('Mean Vaccine Uptake')

# Stacked bar plot for Seasonal vaccine
sns.barplot(x=behavioral_impact_stacked[behavioral_impact_stacked.columns[0]], y=behavio
axes[1].set_title('Impact of Behavioral Factors on Seasonal Vaccine Uptake')
axes[1].set_xlabel('Engaged in Behavior')
axes[1].set_ylabel('Mean Vaccine Uptake')

plt.tight_layout()
plt.show()
```



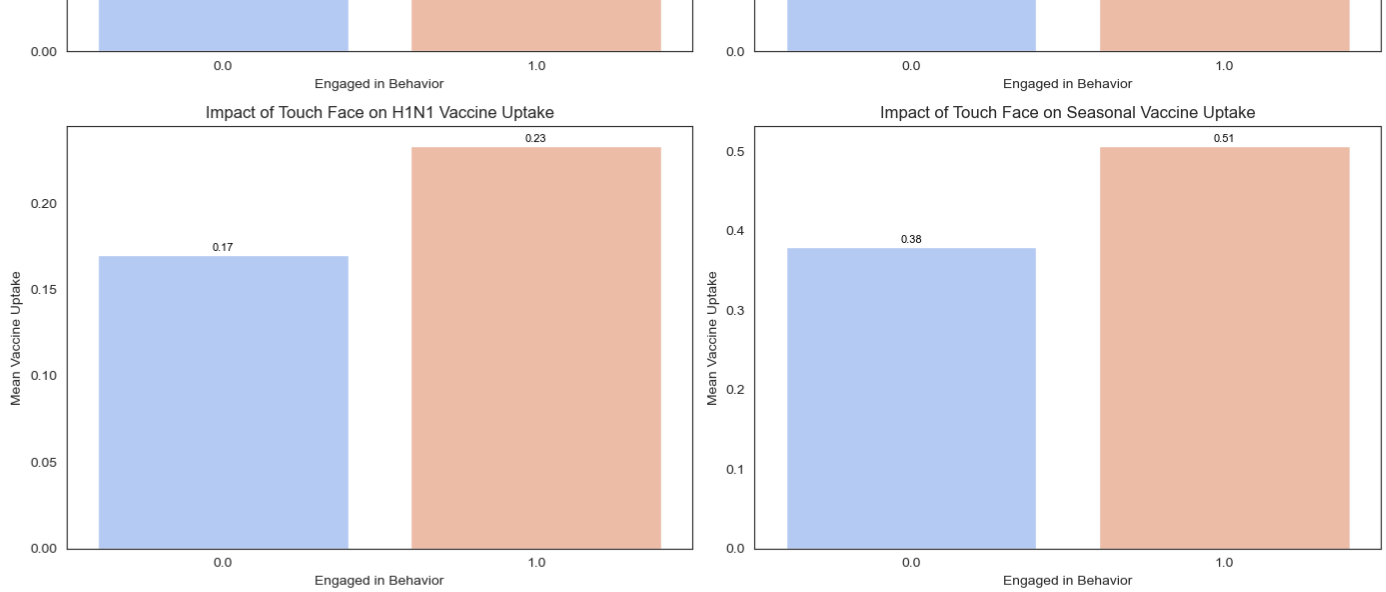
In [38]:

```
# Visualize the impact of each behavioral factor on the likelihood of getting vaccinated

fig, axes = plt.subplots(nrows=len(behavioral_factors), ncols=2, figsize=(14, 5 * len(be

# Adjust spacing between subplots
plt.subplots_adjust(wspace=0.4, hspace=0.5)

for i, factor in enumerate(behavioral_factors):
    # Bar plot for H1N1 vaccine with coolwarm gradient color
    sns.barplot(x=factor, y=factor + '_h1n1', data=behavioral_impact_stacked, ax=axes[i,
    axes[i, 0].set_title('Impact of ' + factor.replace('behavioral_', '').replace('_', '
    axes[i, 0].set_ylabel('Mean Vaccine Uptake')
    axes[i, 0].set_xlabel('Engaged in Behavior')

    # Add data labels for H1N1 vaccine
    for p in axes[i, 0].patches:
        axes[i, 0].annotate(f'{p.get_height():.2f}', (p.get_x() + p.get_width() / 2., p.
                            ha='center', va='center', fontsize=8, color='black', xytext=
                            textcoords='offset points')

    # Bar plot for Seasonal vaccine with coolwarm gradient color
    sns.barplot(x=factor, y=factor + '_seasonal', data=behavioral_impact_stacked, ax=axe
    axes[i, 1].set_title('Impact of ' + factor.replace('behavioral_', '').replace('_', '
    axes[i, 1].set_ylabel('Mean Vaccine Uptake')
    axes[i, 1].set_xlabel('Engaged in Behavior')

    # Add data labels for Seasonal vaccine
    for p in axes[i, 1].patches:
        axes[i, 1].annotate(f'{p.get_height():.2f}', (p.get_x() + p.get_width() / 2., p.
                            ha='center', va='center', fontsize=8, color='black', xytext=
                            textcoords='offset points')

plt.tight_layout()
plt.show()
```





Engaged in Behavior
Engaged in Behavior
Impact of Face Mask on H1N1 Vaccine Uptake
0.20
0.32
Mean Vaccine Uptake
Engaged in Behavior
Impact of Face Mask on Seasonal Vaccine Uptake
0.46
0.56
Mean Vaccine Uptake
Engaged in Behavior
Impact of Wash Hands on H1N1 Vaccine Uptake
0.15
0.23
Mean Vaccine Uptake
Engaged in Behavior
Impact of Wash Hands on Seasonal Vaccine Uptake
0.34
0.49
Mean Vaccine Uptake
Engaged in Behavior
Impact of Large Gatherings on H1N1 Vaccine Uptake
0.21
0.22
Mean Vaccine Uptake
Engaged in Behavior
Impact of Large Gatherings on Seasonal Vaccine Uptake
0.44
0.51
Mean Vaccine Uptake
Engaged in Behavior
Impact of Outside Home on H1N1 Vaccine Uptake
0.21
0.23
Mean Vaccine Uptake
Impact of Outside Home on Seasonal Vaccine Uptake
0.45
0.50
Mean Vaccine Uptake



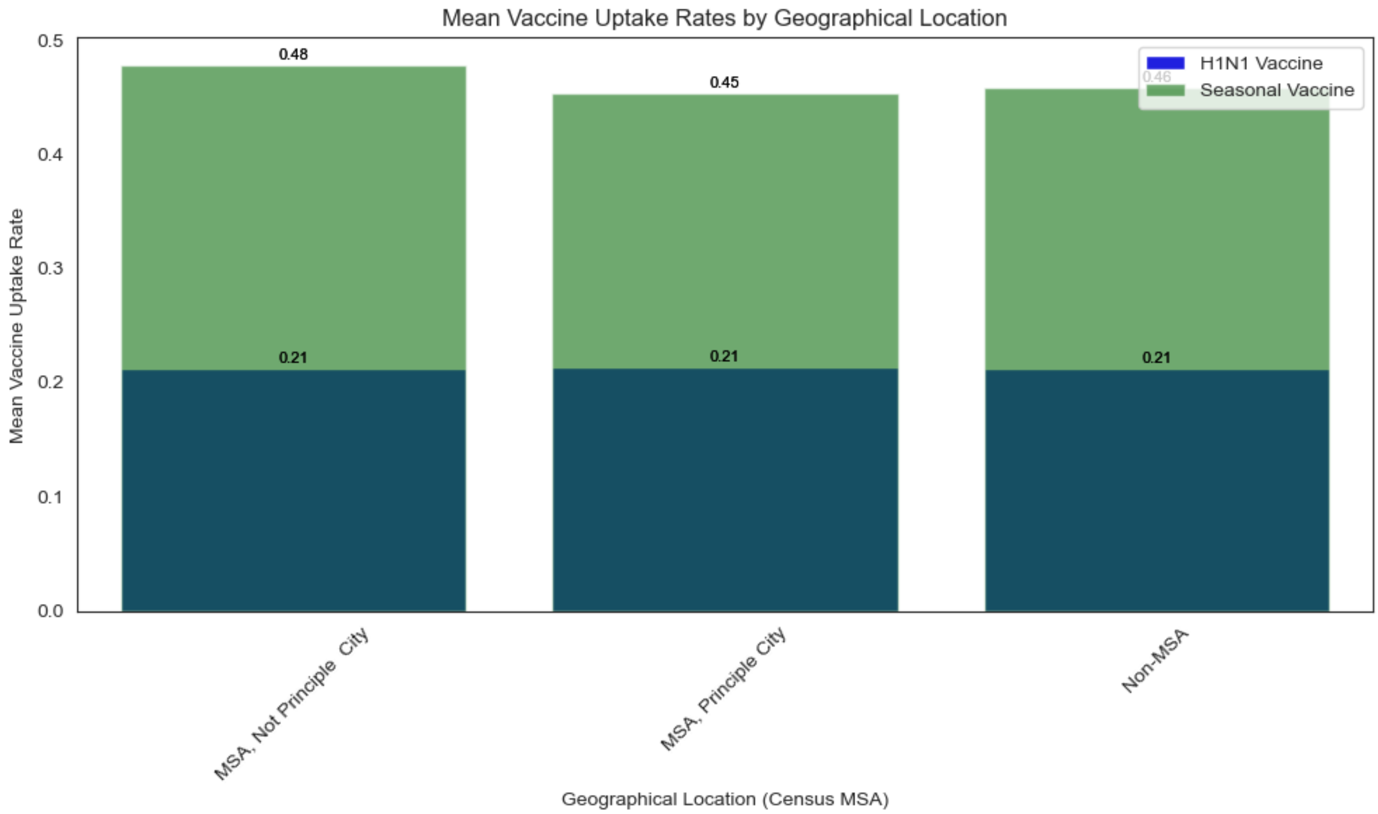
Role of geographical location on vaccine uptake rates.

reload the data then run the code below

In [43]:
```
vaccine_uptake_by_location = data.groupby('census_msa')[['h1n1_vaccine', 'seasonal_vacci

# Display the head of the resulting dataframe
print(vaccine_uptake_by_location.head())
```

```
                  census_msa  h1n1_vaccine  seasonal_vaccine
0  MSA, Not Principle  City      0.211851          0.478231
1       MSA, Principle City      0.213759          0.453713
2                   Non-MSA      0.212003          0.458183
```

In [44]:
```
plt.figure(figsize=(10, 6))

# Plotting the H1N1 vaccine uptake
h1n1_plot = sns.barplot(x='census_msa', y='h1n1_vaccine', data=vaccine_uptake_by_locatio

# Plotting the seasonal vaccine uptake
seasonal_plot = sns.barplot(x='census_msa', y='seasonal_vaccine', data=vaccine_uptake_by

plt.title('Mean Vaccine Uptake Rates by Geographical Location')
plt.xlabel('Geographical Location (Census MSA)')
plt.ylabel('Mean Vaccine Uptake Rate')
plt.legend()

# Adding data labels for H1N1 vaccine
for p in h1n1_plot.patches:
    plt.annotate(f'{p.get_height():.2f}', (p.get_x() + p.get_width() / 2., p.get_height(
                 ha='center', va='center', fontsize=8, color='black', xytext=(0, 5),
                 textcoords='offset points')

# Adding data labels for seasonal vaccine
for p in seasonal_plot.patches:
    plt.annotate(f'{p.get_height():.2f}', (p.get_x() + p.get_width() / 2., p.get_height(
                 ha='center', va='center', fontsize=8, color='black', xytext=(0, 5),
                 textcoords='offset points')

plt.xticks(rotation=45)
plt.tight_layout()
plt.show()
```

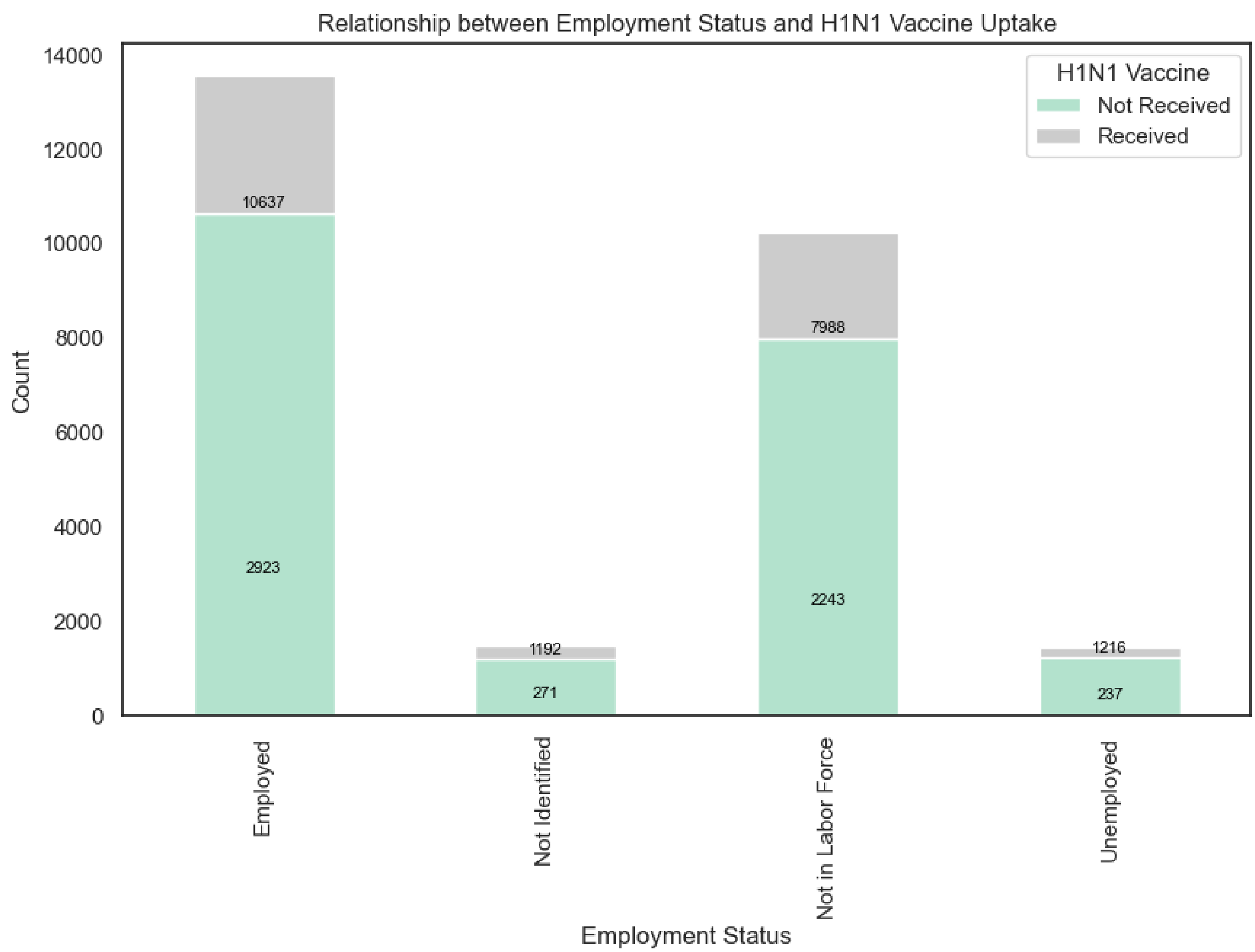


Relationship between respondents' employment status and their vaccination status

In [45]:

```
contingency_table = pd.crosstab(data['employment_status'], data['h1n1_vaccine'])

