Flu Shot Learning: Predict H1N1 and Seasonal Flu Vaccines

In [3]:

```
import pandas as pd
import numpy as np
import seaborn as sb
import matplotlib.pyplot as plt
```

Data Discovery

In [36]:

```
#importing the train_features
train_var = pd.read_csv("training_set_features.csv")
train_var.head()
```

Out[36]:

	respondent_id	h1n1_concern	h1n1_knowledge	behavioral_antiviral_meds	behavioral_avoidan
0	0	1.0	0.0	0.0	
1	1	3.0	2.0	0.0	
2	2	1.0	1.0	0.0	
3	3	1.0	1.0	0.0	
4	4	2.0	1.0	0.0	

5 rows × 36 columns

In [37]:

```
#Importing the train labels
train_labels = pd.read_csv("training_set_labels.csv")
train_labels.head()
```

Out[37]:

	respondent_id	h1n1_vaccine	seasonal_vaccine
0	0	0	0
1	1	0	1
2	2	0	0
3	3	0	1
4	4	0	0

In [38]:

```
#Getting info about the data types of the features
train_var.info()
```

```
<class 'pandas.core.frame.DataFrame'>
RangeIndex: 26707 entries, 0 to 26706
Data columns (total 36 columns):
respondent_id                26707 non-null int64
h1n1_concern                 26615 non-null float64
h1n1_knowledge               26591 non-null float64
behavioral_antiviral_meds    26636 non-null float64
behavioral_avoidance         26499 non-null float64
behavioral_face_mask         26688 non-null float64
behavioral_wash_hands        26665 non-null float64
behavioral_large_gatherings  26620 non-null float64
behavioral_outside_home      26625 non-null float64
behavioral_touch_face        26579 non-null float64
doctor_recc_h1n1             24547 non-null float64
doctor_recc_seasonal         24547 non-null float64
chronic_med_condition        25736 non-null float64
child_under_6_months         25887 non-null float64
health_worker                25903 non-null float64
health_insurance             14433 non-null float64
opinion_h1n1_vacc_effective  26316 non-null float64
opinion_h1n1_risk            26319 non