# Display the contingency table
print(contingency_table)

# Create a stacked bar plot with a gradient color
sns.set(style="white")
ax = contingency_table.plot(kind='bar', stacked=True, colormap='Pastel2', figsize=(10, 6
plt.title('Relationship between Employment Status and H1N1 Vaccine Uptake')
plt.xlabel('Employment Status')
plt.ylabel('Count')
plt.legend(title='H1N1 Vaccine', labels=['Not Received', 'Received'])

for p in ax.patches:
    height = p.get_height()
    if height != 0:  # Exclude bars with zero height
        ax.annotate(f'{int(height)}', (p.get_x() + p.get_width() / 2., height),
                    ha='center', va='center', fontsize=8, color='black', xytext=(0, 5),
                    textcoords='offset points')
plt.show()
```

```
h1n1_vaccine            0     1
employment_status
Employed            10637  2923
Not Identified       1192   271
Not in Labor Force   7988  2243
Unemployed           1216   237
```



Determine if there's a significant difference in vaccine uptake between people with different chronic health conditions.

In [46]:
```
h1n1_contingency_table = pd.crosstab(data['chronic_med_condition'], data['h1n1_vaccine']
print(h1n1_contingency_table)
```

```
h1n1_vaccine              0     1
chronic_med_condition
0                     15751  3666
1                      5282  2008
```

In [47]:
```
seasonal_contingency_table = pd.crosstab(data['chronic_med_condition'], data['seasonal_v
print(seasonal_contingency_table)
```

```
seasonal_vaccine          0     1
chronic_med_condition
0                     11382  8035
1                      2890  4400
```

Perform Chi-Square Test:

In [48]:
```
chi2_1, p1, _, _ = chi2_contingency(h1n1_contingency_table)
chi2_2, p2, _, _ = chi2_contingency(seasonal_contingency_table)
print(f"H1N1 Chi-Square Value: {chi2_1}")
print(f"P-Value: {p1}")

print(f"Seasonal Chi-Square Value: {chi2_2}")
print(f"P-Value: {p2}")
```

```
H1N1 Chi-Square Value: 237.2776362003578
```

```
P-Value: 1.5428233060113362e-53
Seasonal Chi-Square Value: 766.2201795832589
P-Value: 1.1928898604662591e-168
```

In [49]:

```
alpha = 0.05
if p1 < alpha:
    print("There is a significant difference in H1N1 vaccine uptake between people with
else:
    print("There is no significant difference in H1N1 vaccine uptake between people with
```

```
There is a significant difference in H1N1 vaccine uptake between people with different c
hronic health conditions.
```

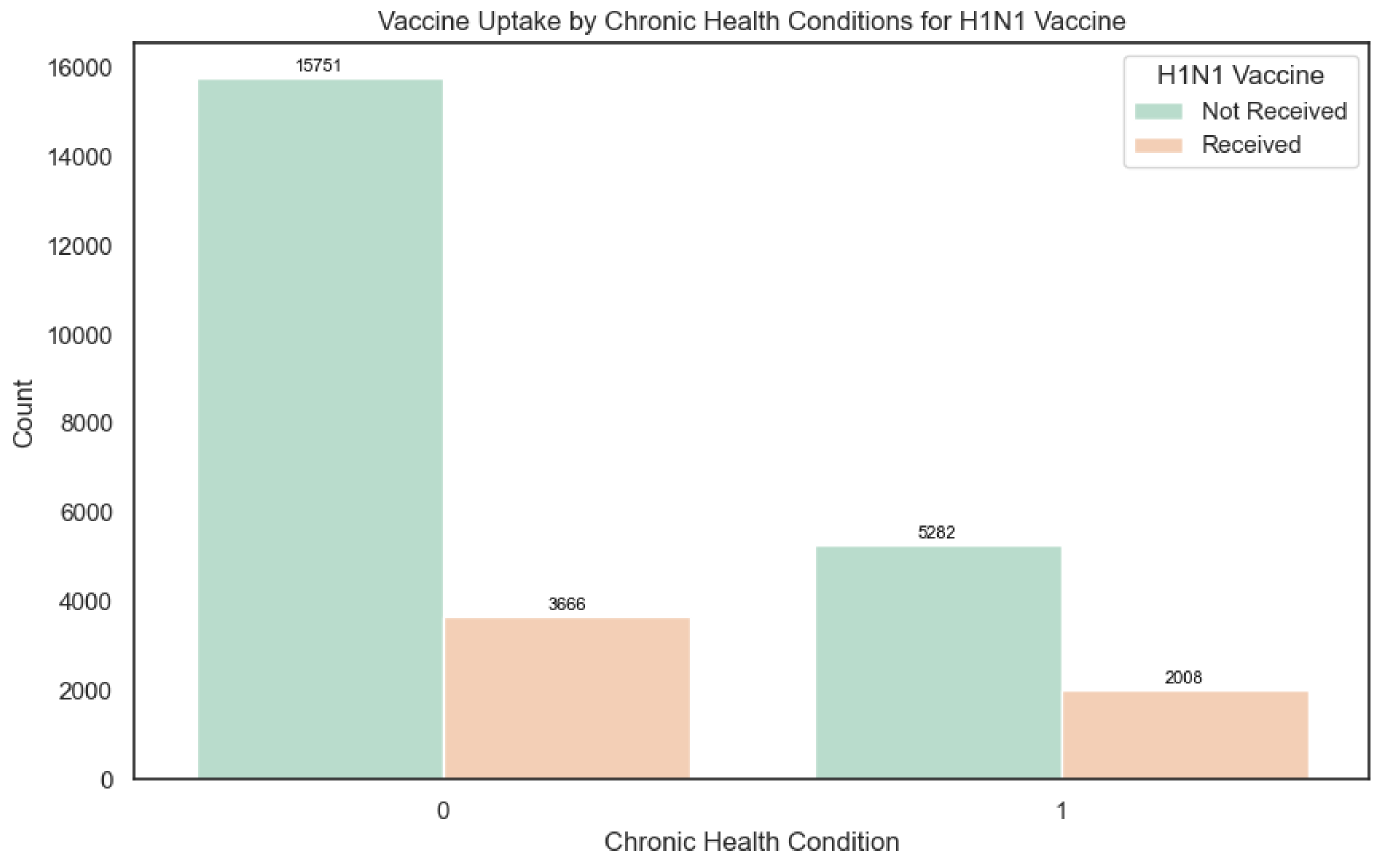
In [50]:

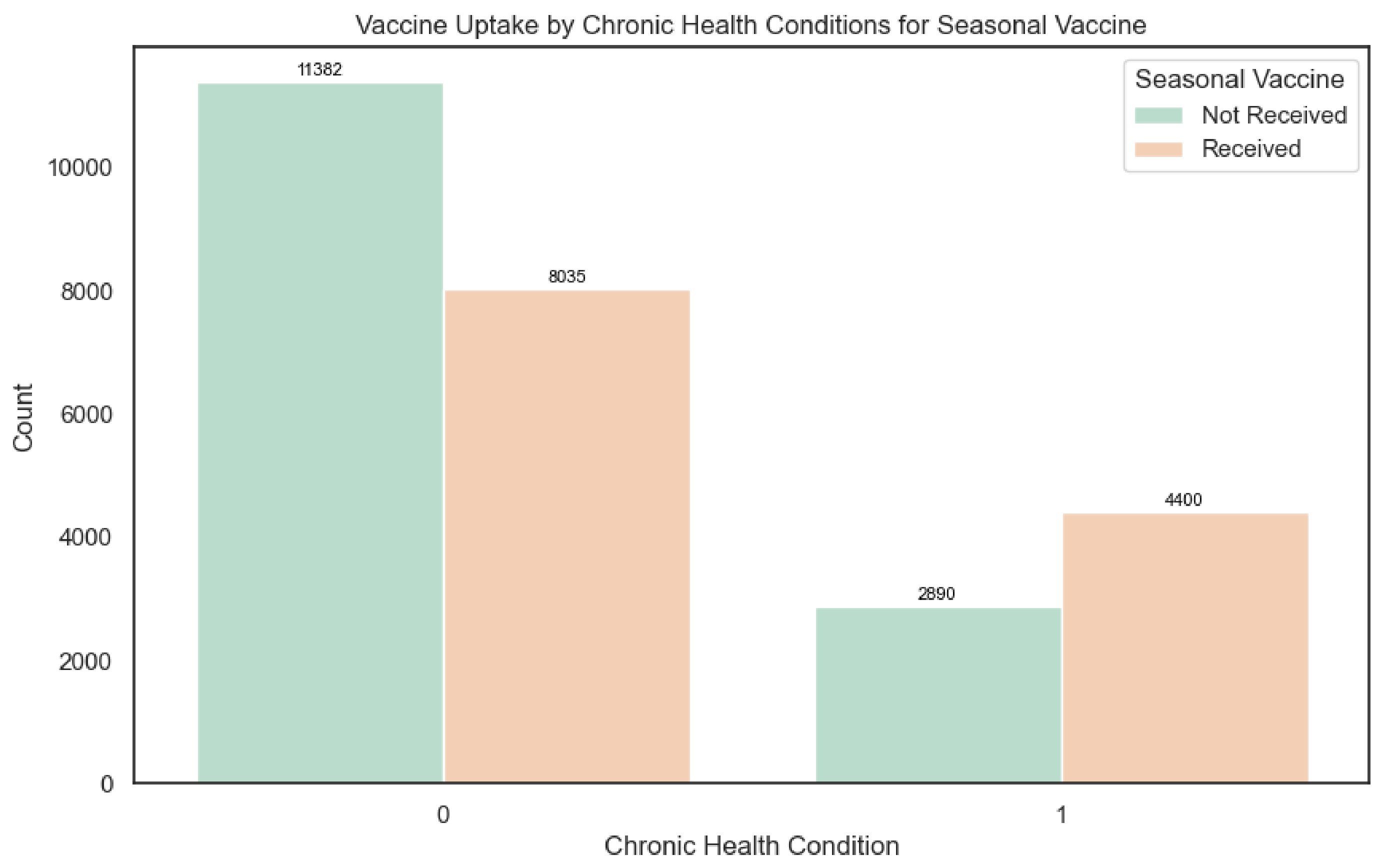
```
if p2 < alpha:
    print("There is a significant difference in Seasonal vaccine uptake between people w
else:
    print("There is no significant difference in Seasonal vaccine uptake between people
```

```
There is a significant difference in Seasonal vaccine uptake between people with differe
nt chronic health conditions.
```

In [51]:

```
# Function to add data labels
def add_data_labels(ax):
    for p in ax.patches:
        height = p.get_height()
        ax.annotate(f'{int(height)}', (p.get_x() + p.get_width() / 2., height),
                    ha='center', va='center', fontsize=8, color='black', xytext=(0, 5),
                    textcoords='offset points')

# Stacked bar plot for H1N1 vaccine
plt.figure(figsize=(10, 6))
ax1 = sns.countplot(x='chronic_med_condition', hue='h1n1_vaccine', data=data, palette='P

# Add data labels for H1N1 vaccine
add_data_labels(ax1)

plt.title('Vaccine Uptake by Chronic Health Conditions for H1N1 Vaccine')
plt.xlabel('Chronic Health Condition')
plt.ylabel('Count')
plt.legend(title='H1N1 Vaccine', labels=['Not Received', 'Received'])
plt.show()

# Stacked bar plot for seasonal vaccine
plt.figure(figsize=(10, 6))
ax2 = sns.countplot(x='chronic_med_condition', hue='seasonal_vaccine', data=data, palett

# Add data labels for seasonal vaccine
add_data_labels(ax2)

plt.title('Vaccine Uptake by Chronic Health Conditions for Seasonal Vaccine')
plt.xlabel('Chronic Health Condition')
plt.ylabel('Count')
plt.legend(title='Seasonal Vaccine', labels=['Not Received', 'Received'])
plt.show()
```





Assess the effect of respondents' attitudes towards vaccines in general on their decision to get the H1N1 and Seasonal flu vaccines.

In [52]:
```
# Assuming 'opinion_h1n1_vacc_effective' and 'opinion_seas_vacc_effective' are columns r
contingency_table_h1n1_attitude = pd.crosstab(data['opinion_h1n1_vacc_effective'], data[
contingency_table_seasonal_attitude = pd.crosstab(data['opinion_seas_vacc_effective'], d
```

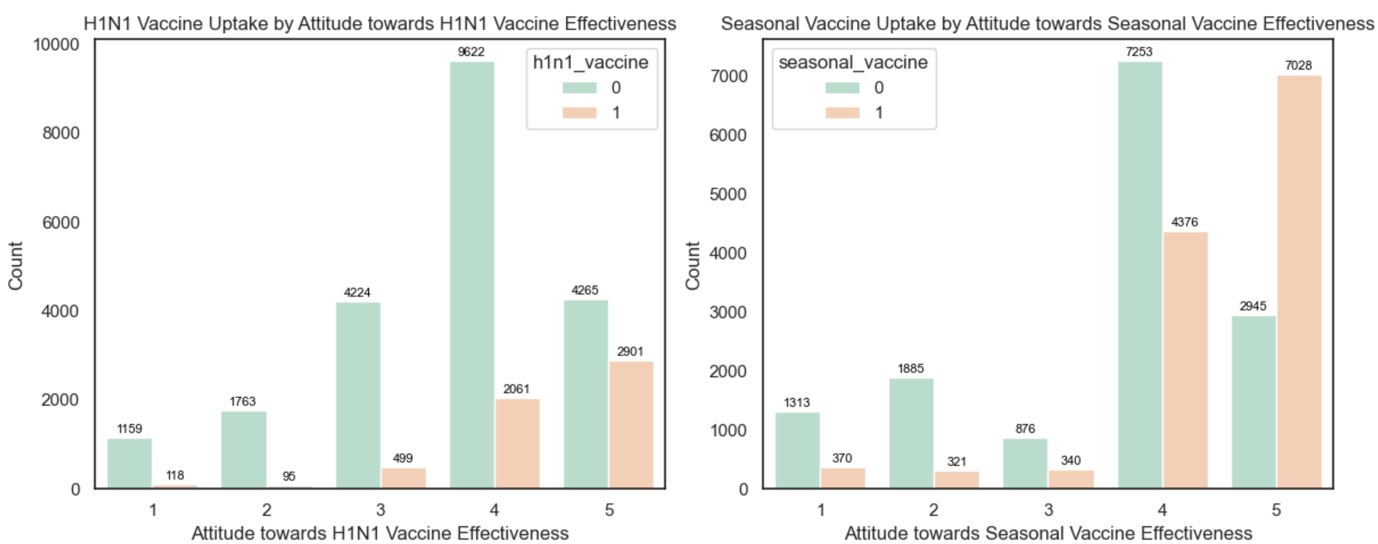
In [53]:
```
chi2_h1n1, p_h1n1, _, _ = chi2_contingency(contingency_table_h1n1_attitude)
```

```
chi2_seasonal, p_seasonal, _, _ = chi2_contingency(contingency_table_seasonal_attitude)

print(f"H1N1 Vaccine - Chi-Square Value: {chi2_h1n1}, P-Value: {p_h1n1}")
print(f"Seasonal Vaccine - Chi-Square Value: {chi2_seasonal}, P-Value: {p_seasonal}")
```

```
H1N1 Vaccine - Chi-Square Value: 2396.6965315459356, P-Value: 0.0
Seasonal Vaccine - Chi-Square Value: 4150.120326928804, P-Value: 0.0
```

In [54]:

```
plt.figure(figsize=(12, 5))
plt.subplot(1, 2, 1)
ax1 = sns.countplot(x='opinion_h1n1_vacc_effective', hue='h1n1_vaccine', data=data, pale

# Add Data Labels for H1N1 Vaccine
for p in ax1.patches:
    height = p.get_height()
    ax1.annotate(f'{int(height)}', (p.get_x() + p.get_width() / 2., height),
                 ha='center', va='center', fontsize=8, color='black', xytext=(0, 5),
                 textcoords='offset points')

plt.title('H1N1 Vaccine Uptake by Attitude towards H1N1 Vaccine Effectiveness')
plt.xlabel('Attitude towards H1N1 Vaccine Effectiveness')
plt.ylabel('Count')

# Plot Grouped Bar Plot for Seasonal Vaccine
plt.subplot(1, 2, 2)
ax2 = sns.countplot(x='opinion_seas_vacc_effective', hue='seasonal_vaccine', data=data,

# Add Data Labels for Seasonal Vaccine
for p in ax2.patches:
    height = p.get_height()
    ax2.annotate(f'{int(height)}', (p.get_x() + p.get_width() / 2., height),
                 ha='center', va='center', fontsize=8, color='black', xytext=(0, 5),
                 textcoords='offset points')

plt.title('Seasonal Vaccine Uptake by Attitude towards Seasonal Vaccine Effectiveness')
plt.xlabel('Attitude towards Seasonal Vaccine Effectiveness')
plt.ylabel('Count')

plt.tight_layout()
plt.show()
```



Build a Machine learning model to predict the likelihood of receiving a H1N1 Vaccine and/or a Seasonal Vaccine

In [56]:

```
# Select relevant columns for the model
features = ['h1n1_concern', 'h1n1_knowledge', 'behavioral_antiviral_meds', 'behavioral_a
```

```
            'behavioral_face_mask', 'behavioral_wash_hands', 'behavioral_large_gathering
            'behavioral_outside_home', 'behavioral_touch_face', 'doctor_recc_h1n1', 'chr
            'child_under_6_months', 'health_worker', 'opinion_h1n1_vacc_effective', 'opi
```

In [57]:

```
# Separate features and target variables for H1N1 vaccine
X_h1n1 = data[features]
y_h1n1 = data['h1n1_vaccine']

# Separate features and target variables for seasonal vaccine
X_seasonal = data[features]
y_seasonal = data['seasonal_vaccine']
```

In [58]:

```
# Split the data into training and testing sets
X_train_h1n1, X_test_h1n1, y_train_h1n1, y_test_h1n1 = train_test_split(X_h1n1, y_h1n1,
X_train_seasonal, X_test_seasonal, y_train_seasonal, y_test_seasonal = train_test_split(
```

In [59]:

```
# Standardize the features
scaler = StandardScaler()
X_train_h1n1 = scaler.fit_transform(X_train_h1n1)
X_test_h1n1 = scaler.transform(X_test_h1n1)

X_train_seasonal = scaler.fit_transform(X_train_seasonal)
X_test_seasonal = scaler.transform(X_test_seasonal)
```

Logistic Regression

In [60]:

```
# Create and train the logistic regression model for H1N1 vaccine
model_h1n1 = LogisticRegression(random_state=42)
model_h1n1.fit(X_train_h1n1, y_train_h1n1)
```

Out[60]:

```
▾ LogisticRegression
LogisticRegression(random_state=42)
```

In [61]:

```
# Create and train the logistic regression model for seasonal vaccine
model_seasonal = LogisticRegression(random_state=42)
model_seasonal.fit(X_train_seasonal, y_train_seasonal)
```

Out[61]:

```
▾ LogisticRegression
LogisticRegression(random_state=42)
```

In [62]:

```
# Make predictions for H1N1 vaccine
predictions_h1n1 = model_h1n1.predict(X_test_h1n1)
```

In [63]:

```
# Make predictions for seasonal vaccine
predictions_seasonal = model_seasonal.predict(X_test_seasonal)
```

In [64]:

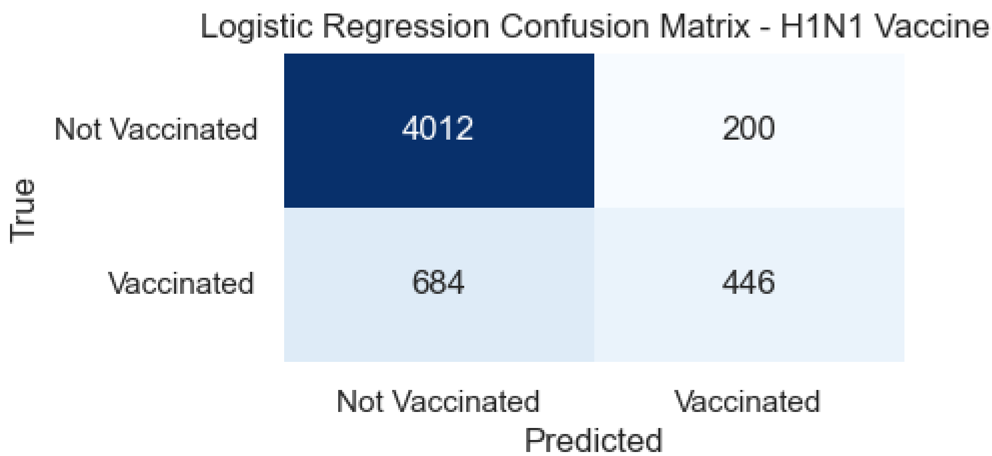
```
# Evaluate the model for H1N1 vaccine
print("H1N1 Vaccine Model Evaluation:")
print(confusion_matrix(y_test_h1n1, predictions_h1n1))
print(classification_report(y_test_h1n1, predictions_h1n1))
print(f"Accuracy: {accuracy_score(y_test_h1n1, predictions_h1n1)}\n")
```

```
H1N1 Vaccine Model Evaluation:
[[4012  200]
 [ 684  446]]
              precision    recall  f1-score   support

           0       0.85      0.95      0.90      4212
           1       0.69      0.39      0.50      1130
```

```
    accuracy                           0.83      5342
   macro avg       0.77      0.67      0.70      5342
weighted avg       0.82      0.83      0.82      5342

Accuracy: 0.8345189067764882
```

In [66]:
```python
# Create confusion matrix for H1N1 vaccine
confusionmatrix_h1n1 = confusion_matrix(y_test_h1n1, predictions_h1n1)
```

In [68]:
```python
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(confusionmatrix_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Logistic Regression Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



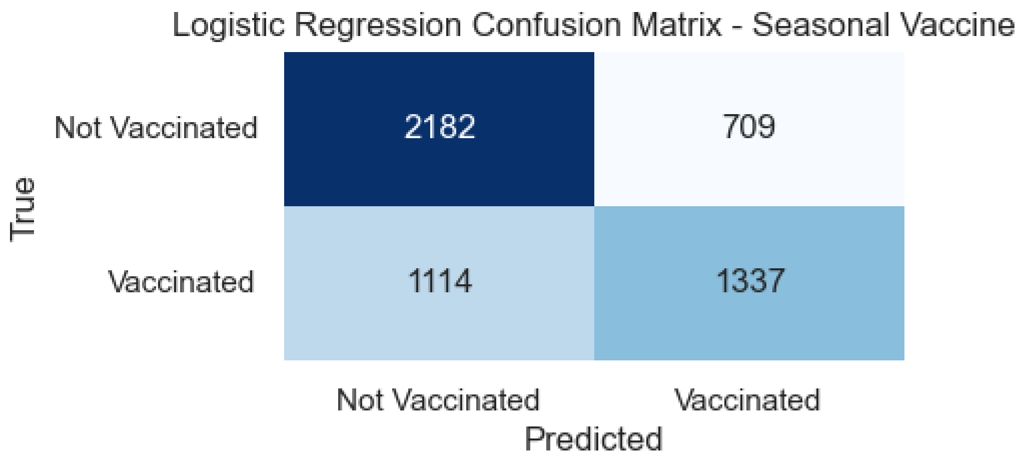
In [69]:
```python
# Evaluate the model for seasonal vaccine
print("Seasonal Vaccine Model Evaluation:")
print(confusion_matrix(y_test_seasonal, predictions_seasonal))
print(classification_report(y_test_seasonal, predictions_seasonal))
print(f"Accuracy: {accuracy_score(y_test_seasonal, predictions_seasonal)}")
```

```
Seasonal Vaccine Model Evaluation:
[[2182  709]
 [1114 1337]]
              precision    recall  f1-score   support

           0       0.66      0.75      0.71      2891
           1       0.65      0.55      0.59      2451

    accuracy                           0.66      5342
   macro avg       0.66      0.65      0.65      5342
weighted avg       0.66      0.66      0.65      5342

Accuracy: 0.6587420441782104
```

In [70]:
```python
# Create confusion matrix for seasonal vaccine
confusionmatrix_seasonal = confusion_matrix(y_test_seasonal, predictions_seasonal)
```

In [71]:
```python
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(confusionmatrix_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
```

```python
plt.title('Logistic Regression Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



Random Tree Forest

In [72]:

```python
# Create and train Random Forest models for H1N1 and seasonal vaccines
rf_h1n1 = RandomForestClassifier(random_state=42)
rf_seasonal = RandomForestClassifier(random_state=42)
```

In [73]:

```python
# Hyperparameter tuning using GridSearchCV
param_grid = {
    'n_estimators': [50, 100, 150],
    'max_depth': [None, 10, 20, 30],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}
```

In [74]:

```python
grid_search_h1n1 = GridSearchCV(rf_h1n1, param_grid, cv=5, scoring='accuracy')
grid_search_seasonal = GridSearchCV(rf_seasonal, param_grid, cv=5, scoring='accuracy')
```

In [75]:

```python
grid_search_h1n1.fit(X_train_h1n1, y_train_h1n1)
grid_search_seasonal.fit(X_train_seasonal, y_train_seasonal)
```

Out[75]:

```
▸ GridSearchCV
▸ estimator: RandomForestClassifier
    ▸ RandomForestClassifier
```

In [76]:

```python
# Get the best models from the grid search
best_rf_h1n1 = grid_search_h1n1.best_estimator_
best_rf_seasonal = grid_search_seasonal.best_estimator_
```

In [77]:

```python
# Make predictions for H1N1 vaccine
rf_predictions_h1n1 = best_rf_h1n1.predict(X_test_h1n1)
```

In [78]:

```python
# Make predictions for seasonal vaccine
rf_predictions_seasonal = best_rf_seasonal.predict(X_test_seasonal)
```

In [79]:

```python
# Evaluate the model for H1N1 vaccine
print("H1N1 Vaccine Model Evaluation:")
print(confusion_matrix(y_test_h1n1, rf_predictions_h1n1))
```

```
print(classification_report(y_test_h1n1, rf_predictions_h1n1))
print(f"Accuracy: {accuracy_score(y_test_h1n1, rf_predictions_h1n1)}\n")
```

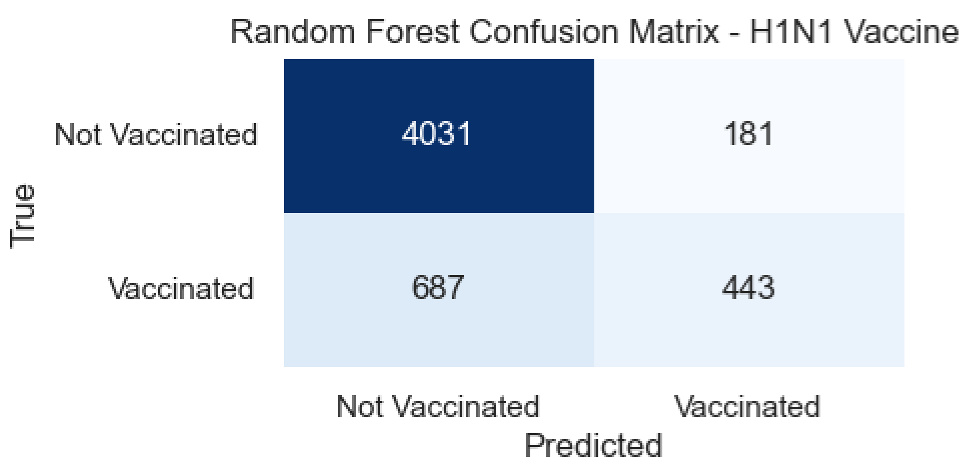
```
H1N1 Vaccine Model Evaluation:
[[4031  181]
 [ 687  443]]
              precision    recall  f1-score   support

           0       0.85      0.96      0.90      4212
           1       0.71      0.39      0.51      1130

    accuracy                           0.84      5342
   macro avg       0.78      0.67      0.70      5342
weighted avg       0.82      0.84      0.82      5342

Accuracy: 0.8375140396855111
```

In [80]:

```
# Create confusion matrix for H1N1 vaccine
rf_cm_h1n1 = confusion_matrix(y_test_h1n1, rf_predictions_h1n1)
```

In [81]:

```
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(rf_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Random Forest Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



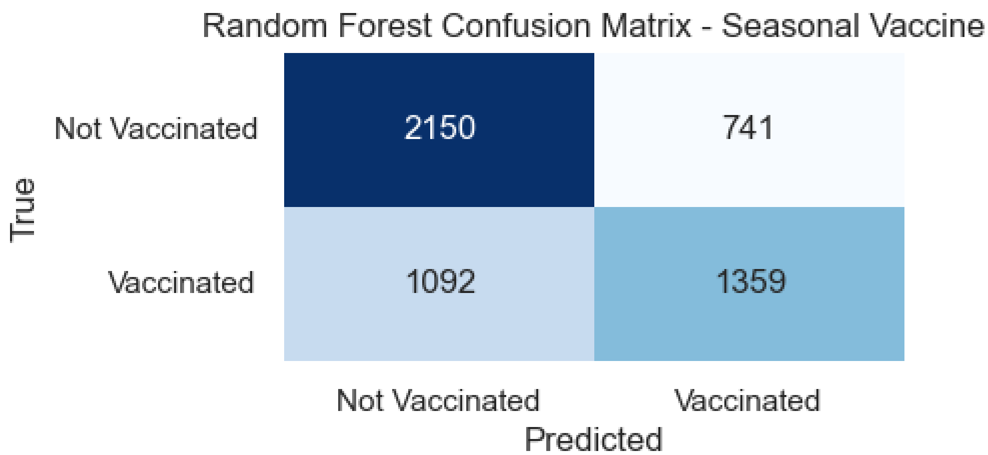
In [82]:

```
# Evaluate the model for seasonal vaccine
print("Seasonal Vaccine Model Evaluation:")
print(confusion_matrix(y_test_seasonal, rf_predictions_seasonal))
print(classification_report(y_test_seasonal, rf_predictions_seasonal))
print(f"Accuracy: {accuracy_score(y_test_seasonal, rf_predictions_seasonal)}")
```

```
Seasonal Vaccine Model Evaluation:
[[2150  741]
 [1092 1359]]
              precision    recall  f1-score   support

           0       0.66      0.74      0.70      2891
           1       0.65      0.55      0.60      2451

    accuracy                           0.66      5342
   macro avg       0.66      0.65      0.65      5342
weighted avg       0.66      0.66      0.65      5342

Accuracy: 0.6568700861100711
```

In [83]:
```
# Create confusion matrix for seasonal vaccine
rf_cm_seasonal = confusion_matrix(y_test_seasonal, rf_predictions_seasonal)
```

In [84]:
```
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(rf_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Random Forest Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



Support Vector Machines (SVM)

In [85]:
```
# Create an SVM model for H1N1 vaccine
svm_h1n1 = SVC(random_state=42)
```

In [86]:
```
# Create an SVM model for H1N1 vaccine
svm_seasonal = SVC(random_state=42)
```

In [87]:
```
# Hyperparameter tuning using GridSearchCV for H1N1 vaccine
param_grid_h1n1 = {
    'C': [0.1, 1, 10],
    'kernel': ['linear', 'rbf', 'poly'],
    'gamma': ['scale', 'auto']
}
```

In [88]:
```
# Hyperparameter tuning using GridSearchCV for Seasonal vaccine
param_grid_seasonal = {
    'C': [0.1, 1, 10],
    'kernel': ['linear', 'rbf', 'poly'],
    'gamma': ['scale', 'auto']
}
```

In [89]:
```
svm_grid_search_h1n1 = GridSearchCV(svm_h1n1, param_grid_h1n1, cv=5, scoring='accuracy')
svm_grid_search_h1n1.fit(X_train_h1n1, y_train_h1n1)
```

Out[89]:
```
▸ GridSearchCV
▸ estimator: SVC
  ▸ SVC
```

In [90]:
```python
svm_grid_search_seasonal = GridSearchCV(svm_seasonal, param_grid_seasonal, cv=5, scoring
svm_grid_search_seasonal.fit(X_train_seasonal, y_train_seasonal)
```

Out[90]:
```
▸ GridSearchCV
▸ estimator: SVC
    ▸ SVC
```

In [91]:
```python
# Get the best model from the grid search for H1N1 vaccine
best_svm_h1n1 = svm_grid_search_h1n1.best_estimator_
```

In [92]:
```python
# Get the best model from the grid search for seasonal vaccine
best_svm_seasonal = svm_grid_search_seasonal.best_estimator_
```

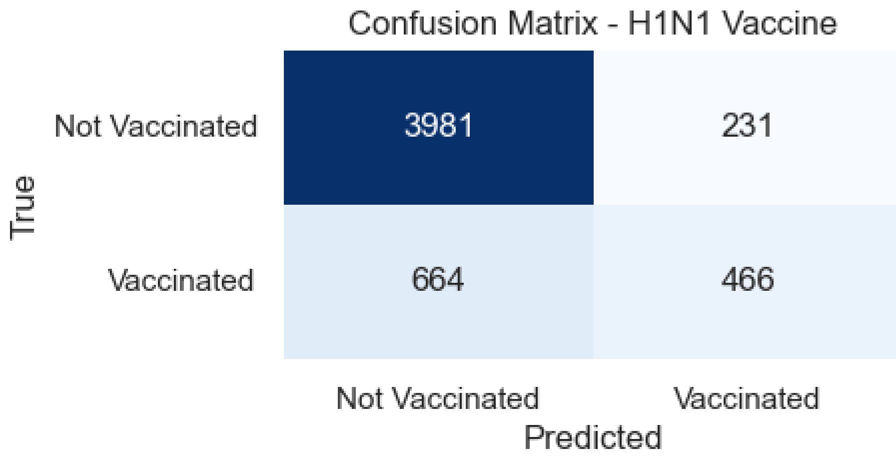
In [93]:
```python
# Make predictions for H1N1 vaccine
svm_predictions_h1n1 = best_svm_h1n1.predict(X_test_h1n1)
# Make predictions for seasonal vaccine
svm_predictions_seasonal = best_svm_seasonal.predict(X_test_seasonal)
```

In [94]:
```python
# Evaluate the model for H1N1 vaccine
print("H1N1 Vaccine Model Evaluation:")
print(confusion_matrix(y_test_h1n1, svm_predictions_h1n1))
print(classification_report(y_test_h1n1, svm_predictions_h1n1))
print(f"Accuracy: {accuracy_score(y_test_h1n1, svm_predictions_h1n1)}\n")
```

```
H1N1 Vaccine Model Evaluation:
[[3981  231]
 [ 664  466]]
              precision    recall  f1-score   support

           0       0.86      0.95      0.90      4212
           1       0.67      0.41      0.51      1130

    accuracy                           0.83      5342
   macro avg       0.76      0.68      0.70      5342
weighted avg       0.82      0.83      0.82      5342

Accuracy: 0.832459752901535
```

In [95]:
```python
# Create confusion matrix for H1N1 vaccine
svm_cm_h1n1 = confusion_matrix(y_test_h1n1, svm_predictions_h1n1)
```

In [96]:
```python
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(svm_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



In [97]:

```python
# Evaluate the model for seasonal vaccine
print("Seasonal Vaccine Model Evaluation:")
print(confusion_matrix(y_test_seasonal, svm_predictions_seasonal))
print(classification_report(y_test_seasonal, svm_predictions_seasonal))
print(f"Accuracy: {accuracy_score(y_test_seasonal, svm_predictions_seasonal)}")
```

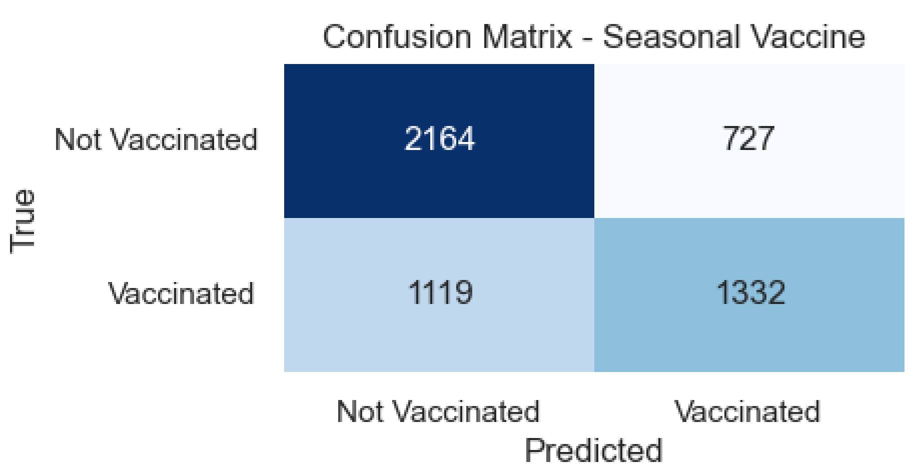
```
Seasonal Vaccine Model Evaluation:
[[2164  727]
 [1119 1332]]
              precision    recall  f1-score   support

           0       0.66      0.75      0.70      2891
           1       0.65      0.54      0.59      2451

    accuracy                           0.65      5342
   macro avg       0.65      0.65      0.65      5342
weighted avg       0.65      0.65      0.65      5342

Accuracy: 0.65443654062149
```

In [98]:

```python
# Create confusion matrix for seasonal vaccine
svm_cm_seasonal = confusion_matrix(y_test_seasonal, svm_predictions_seasonal)
```

In [99]:

```python
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(svm_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



K-NN

In [100…

```
# Create a k-NN model for H1N1 vaccine
knn_h1n1 = KNeighborsClassifier()
```

In [101…

```
# Create a k-NN model for seasonal vaccine
knn_seasonal = KNeighborsClassifier()
```

In [102…

```
# Hyperparameter tuning using GridSearchCV for H1N1 vaccine
param_grid_h1n1 = {
    'n_neighbors': [3, 5, 7, 9],
    'weights': ['uniform', 'distance'],
    'p': [1, 2]   # 1 for Manhattan distance, 2 for Euclidean distance
}
```

In [103…

```
# Hyperparameter tuning using GridSearchCV for seasonal vaccine
param_grid_seasonal = {
    'n_neighbors': [3, 5, 7, 9],
    'weights': ['uniform', 'distance'],
    'p': [1, 2]   # 1 for Manhattan distance, 2 for Euclidean distance
}
```

In [104…

```
knn_grid_search_h1n1 = GridSearchCV(knn_h1n1, param_grid_h1n1, cv=5, scoring='accuracy')
knn_grid_search_h1n1.fit(X_train_h1n1, y_train_h1n1)
```

Out[104]:

```
▸ GridSearchCV
▸ estimator: KNeighborsClassifier
    ▸ KNeighborsClassifier
```

In [105…

```
knn_grid_search_seasonal = GridSearchCV(knn_seasonal, param_grid_seasonal, cv=5, scoring
knn_grid_search_seasonal.fit(X_train_seasonal, y_train_seasonal)
```

Out[105]:

```
▸ GridSearchCV
▸ estimator: KNeighborsClassifier
    ▸ KNeighborsClassifier
```

In [106…

```
# Get the best model from the grid search for H1N1 vaccine
best_knn_h1n1 = knn_grid_search_h1n1.best_estimator_
```

In [107…

```
# Get the best model from the grid search for seasonal vaccine
best_knn_seasonal = knn_grid_search_seasonal.best_estimator_
```

In [108…

```
# Make predictions for H1N1 vaccine
knn_predictions_h1n1 = best_knn_h1n1.predict(X_test_h1n1)
```

In [109…

```
# Make predictions for seasonal vaccine
knn_predictions_seasonal = best_knn_seasonal.predict(X_test_seasonal)
```

In [110…

```
# Evaluate the model for H1N1 vaccine
print("H1N1 Vaccine Model Evaluation:")
print(confusion_matrix(y_test_h1n1, knn_predictions_h1n1))
print(classification_report(y_test_h1n1, knn_predictions_h1n1))
print(f"Accuracy: {accuracy_score(y_test_h1n1, knn_predictions_h1n1)}\n")
```

```
H1N1 Vaccine Model Evaluation:
```

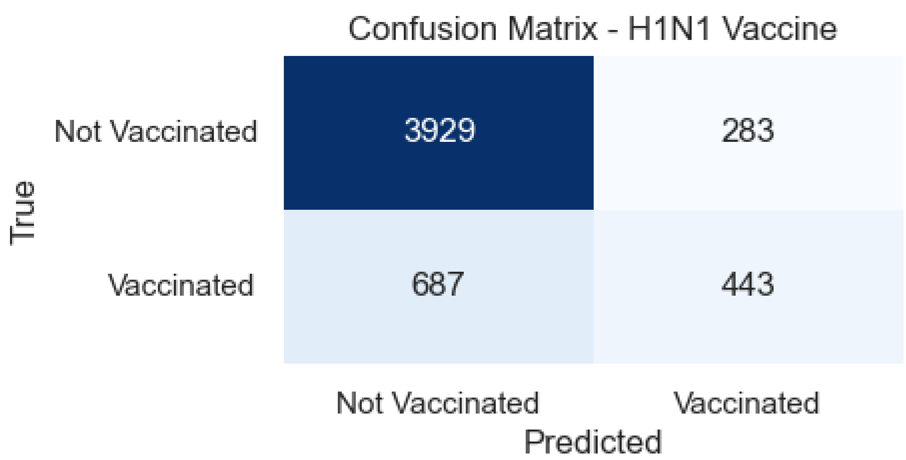
```
[[3929  283]
 [ 687  443]]
              precision    recall  f1-score   support

           0       0.85      0.93      0.89      4212
           1       0.61      0.39      0.48      1130

    accuracy                           0.82      5342
   macro avg       0.73      0.66      0.68      5342
weighted avg       0.80      0.82      0.80      5342

Accuracy: 0.8184200673904904
```

In [111…

```python
# Create confusion matrix for H1N1 vaccine
knn_cm_h1n1 = confusion_matrix(y_test_h1n1, knn_predictions_h1n1)

# Create confusion matrix for seasonal vaccine
knn_cm_seasonal = confusion_matrix(y_test_seasonal, knn_predictions_seasonal)
```

In [112…

```python
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(knn_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```

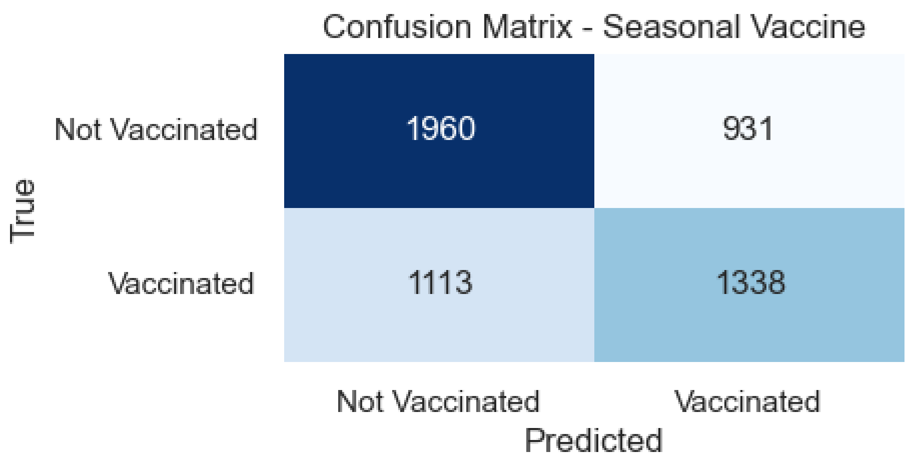


In [113…

```python
# Evaluate the model for seasonal vaccine
print("Seasonal Vaccine Model Evaluation:")
print(confusion_matrix(y_test_seasonal, predictions_seasonal))
print(classification_report(y_test_seasonal, predictions_seasonal))
print(f"Accuracy: {accuracy_score(y_test_seasonal, predictions_seasonal)}")
```

```
Seasonal Vaccine Model Evaluation:
[[2182  709]
 [1114 1337]]
              precision    recall  f1-score   support

           0       0.66      0.75      0.71      2891
           1       0.65      0.55      0.59      2451

    accuracy                           0.66      5342
   macro avg       0.66      0.65      0.65      5342
weighted avg       0.66      0.66      0.65      5342

Accuracy: 0.6587420441782104
```

In [114…
```python
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(knn_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



Naive Bayes

In [115…
```python
# Create a Gaussian Naive Bayes model for H1N1 vaccine
nb_h1n1 = GaussianNB()
```

In [116…
```python
# Create a Gaussian Naive Bayes model for seasonal vaccine
nb_seasonal = GaussianNB()
```

In [117…
```python
# Fit the model for H1N1 vaccine
nb_h1n1.fit(X_train_h1n1, y_train_h1n1)
```

Out[117]:
```
▾ GaussianNB
GaussianNB()
```

In [118…
```python
# Fit the model for seasonal vaccine
nb_seasonal.fit(X_train_seasonal, y_train_seasonal)
```

Out[118]:
```
▾ GaussianNB
GaussianNB()
```

In [119…
```python
# Make predictions for H1N1 vaccine
nb_predictions_h1n1 = nb_h1n1.predict(X_test_h1n1)
```

In [120…
```python
# Make predictions for seasonal vaccine
nb_predictions_seasonal = nb_seasonal.predict(X_test_seasonal)
```

In [121…
```python
# Evaluate the model for H1N1 vaccine
print("H1N1 Vaccine Model Evaluation:")
print(confusion_matrix(y_test_h1n1, nb_predictions_h1n1))
print(classification_report(y_test_h1n1, nb_predictions_h1n1))
print(f"Accuracy: {accuracy_score(y_test_h1n1, nb_predictions_h1n1)}\n")
```

```
H1N1 Vaccine Model Evaluation:
```

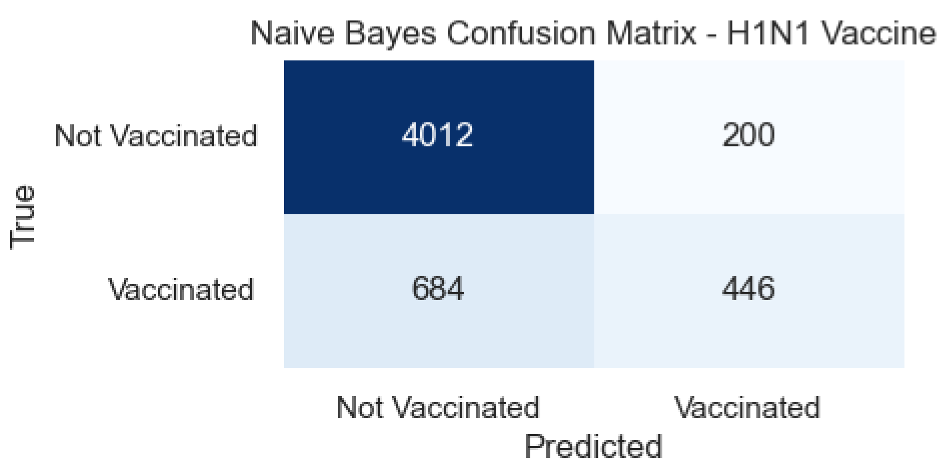
```
[[3496  716]
 [ 481  649]]
              precision    recall  f1-score   support

           0       0.88      0.83      0.85      4212
           1       0.48      0.57      0.52      1130

    accuracy                           0.78      5342
   macro avg       0.68      0.70      0.69      5342
weighted avg       0.79      0.78      0.78      5342

Accuracy: 0.775926619243729
```

In [122…

```
# Create confusion matrix for H1N1 vaccine
nb_cm_h1n1 = confusion_matrix(y_test_h1n1, predictions_h1n1)
```

In [123…

```
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(nb_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Naive Bayes Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



In [124…

```
# Evaluate the model for seasonal vaccine
print("Seasonal Vaccine Model Evaluation:")
print(confusion_matrix(y_test_seasonal, predictions_seasonal))
print(classification_report(y_test_seasonal, predictions_seasonal))
print(f"Accuracy: {accuracy_score(y_test_seasonal, predictions_seasonal)}")
```

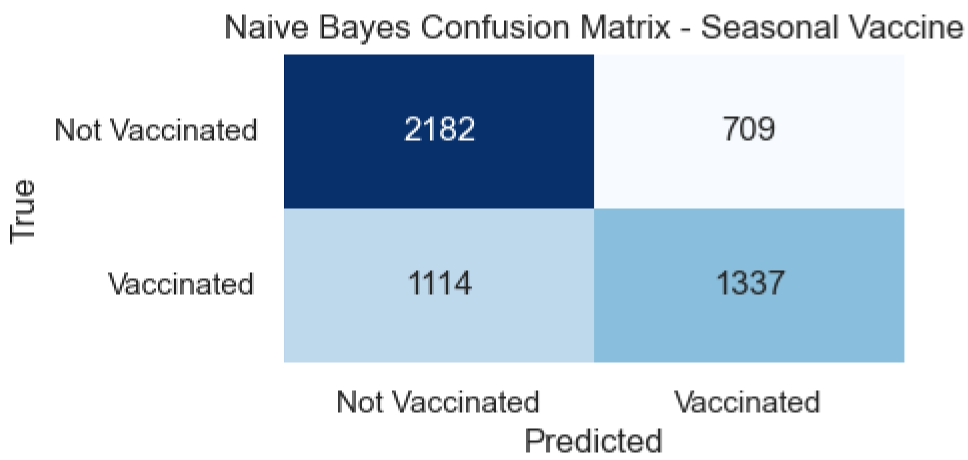
```
Seasonal Vaccine Model Evaluation:
[[2182  709]
 [1114 1337]]
              precision    recall  f1-score   support

           0       0.66      0.75      0.71      2891
           1       0.65      0.55      0.59      2451

    accuracy                           0.66      5342
   macro avg       0.66      0.65      0.65      5342
weighted avg       0.66      0.66      0.65      5342

Accuracy: 0.6587420441782104
```

In [125…

```
# Create confusion matrix for seasonal vaccine
nb_cm_seasonal = confusion_matrix(y_test_seasonal, predictions_seasonal)
```

In [126…

```python
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(nb_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Naive Bayes Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



Ensemble Models

Gradient Boosting

Gradient Boosting Machine (GBM)

In [127…

```python
# Create a Gradient Boosting Classifier for H1N1 vaccine
gbm_h1n1 = GradientBoostingClassifier(random_state=42)
```

In [128…

```python
# Create a Gradient Boosting Classifier for H1N1 vaccine
gbm_seasonal = GradientBoostingClassifier(random_state=42)
```

In [129…

```python
# Hyperparameter tuning using GridSearchCV for H1N1 vaccine
param_grid_h1n1 = {
    'n_estimators': [50, 100, 150],
    'learning_rate': [0.01, 0.1, 0.2],
    'max_depth': [3, 4, 5],
    'subsample': [0.8, 0.9, 1.0],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}
```

In [130…

```python
# Hyperparameter tuning using GridSearchCV for H1N1 vaccine
param_grid_seasonal = {
    'n_estimators': [50, 100, 150],
    'learning_rate': [0.01, 0.1, 0.2],
    'max_depth': [3, 4, 5],
    'subsample': [0.8, 0.9, 1.0],
    'min_samples_split': [2, 5, 10],
    'min_samples_leaf': [1, 2, 4]
}
```

In [131…

```python
gbm_grid_search_h1n1 = GridSearchCV(gbm_h1n1, param_grid_h1n1, cv=5, scoring='accuracy')
gbm_grid_search_h1n1.fit(X_train_h1n1, y_train_h1n1)
```

Out[131]:

```
▸ GridSearchCV
▸ estimator: GradientBoostingClassifier
  ▸ GradientBoostingClassifier
```

In [132…

```
gbm_grid_search_seasonal = GridSearchCV(gbm_seasonal, param_grid_seasonal, cv=5, scoring
gbm_grid_search_seasonal.fit(X_train_seasonal, y_train_seasonal)
```

Out[132]:

```
▸ GridSearchCV
▸ estimator: GradientBoostingClassifier
  ▸ GradientBoostingClassifier
```

In [133…

```
# Get the best model from the grid search for H1N1 vaccine
best_gbm_h1n1 = gbm_grid_search_h1n1.best_estimator_
```

In [134…

```
# Get the best model from the grid search for seasonal vaccine
best_gbm_seasonal = gbm_grid_search_seasonal.best_estimator_
```

In [135…

```
# Make predictions for H1N1 vaccine
gbm_predictions_h1n1 = best_gbm_h1n1.predict(X_test_h1n1)
```

In [137…

```
# Make predictions for seasonal vaccine
gbm_predictions_seasonal = best_gbm_seasonal.predict(X_test_seasonal)
```

In [138…

```
# Evaluate the model for H1N1 vaccine
print("H1N1 Vaccine Model Evaluation:")
print(confusion_matrix(y_test_h1n1, gbm_predictions_h1n1))
print(classification_report(y_test_h1n1, gbm_predictions_h1n1))
print(f"Accuracy: {accuracy_score(y_test_h1n1, gbm_predictions_h1n1)}\n")
```

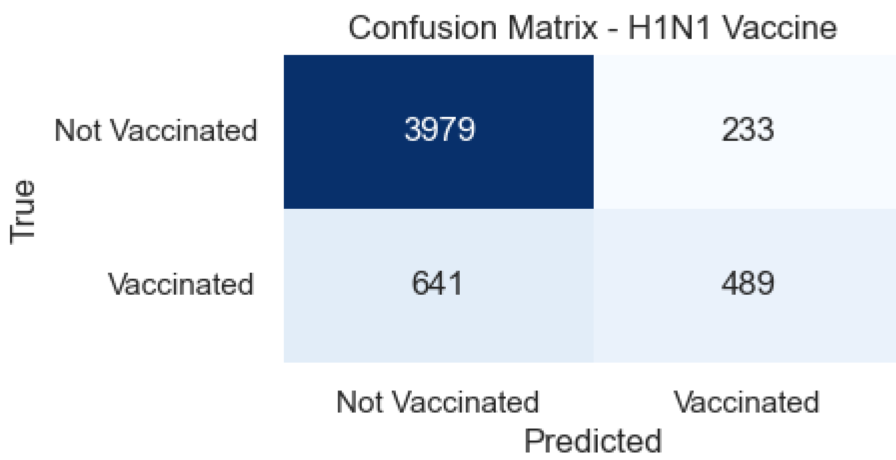
```
H1N1 Vaccine Model Evaluation:
[[3979  233]
 [ 641  489]]
              precision    recall  f1-score   support

           0       0.86      0.94      0.90      4212
           1       0.68      0.43      0.53      1130

    accuracy                           0.84      5342
   macro avg       0.77      0.69      0.71      5342
weighted avg       0.82      0.84      0.82      5342

Accuracy: 0.8363908648446274
```

In [139…

```
# Create confusion matrix for H1N1 vaccine
gbm_cm_h1n1 = confusion_matrix(y_test_h1n1, gbm_predictions_h1n1)
```

In [140…

```
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(gbm_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



In [141…

```
# Evaluate the model for seasonal vaccine
print("Seasonal Vaccine Model Evaluation:")
print(confusion_matrix(y_test_seasonal, predictions_seasonal))
print(classification_report(y_test_seasonal, predictions_seasonal))
print(f"Accuracy: {accuracy_score(y_test_seasonal, predictions_seasonal)}")
```

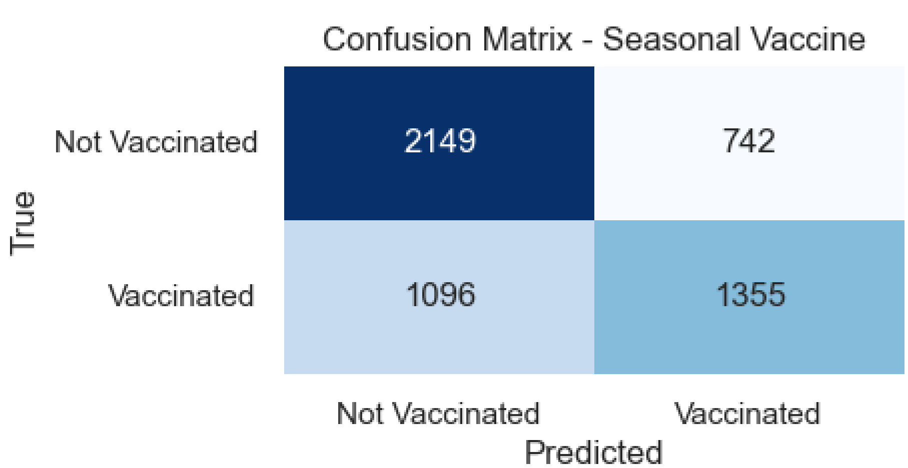
```
Seasonal Vaccine Model Evaluation:
[[2182  709]
 [1114 1337]]
              precision    recall  f1-score   support

           0       0.66      0.75      0.71      2891
           1       0.65      0.55      0.59      2451

    accuracy                           0.66      5342
   macro avg       0.66      0.65      0.65      5342
weighted avg       0.66      0.66      0.65      5342

Accuracy: 0.6587420441782104
```

In [142…

```
# Create confusion matrix for seasonal vaccine
gbm_cm_seasonal = confusion_matrix(y_test_seasonal, gbm_predictions_seasonal)
```

In [143…

```
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(gbm_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



XGBoost (Extreme Gradient Boosting)

In [144…
```
# Create a Gradient Boosting Classifier for H1N1 vaccine
xgb_h1n1 = XGBClassifier(random_state=42)
```

In [145…
```
# Create a Gradient Boosting Classifier for seasonal vaccine
xgb_seasonal = XGBClassifier(random_state=42)
```

In [146…
```
# Hyperparameter tuning using GridSearchCV for H1N1 vaccine
param_grid_h1n1 = {
    'n_estimators': [100, 150, 200],
    'learning_rate': [0.05, 0.1, 0.2],
    'max_depth': [3, 4, 5],
    'subsample': [0.8, 0.9, 1.0],
    'colsample_bytree': [0.8, 0.9, 1.0],
    'gamma': [0, 1, 5]
}
```

In [147…
```
# Hyperparameter tuning using GridSearchCV for H1N1 vaccine
param_grid_seasonal = {
    'n_estimators': [100, 150, 200],
    'learning_rate': [0.05, 0.1, 0.2],
    'max_depth': [3, 4, 5],
    'subsample': [0.8, 0.9, 1.0],
    'colsample_bytree': [0.8, 0.9, 1.0],
    'gamma': [0, 1, 5]
}
```

In [149…
```
xgb_grid_search_h1n1 = GridSearchCV(xgb_h1n1, param_grid_h1n1, cv=5, scoring='accuracy')
xgb_grid_search_h1n1.fit(X_train_h1n1, y_train_h1n1)
```

Out[149]:
```
▸ GridSearchCV
▸ estimator: XGBClassifier
  ▸ XGBClassifier
```

In [150…
```
xgb_grid_search_seasonal = GridSearchCV(xgb_seasonal, param_grid_seasonal, cv=5, scoring
xgb_grid_search_seasonal.fit(X_train_seasonal, y_train_seasonal)
```

Out[150]:
```
▸ GridSearchCV
▸ estimator: XGBClassifier
  ▸ XGBClassifier
```

In [151…
```
# Get the best model from the grid search for H1N1 vaccine
best_xgb_h1n1 = xgb_grid_search_h1n1.best_estimator_
```

In [152…
```
# Get the best model from the grid search for seasonal vaccine
best_xgb_seasonal = xgb_grid_search_seasonal.best_estimator_
```

In [153…
```
# Make predictions for H1N1 vaccine
xgb_predictions_h1n1 = best_xgb_h1n1.predict(X_test_h1n1)
```

In [154…
```
# Make predictions for seasonal vaccine
xgb_predictions_seasonal = best_xgb_seasonal.predict(X_test_seasonal)
```

In [155…
```
# Evaluate the model for H1N1 vaccine
```

```
print("H1N1 Vaccine Model Evaluation:")
print(confusion_matrix(y_test_h1n1, xgb_predictions_h1n1))
print(classification_report(y_test_h1n1, xgb_predictions_h1n1))
print(f"Accuracy: {accuracy_score(y_test_h1n1, xgb_predictions_h1n1)}\n")
```

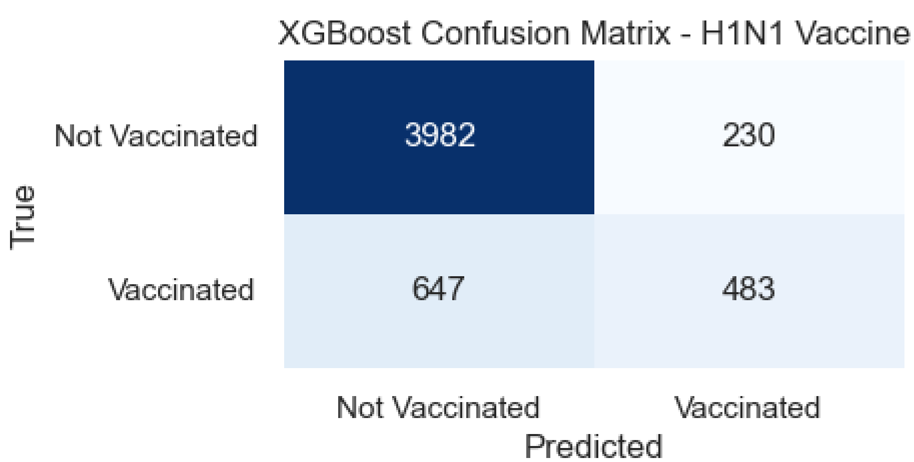
```
H1N1 Vaccine Model Evaluation:
[[3982  230]
 [ 647  483]]
              precision    recall  f1-score   support

           0       0.86      0.95      0.90      4212
           1       0.68      0.43      0.52      1130

    accuracy                           0.84      5342
   macro avg       0.77      0.69      0.71      5342
weighted avg       0.82      0.84      0.82      5342

Accuracy: 0.8358292774241857
```

In [156…

```
# Create confusion matrix for H1N1 vaccine
xgb_cm_h1n1 = confusion_matrix(y_test_h1n1, xgb_predictions_h1n1)
```

In [157…

```
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(xgb_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('XGBoost Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



In [158…

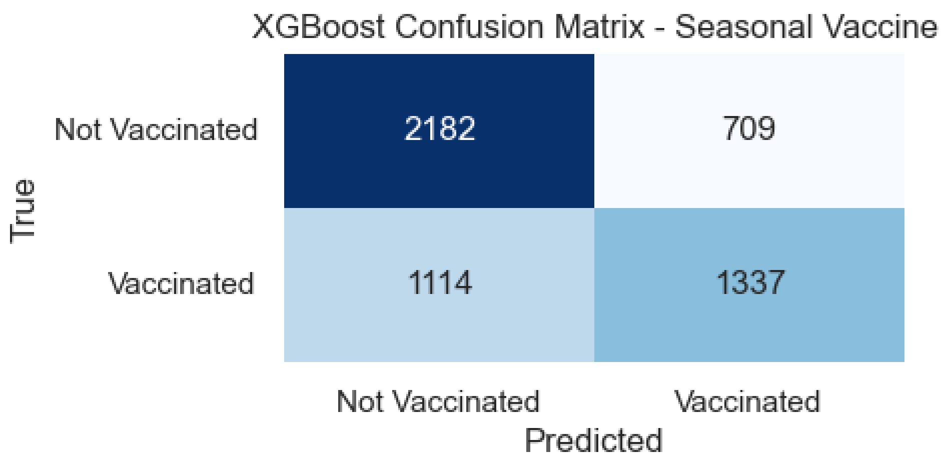
```
# Evaluate the model for seasonal vaccine
print("Seasonal Vaccine Model Evaluation:")
print(confusion_matrix(y_test_seasonal, predictions_seasonal))
print(classification_report(y_test_seasonal, predictions_seasonal))
print(f"Accuracy: {accuracy_score(y_test_seasonal, predictions_seasonal)}")
```

```
Seasonal Vaccine Model Evaluation:
[[2182  709]
 [1114 1337]]
              precision    recall  f1-score   support

           0       0.66      0.75      0.71      2891
           1       0.65      0.55      0.59      2451

    accuracy                           0.66      5342
   macro avg       0.66      0.65      0.65      5342
weighted avg       0.66      0.66      0.65      5342
```

```
Accuracy: 0.6587420441782104
```

In [159…
```python
# Create confusion matrix for seasonal vaccine
xgb_cm_seasonal = confusion_matrix(y_test_seasonal, predictions_seasonal)
```

In [160…
```python
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(xgb_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('XGBoost Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



Light GBM

In [161…
```python
# Create a LightGBM classifier for H1N1 vaccine
lgbm_h1n1 = LGBMClassifier(random_state=42)
# Create a LightGBM classifier for seasonal vaccine
lgbm_seasonal = LGBMClassifier(random_state=42)
```

In [162…
```python
# Fit the model to your training data for H1N1 vaccine
lgbm_h1n1.fit(X_train_h1n1, y_train_h1n1)
```

```
[LightGBM] [Info] Number of positive: 4544, number of negative: 16821
[LightGBM] [Info] Auto-choosing row-wise multi-threading, the overhead of testing was 0.
001098 seconds.
You can set `force_row_wise=true` to remove the overhead.
And if memory is not enough, you can set `force_col_wise=true`.
[LightGBM] [Info] Total Bins 54
[LightGBM] [Info] Number of data points in the train set: 21365, number of used feature
s: 15
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.212684 -> initscore=-1.308820
[LightGBM] [Info] Start training from score -1.308820
```

Out[162]:
```
▾ LGBMClassifier
LGBMClassifier(random_state=42)
```

In [163…
```python
# Fit the model to your training data for seasonal vaccine
lgbm_seasonal.fit(X_train_seasonal, y_train_seasonal)
```

```
[LightGBM] [Info] Number of positive: 9984, number of negative: 11381
[LightGBM] [Info] Auto-choosing row-wise multi-threading, the overhead of testing was 0.
000744 seconds.
You can set `force_row_wise=true` to remove the overhead.
```

```
And if memory is not enough, you can set `force_col_wise=true`.
[LightGBM] [Info] Total Bins 54
[LightGBM] [Info] Number of data points in the train set: 21365, number of used feature
s: 15
[LightGBM] [Info] [binary:BoostFromScore]: pavg=0.467306 -> initscore=-0.130961
[LightGBM] [Info] Start training from score -0.130961
```

Out[163]:

```
LGBMClassifier
LGBMClassifier(random_state=42)
```

In [164…

```python
# Make predictions for H1N1 vaccine
lgbm_predictions_h1n1 = lgbm_h1n1.predict(X_test_h1n1)
```

In [165…

```python
# Make predictions for seasonal vaccine
lgbm_predictions_seasonal = lgbm_seasonal.predict(X_test_seasonal)
```

In [166…

```python
# Evaluate the model for H1N1 vaccine
print("H1N1 Vaccine Model Evaluation:")
print(confusion_matrix(y_test_h1n1, lgbm_predictions_h1n1))
print(classification_report(y_test_h1n1, lgbm_predictions_h1n1))
print(f"Accuracy: {accuracy_score(y_test_h1n1, lgbm_predictions_h1n1)}\n")
```

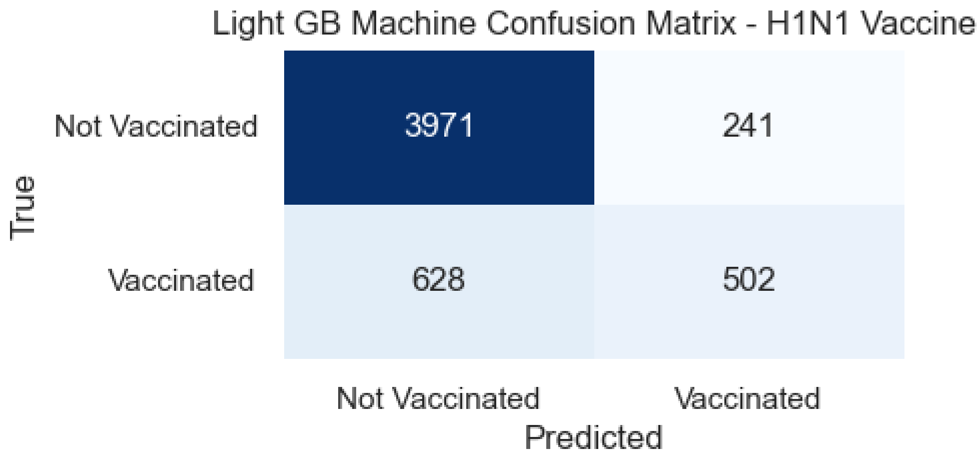
```
H1N1 Vaccine Model Evaluation:
[[3971  241]
 [ 628  502]]
              precision    recall  f1-score   support

           0       0.86      0.94      0.90      4212
           1       0.68      0.44      0.54      1130

    accuracy                           0.84      5342
   macro avg       0.77      0.69      0.72      5342
weighted avg       0.82      0.84      0.82      5342

Accuracy: 0.8373268438786972
```

In [167…

```python
# Create confusion matrix for H1N1 vaccine
lgbm_cm_h1n1 = confusion_matrix(y_test_h1n1, lgbm_predictions_h1n1)
```

In [168…

```python
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(lgbm_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Light GB Machine Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



In [169…

```
# Evaluate the model for seasonal vaccine
print("Seasonal Vaccine Model Evaluation:")
print(confusion_matrix(y_test_seasonal, lgbm_predictions_seasonal))
print(classification_report(y_test_seasonal, lgbm_predictions_seasonal))
print(f"Accuracy: {accuracy_score(y_test_seasonal, lgbm_predictions_seasonal)}")
```

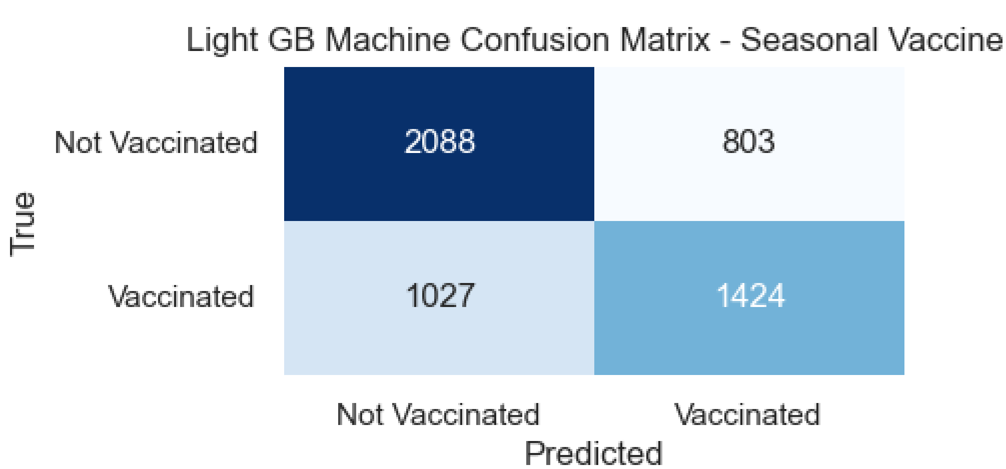
```
Seasonal Vaccine Model Evaluation:
[[2088  803]
 [1027 1424]]
              precision    recall  f1-score   support

           0       0.67      0.72      0.70      2891
           1       0.64      0.58      0.61      2451

    accuracy                           0.66      5342
   macro avg       0.65      0.65      0.65      5342
weighted avg       0.66      0.66      0.66      5342

Accuracy: 0.6574316735305129
```

In [170…

```
# Create confusion matrix for H1N1 vaccine
lgbm_cm_seasonal = confusion_matrix(y_test_seasonal, lgbm_predictions_seasonal)
```

In [171…

```
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(lgbm_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Light GB Machine Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



Ada Boost

In [172…

```
# Create an AdaBoost classifier for H1N1 vaccine
adaboost_h1n1 = AdaBoostClassifier(random_state=42)

# Create an AdaBoost classifier for seasonal vaccine
adaboost_seasonal = AdaBoostClassifier(random_state=42)
```

In [173…

```
# Fit the model to your training data for H1N1 vaccine
adaboost_h1n1.fit(X_train_h1n1, y_train_h1n1)
```

Out[173]:

```
▾ AdaBoostClassifier
AdaBoostClassifier(random_state=42)
```

In [174…

```
# Fit the model to your training data for seasonal vaccine
adaboost_seasonal.fit(X_train_seasonal, y_train_seasonal)
```

Out[174]:

```
▾ AdaBoostClassifier
AdaBoostClassifier(random_state=42)
```

In [175…

```
# Make predictions for H1N1 vaccine
adaboost_predictions_h1n1 = adaboost_h1n1.predict(X_test_h1n1)

# Make predictions for seasonal vaccine
adaboost_predictions_seasonal = adaboost_seasonal.predict(X_test_seasonal)
```

In [179…

```
# Evaluate the model for H1N1 vaccine
print("H1N1 Vaccine Model Evaluation:")
print(confusion_matrix(y_test_h1n1, adaboost_predictions_h1n1))
print(classification_report(y_test_h1n1, adaboost_predictions_h1n1))
print(f"Accuracy: {accuracy_score(y_test_h1n1, adaboost_predictions_h1n1)}\n")
```

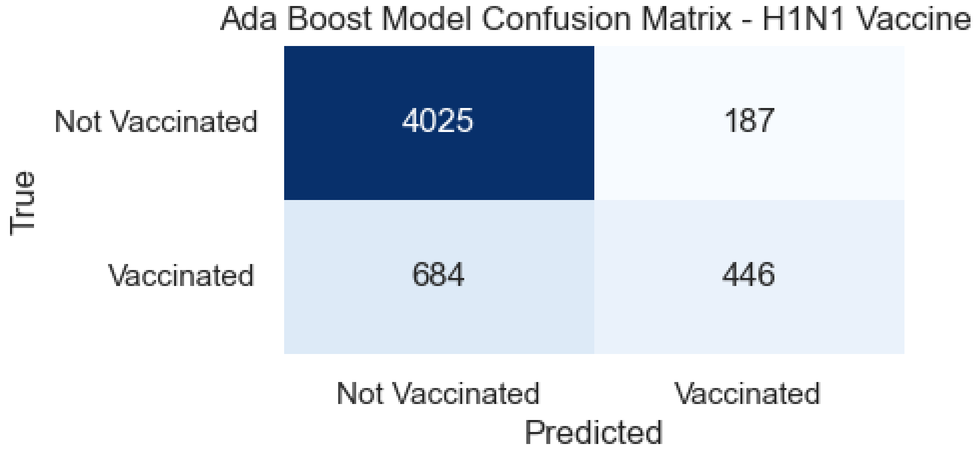
```
H1N1 Vaccine Model Evaluation:
[[4025  187]
 [ 684  446]]
              precision    recall  f1-score   support

           0       0.85      0.96      0.90      4212
           1       0.70      0.39      0.51      1130

    accuracy                           0.84      5342
   macro avg       0.78      0.68      0.70      5342
weighted avg       0.82      0.84      0.82      5342

Accuracy: 0.8369524522650693
```

In [180…

```
# Create confusion matrix for H1N1 vaccine
adaboost_cm_h1n1 = confusion_matrix(y_test_h1n1, adaboost_predictions_h1n1)
```

In [181…

```
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(adaboost_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Ada Boost Model Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



In [182…

```
# Evaluate the model for seasonal vaccine
print("Seasonal Vaccine Model Evaluation:")
print(confusion_matrix(y_test_seasonal, adaboost_predictions_seasonal))
print(classification_report(y_test_seasonal, adaboost_predictions_seasonal))
print(f"Accuracy: {accuracy_score(y_test_seasonal, adaboost_predictions_seasonal)}")
```

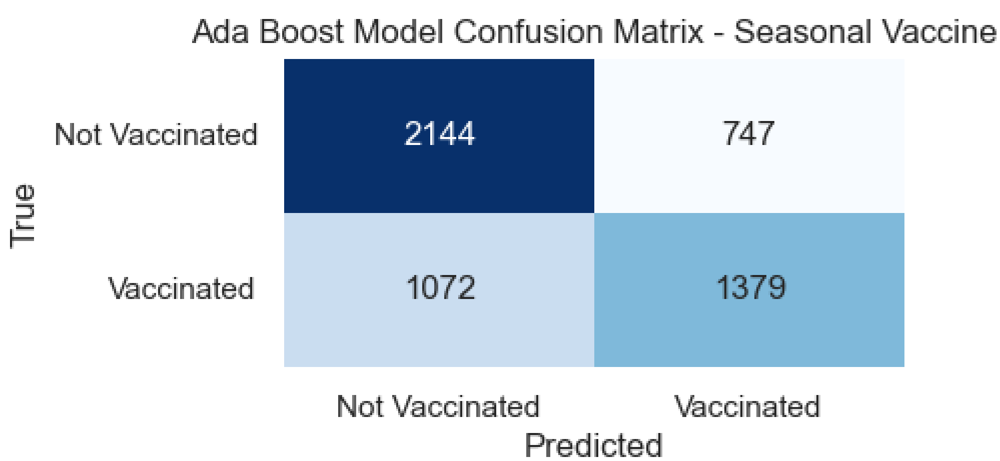
```
Seasonal Vaccine Model Evaluation:
[[2144  747]
 [1072 1379]]
              precision    recall  f1-score   support

           0       0.67      0.74      0.70      2891
           1       0.65      0.56      0.60      2451

    accuracy                           0.66      5342
   macro avg       0.66      0.65      0.65      5342
weighted avg       0.66      0.66      0.66      5342

Accuracy: 0.6594908274054662
```

In [183…

```
# Create confusion matrix for seasonal vaccine
adaboost_cm_seasonal = confusion_matrix(y_test_seasonal, adaboost_predictions_seasonal)
```

In [184…

```
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(adaboost_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Ada Boost Model Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



Neural Network

Multi-layer Perception

In [185…
```
# Create an MLP classifier for H1N1 vaccine
mlp_h1n1 = MLPClassifier(random_state=42, max_iter=5000, early_stopping=True,)

# Create an MLP classifier for seasonal vaccine
mlp_seasonal = MLPClassifier(random_state=42, max_iter=5000, early_stopping=True,)
```

In [186…
```
# Fit the model to your training data for H1N1 vaccine
mlp_h1n1.fit(X_train_h1n1, y_train_h1n1)
```

Out[186]:
```
▾ MLPClassifier
MLPClassifier(early_stopping=True, max_iter=5000, random_state=42)
```

In [187…
```
# Fit the model to your training data for seasonal vaccine
mlp_seasonal.fit(X_train_seasonal, y_train_seasonal)
```

Out[187]:
```
▾ MLPClassifier
MLPClassifier(early_stopping=True, max_iter=5000, random_state=42)
```

In [188…
```
# Make predictions for H1N1 vaccine
mlp_predictions_h1n1 = mlp_h1n1.predict(X_test_h1n1)

# Make predictions for seasonal vaccine
mlp_predictions_seasonal = mlp_seasonal.predict(X_test_seasonal)
```

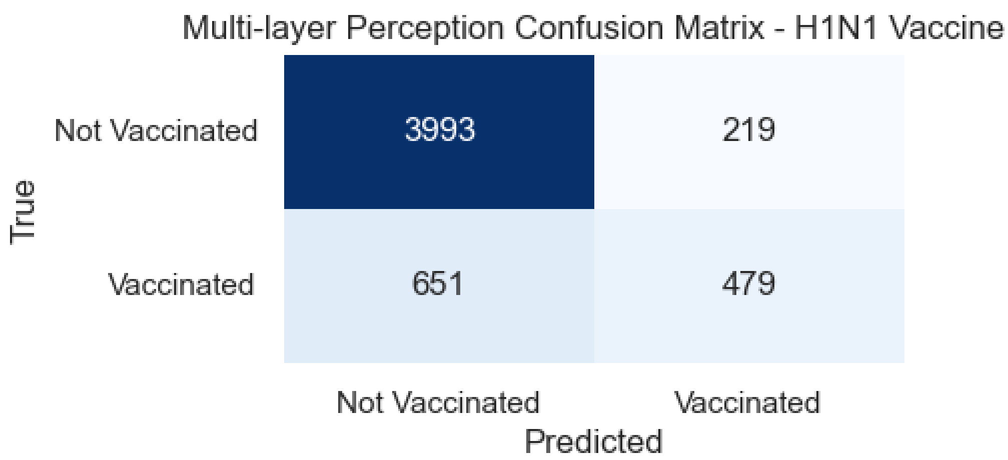
In [189…
```
# Evaluate the model for H1N1 vaccine
print("H1N1 Vaccine Model Evaluation:")
print(confusion_matrix(y_test_h1n1, mlp_predictions_h1n1))
print(classification_report(y_test_h1n1, mlp_predictions_h1n1))
print(f"Accuracy: {accuracy_score(y_test_h1n1, mlp_predictions_h1n1)}\n")
```

```
H1N1 Vaccine Model Evaluation:
[[3993  219]
 [ 651  479]]
              precision    recall  f1-score   support

           0       0.86      0.95      0.90      4212
           1       0.69      0.42      0.52      1130

    accuracy                           0.84      5342
   macro avg       0.77      0.69      0.71      5342
weighted avg       0.82      0.84      0.82      5342

Accuracy: 0.8371396480718832
```

In [190…
```
# Create confusion matrix for H1N1 vaccine
mlp_cm_h1n1 = confusion_matrix(y_test_h1n1, mlp_predictions_h1n1)
```

In [191…
```
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(mlp_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Multi-layer Perception Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
```

```
plt.ylabel('True')
plt.show()
```



In [192…

```
# Evaluate the model for seasonal vaccine
print("Seasonal Vaccine Model Evaluation:")
print(confusion_matrix(y_test_seasonal, mlp_predictions_seasonal))
print(classification_report(y_test_seasonal, mlp_predictions_seasonal))
print(f"Accuracy: {accuracy_score(y_test_seasonal, mlp_predictions_seasonal)}")
```

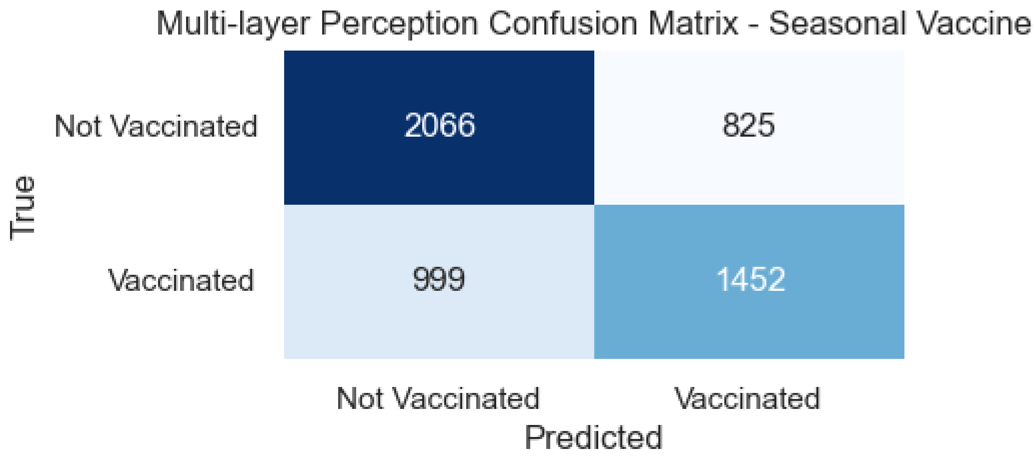
```
Seasonal Vaccine Model Evaluation:
[[2066  825]
 [ 999 1452]]
              precision    recall  f1-score   support

           0       0.67      0.71      0.69      2891
           1       0.64      0.59      0.61      2451

    accuracy                           0.66      5342
   macro avg       0.66      0.65      0.65      5342
weighted avg       0.66      0.66      0.66      5342

Accuracy: 0.6585548483713964
```

In [193…

```
# Create confusion matrix for seasonal vaccine
mlp_cm_seasonal = confusion_matrix(y_test_seasonal, mlp_predictions_seasonal)
```

In [194…

```
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(mlp_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('Multi-layer Perception Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



Convolutional Neural Network (CNN)

In [195…

```
# Reshape the data into 2D grid (number of features, 1)
cnn_X_train_h1n1 = X_train_h1n1.reshape(X_train_h1n1.shape[0], X_train_h1n1.shape[1], 1)
cnn_X_test_h1n1 = X_test_h1n1.reshape(X_test_h1n1.shape[0], X_test_h1n1.shape[1], 1)

cnn_X_train_seasonal = X_train_seasonal.reshape(X_train_seasonal.shape[0], X_train_seaso
cnn_X_test_seasonal = X_test_seasonal.reshape(X_test_seasonal.shape[0], X_test_seasonal.
```

In [202…

```
# Build a simple CNN model for H1N1 vaccine
cnn_model_h1n1 = Sequential([
    Reshape((cnn_X_train_h1n1.shape[1], 1), input_shape=(cnn_X_train_h1n1.shape[1],)),
    Dense(64, activation='relu'),
    Flatten(),
    Dense(1, activation='sigmoid')
])
```

In [203…

```
# Build a simple CNN model for seasonal vaccine
cnn_model_seasonal = Sequential([
    Reshape((cnn_X_train_seasonal.shape[1], 1), input_shape=(cnn_X_train_seasonal.shape[
    Dense(64, activation='relu'),
    Flatten(),
    Dense(1, activation='sigmoid')
])
```

In [204…

```
# Compile the model
cnn_model_h1n1.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'
```

```
WARNING:tensorflow:From C:\Users\kariu\anaconda3\Lib\site-packages\keras\src\optimizers
\__init__.py:309: The name tf.train.Optimizer is deprecated. Please use tf.compat.v1.tra
in.Optimizer instead.
```

In [205…

```
# Compile the model
cnn_model_seasonal.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accur
```

In [207…

```
# Fit the model to your training data for H1N1 vaccine
cnn_model_h1n1.fit(cnn_X_train_h1n1, y_train_h1n1, epochs=10, batch_size=32, validation_
```

```
Epoch 1/10
WARNING:tensorflow:From C:\Users\kariu\anaconda3\Lib\site-packages\keras\src\utils\tf_ut
ils.py:492: The name tf.ragged.RaggedTensorValue is deprecated. Please use tf.compat.v1.
ragged.RaggedTensorValue instead.

WARNING:tensorflow:From C:\Users\kariu\anaconda3\Lib\site-packages\keras\src\engine\base
_layer_utils.py:384: The name tf.executing_eagerly_outside_functions is deprecated. Plea
se use tf.compat.v1.executing_eagerly_outside_functions instead.
```

```
601/601 [==============================] - 1s 1ms/step - loss: 0.4162 - accuracy: 0.8213
- val_loss: 0.3904 - val_accuracy: 0.8376
Epoch 2/10
601/601 [==============================] - 1s 902us/step - loss: 0.4002 - accuracy: 0.82
91 - val_loss: 0.3881 - val_accuracy: 0.8381
Epoch 3/10
601/601 [==============================] - 1s 901us/step - loss: 0.3996 - accuracy: 0.82
82 - val_loss: 0.3905 - val_accuracy: 0.8372
Epoch 4/10
601/601 [==============================] - 1s 840us/step - loss: 0.4000 - accuracy: 0.82
87 - val_loss: 0.3893 - val_accuracy: 0.8348
Epoch 5/10
601/601 [==============================] - 1s 856us/step - loss: 0.3996 - accuracy: 0.82
79 - val_loss: 0.3890 - val_accuracy: 0.8381
Epoch 6/10
601/601 [==============================] - 1s 835us/step - loss: 0.3995 - accuracy: 0.82
86 - val_loss: 0.3980 - val_accuracy: 0.8306
Epoch 7/10
601/601 [==============================] - 0s 828us/step - loss: 0.4000 - accuracy: 0.82
94 - val_loss: 0.3898 - val_accuracy: 0.8358
Epoch 8/10
601/601 [==============================] - 0s 828us/step - loss: 0.3996 - accuracy: 0.82
83 - val_loss: 0.3914 - val_accuracy: 0.8362
Epoch 9/10
601/601 [==============================] - 1s 835us/step - loss: 0.3996 - accuracy: 0.82
78 - val_loss: 0.3887 - val_accuracy: 0.8358
Epoch 10/10
601/601 [==============================] - 1s 835us/step - loss: 0.3993 - accuracy: 0.82
85 - val_loss: 0.3892 - val_accuracy: 0.8372
```

Out[207]:

```
<keras.src.callbacks.History at 0x27a318e3a90>
```

In [208…

```python
# Fit the model to your training data for seasonal vaccine
cnn_model_seasonal.fit(cnn_X_train_seasonal, y_train_seasonal, epochs=10, batch_size=32,
```

```
Epoch 1/10
601/601 [==============================] - 1s 989us/step - loss: 0.6342 - accuracy: 0.63
99 - val_loss: 0.6249 - val_accuracy: 0.6584
Epoch 2/10
601/601 [==============================] - 0s 799us/step - loss: 0.6288 - accuracy: 0.64
91 - val_loss: 0.6309 - val_accuracy: 0.6500
Epoch 3/10
601/601 [==============================] - 1s 838us/step - loss: 0.6281 - accuracy: 0.65
08 - val_loss: 0.6228 - val_accuracy: 0.6607
Epoch 4/10
601/601 [==============================] - 1s 847us/step - loss: 0.6279 - accuracy: 0.64
98 - val_loss: 0.6237 - val_accuracy: 0.6589
Epoch 5/10
601/601 [==============================] - 1s 904us/step - loss: 0.6278 - accuracy: 0.64
90 - val_loss: 0.6236 - val_accuracy: 0.6626
Epoch 6/10
601/601 [==============================] - 1s 842us/step - loss: 0.6275 - accuracy: 0.65
00 - val_loss: 0.6223 - val_accuracy: 0.6626
Epoch 7/10
601/601 [==============================] - 0s 828us/step - loss: 0.6273 - accuracy: 0.65
20 - val_loss: 0.6237 - val_accuracy: 0.6598
Epoch 8/10
601/601 [==============================] - 1s 837us/step - loss: 0.6271 - accuracy: 0.65
25 - val_loss: 0.6260 - val_accuracy: 0.6570
Epoch 9/10
601/601 [==============================] - 0s 826us/step - loss: 0.6272 - accuracy: 0.65
23 - val_loss: 0.6230 - val_accuracy: 0.6631
Epoch 10/10
601/601 [==============================] - 1s 835us/step - loss: 0.6273 - accuracy: 0.65
08 - val_loss: 0.6307 - val_accuracy: 0.6547
```

Out[208]: <keras.src.callbacks.History at 0x27a340e7990>

In [209…
```
# Make predictions for H1N1 vaccine
cnn_predictions_h1n1 = (cnn_model_h1n1.predict(cnn_X_test_h1n1) > 0.5).astype(int)
```

```
167/167 [==============================] - 0s 742us/step
```

In [210…
```
# Make predictions for seasonal vaccine
cnn_predictions_seasonal = (cnn_model_seasonal.predict(cnn_X_test_seasonal) > 0.5).astyp
```

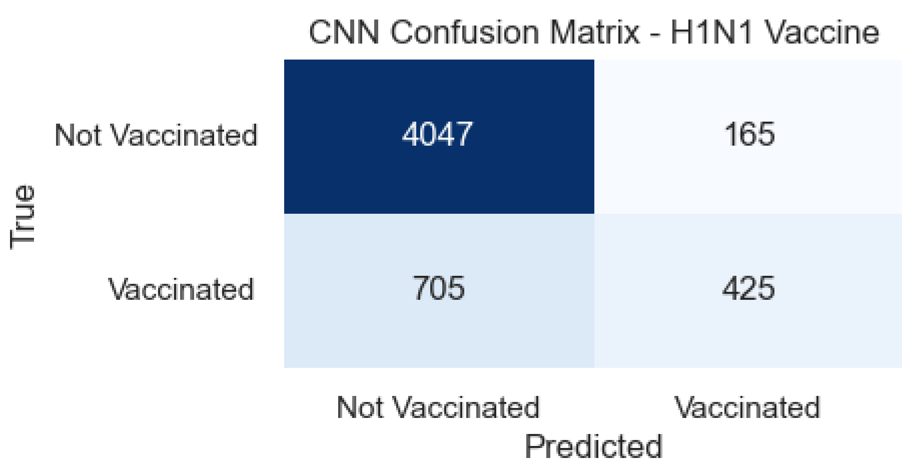
```
167/167 [==============================] - 0s 737us/step
```

In [211…
```
# Evaluate the model for H1N1 vaccine
cnn_accuracy_h1n1 = accuracy_score(y_test_h1n1, cnn_predictions_h1n1)
print(f"H1N1 Vaccine Accuracy: {cnn_accuracy_h1n1}")
```

```
H1N1 Vaccine Accuracy: 0.8371396480718832
```

In [215…
```
# Create a confusion matrix for H1N1 vaccine
cnn_cm_h1n1 = confusion_matrix(y_test_h1n1, cnn_predictions_h1n1)
```

In [216…
```
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(cnn_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('CNN Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```

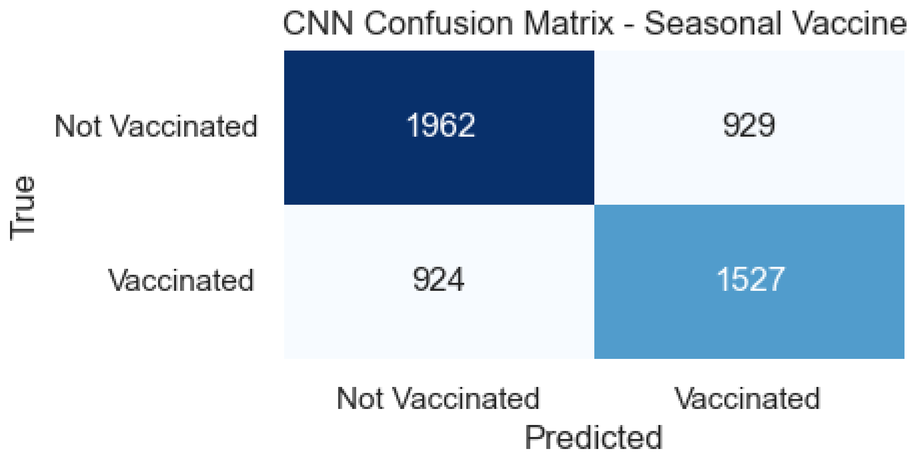


In [214…
```
# Evaluate the model for seasonal vaccine
cnn_accuracy_seasonal = accuracy_score(y_test_seasonal, cnn_predictions_seasonal)
print(f"Seasonal Vaccine Accuracy: {cnn_accuracy_seasonal}")
```

```
Seasonal Vaccine Accuracy: 0.6531261699737926
```

In [217…
```
# Create a confusion matrix for seasonal vaccine
cnn_cm_seasonal = confusion_matrix(y_test_seasonal, cnn_predictions_seasonal)
```

In [218…
```
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(cnn_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('CNN Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



Recurrent Neural Network (RNN)

In [219…
```
# Reshape the data into 3D tensor (number of samples, number of timesteps, number of fea
rnn_X_train_h1n1 = X_train_h1n1.reshape(X_train_h1n1.shape[0], 1, X_train_h1n1.shape[1])
rnn_X_test_h1n1 = X_test_h1n1.reshape(X_test_h1n1.shape[0], 1, X_test_h1n1.shape[1])


# # Build a simple RNN model for H1N1 vaccine
# model_h1n1 = Sequential([
#     SimpleRNN(32, input_shape=(X_train_h1n1.shape[1], X_train_h1n1.shape[2])),
#     Dense(1, activation='sigmoid')
# ])
```

In [220…
```
rnn_X_train_seasonal = X_train_seasonal.reshape(X_train_seasonal.shape[0], 1, X_train_se
rnn_X_test_seasonal = X_test_seasonal.reshape(X_test_seasonal.shape[0], 1, X_test_season


# # Build a simple RNN model for seasonal vaccine
# model_seasonal = Sequential([
#     SimpleRNN(32, input_shape=(X_train_seasonal.shape[1], X_train_seasonal.shape[2])),
#     Dense(1, activation='sigmoid')
# ])
```

In [225…
```
# Build a simple LSTM model for H1N1 vaccine
rnn_model_h1n1 = Sequential([
    LSTM(64, activation='relu', input_shape=(rnn_X_train_h1n1.shape[1], rnn_X_train_h1n1
    Dense(1, activation='sigmoid')
])
```

In [226…
```
# Build a simple LSTM model for seasonal vaccine
rnn_model_seasonal = Sequential([
    LSTM(64, activation='relu', input_shape=(rnn_X_train_seasonal.shape[1], rnn_X_train_
    Dense(1, activation='sigmoid')
])
```

In [227…
```
# Compile the model
rnn_model_h1n1.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accuracy'
```

In [228…
```
# Compile the model
rnn_model_seasonal.compile(optimizer='adam', loss='binary_crossentropy', metrics=['accur
```

In [230…
```
# Fit the model to your training data for H1N1 vaccine
rnn_model_h1n1.fit(rnn_X_train_h1n1, y_train_h1n1, epochs=10, batch_size=32, validation_
```

```
Epoch 1/10
601/601 [==============================] - 2s 1ms/step - loss: 0.4384 - accuracy: 0.8176
```

```
- val_loss: 0.3915 - val_accuracy: 0.8390
Epoch 2/10
601/601 [==============================] - 1s 1ms/step - loss: 0.3962 - accuracy: 0.8299
- val_loss: 0.3855 - val_accuracy: 0.8423
Epoch 3/10
601/601 [==============================] - 1s 997us/step - loss: 0.3931 - accuracy: 0.83
12 - val_loss: 0.3855 - val_accuracy: 0.8418
Epoch 4/10
601/601 [==============================] - 1s 981us/step - loss: 0.3913 - accuracy: 0.83
10 - val_loss: 0.3852 - val_accuracy: 0.8442
Epoch 5/10
601/601 [==============================] - 1s 1ms/step - loss: 0.3905 - accuracy: 0.8316
- val_loss: 0.3835 - val_accuracy: 0.8446
Epoch 6/10
601/601 [==============================] - 1s 1ms/step - loss: 0.3896 - accuracy: 0.8319
- val_loss: 0.3830 - val_accuracy: 0.8446
Epoch 7/10
601/601 [==============================] - 1s 1ms/step - loss: 0.3886 - accuracy: 0.8331
- val_loss: 0.3842 - val_accuracy: 0.8404
Epoch 8/10
601/601 [==============================] - 1s 991us/step - loss: 0.3883 - accuracy: 0.83
26 - val_loss: 0.3819 - val_accuracy: 0.8409
Epoch 9/10
601/601 [==============================] - 1s 996us/step - loss: 0.3871 - accuracy: 0.83
45 - val_loss: 0.3828 - val_accuracy: 0.8418
Epoch 10/10
601/601 [==============================] - 1s 998us/step - loss: 0.3868 - accuracy: 0.83
44 - val_loss: 0.3834 - val_accuracy: 0.8400
```

Out[230]:

```
<keras.src.callbacks.History at 0x27a338a5d90>
```

In [231…

```python
# Fit the model to your training data for seasonal vaccine
rnn_model_seasonal.fit(rnn_X_train_seasonal, y_train_seasonal, epochs=10, batch_size=32,
```

```
Epoch 1/10
601/601 [==============================] - 2s 1ms/step - loss: 0.6346 - accuracy: 0.6442
- val_loss: 0.6202 - val_accuracy: 0.6645
Epoch 2/10
601/601 [==============================] - 1s 997us/step - loss: 0.6240 - accuracy: 0.65
23 - val_loss: 0.6188 - val_accuracy: 0.6598
Epoch 3/10
601/601 [==============================] - 1s 1ms/step - loss: 0.6224 - accuracy: 0.6539
- val_loss: 0.6184 - val_accuracy: 0.6640
Epoch 4/10
601/601 [==============================] - 1s 1ms/step - loss: 0.6212 - accuracy: 0.6576
- val_loss: 0.6176 - val_accuracy: 0.6612
Epoch 5/10
601/601 [==============================] - 1s 1ms/step - loss: 0.6204 - accuracy: 0.6573
- val_loss: 0.6187 - val_accuracy: 0.6664
Epoch 6/10
601/601 [==============================] - 1s 1ms/step - loss: 0.6197 - accuracy: 0.6585
- val_loss: 0.6160 - val_accuracy: 0.6617
Epoch 7/10
601/601 [==============================] - 1s 1ms/step - loss: 0.6186 - accuracy: 0.6602
- val_loss: 0.6171 - val_accuracy: 0.6593
Epoch 8/10
601/601 [==============================] - 1s 1ms/step - loss: 0.6179 - accuracy: 0.6599
- val_loss: 0.6165 - val_accuracy: 0.6607
Epoch 9/10
601/601 [==============================] - 1s 1ms/step - loss: 0.6175 - accuracy: 0.6604
- val_loss: 0.6157 - val_accuracy: 0.6640
Epoch 10/10
601/601 [==============================] - 1s 1ms/step - loss: 0.6170 - accuracy: 0.6625
- val_loss: 0.6179 - val_accuracy: 0.6607
```

Out[231]:

```
<keras.src.callbacks.History at 0x27a2ffe0190>
```

In [232...
```python
# Make predictions for H1N1 vaccine
rnn_predictions_h1n1 = (rnn_model_h1n1.predict(rnn_X_test_h1n1) > 0.5).astype(int)
```

```
167/167 [==============================] - 0s 800us/step
```

In [233...
```python
# Make predictions for seasonal vaccine
rnn_predictions_seasonal = (rnn_model_seasonal.predict(rnn_X_test_seasonal) > 0.5).astyp
```

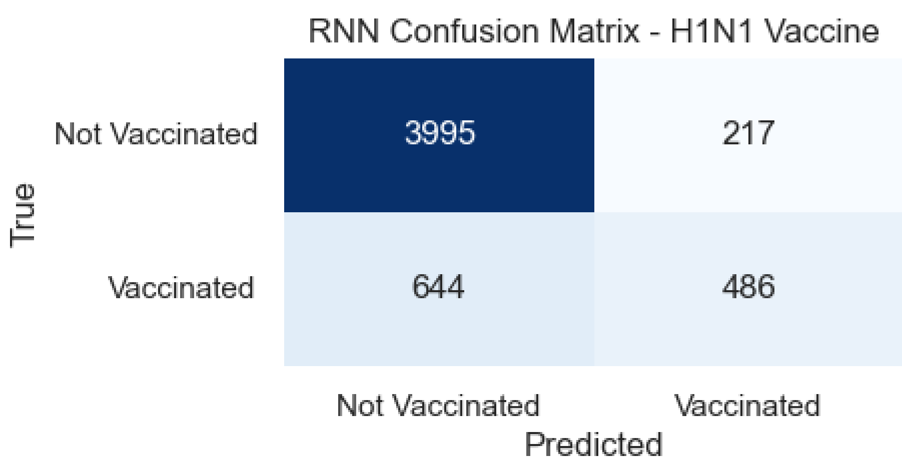
```
167/167 [==============================] - 0s 761us/step
```

In [234...
```python
# Evaluate the model for H1N1 vaccine
rnn_accuracy_h1n1 = accuracy_score(y_test_h1n1, rnn_predictions_h1n1)
print(f"H1N1 Vaccine Accuracy: {rnn_accuracy_h1n1}")
```

```
H1N1 Vaccine Accuracy: 0.8388244103332085
```

In [235...
```python
# Create a confusion matrix for H1N1 vaccine
rnn_cm_h1n1 = confusion_matrix(y_test_h1n1, rnn_predictions_h1n1)
```

In [236...
```python
# Plot confusion matrix for H1N1 vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(rnn_cm_h1n1, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('RNN Confusion Matrix - H1N1 Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```

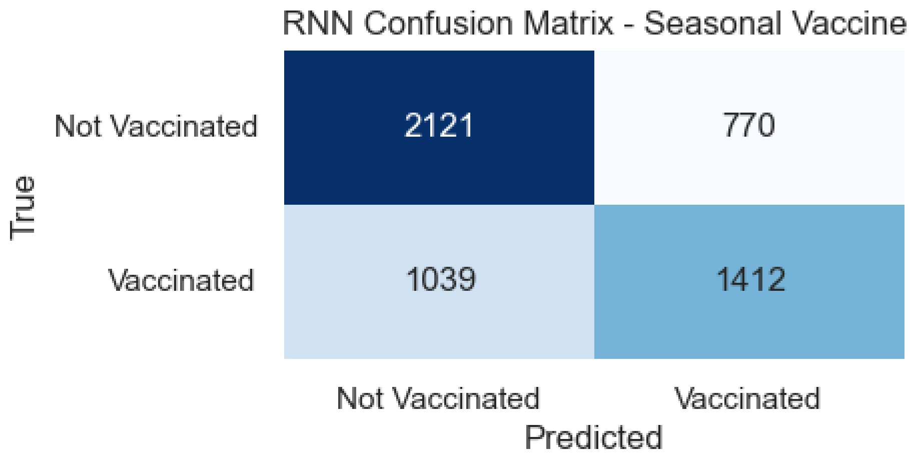


In [237...
```python
# Evaluate the model for seasonal vaccine
rnn_accuracy_seasonal = accuracy_score(y_test_seasonal, rnn_predictions_seasonal)
print(f"Seasonal Vaccine Accuracy: {rnn_accuracy_seasonal}")
```

```
Seasonal Vaccine Accuracy: 0.6613627854736054
```

In [238...
```python
# Create a confusion matrix for seasonal vaccine
rnn_cm_seasonal = confusion_matrix(y_test_seasonal, rnn_predictions_seasonal)
```

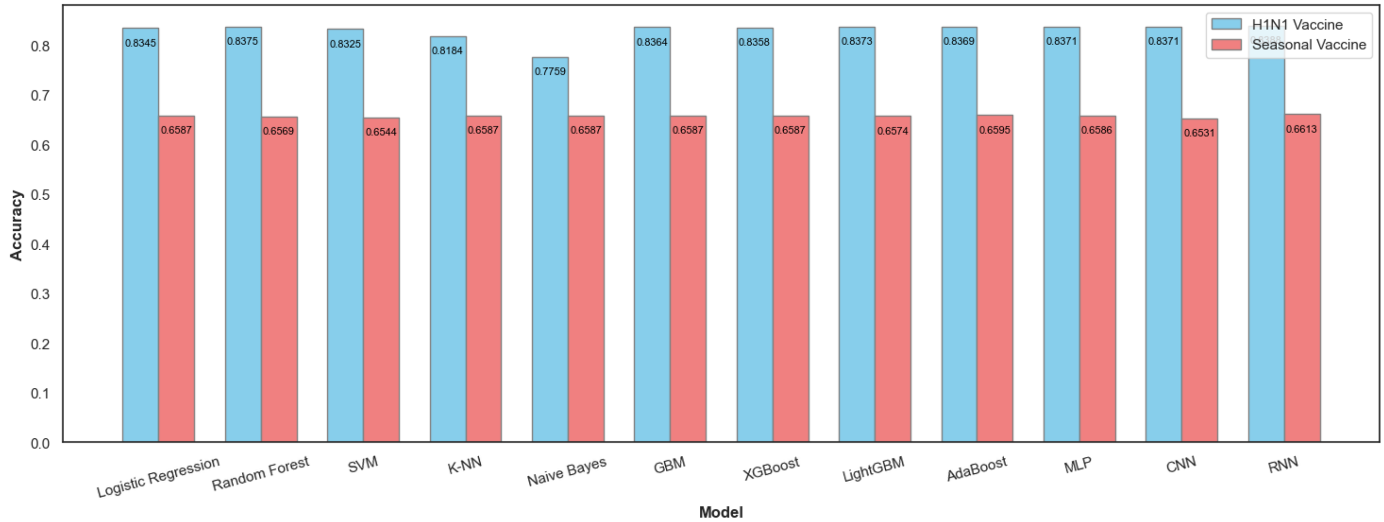
In [240...
```python
# Plot confusion matrix for seasonal vaccine
plt.figure(figsize=(4, 2))
sns.heatmap(rnn_cm_seasonal, annot=True, fmt='d', cmap='Blues', cbar=False,
            xticklabels=['Not Vaccinated', 'Vaccinated'],
            yticklabels=['Not Vaccinated', 'Vaccinated'])
plt.title('RNN Confusion Matrix - Seasonal Vaccine')
plt.xlabel('Predicted')
plt.ylabel('True')
plt.show()
```



Best Performing Model

In [269…

```
# Model names
models = ['Logistic Regression', 'Random Forest', 'SVM', 'K-NN', 'Naive Bayes', 'GBM', '

# Corresponding accuracy scores
accuracy_h1n1 = [0.8345, 0.8375, 0.8325, 0.8184, 0.7759, 0.8364, 0.8358, 0.8373, 0.8369,
accuracy_seasonal = [0.6587, 0.6569, 0.6544, 0.6587, 0.6587, 0.6587, 0.6587, 0.6574, 0.6

bar_width = 0.35

# Set positions for the bars
r1 = np.arange(len(models))
r2 = [x + bar_width for x in r1]

# Plotting
plt.figure(figsize=(18, 6))

# Bar chart for both vaccines
bars1 = plt.bar(r1, accuracy_h1n1, color='skyblue', width=bar_width, edgecolor='grey', l
bars2 = plt.bar(r2, accuracy_seasonal, color='lightcoral', width=bar_width, edgecolor='g

# Add labels
plt.xlabel('Model', fontweight='bold')
plt.xticks([r + bar_width/2 for r in range(len(models))], models, rotation=15)
plt.ylabel('Accuracy', fontweight='bold')

# Add data labels
for bar, label in zip(bars1, accuracy_h1n1):
    plt.text(bar.get_x() + bar.get_width() / 2, bar.get_height() - 0.02, f'{label:.4f}',

for bar, label in zip(bars2, accuracy_seasonal):
    plt.text(bar.get_x() + bar.get_width() / 2, bar.get_height() - 0.02, f'{label:.4f}',

plt.legend()
plt.show()
```



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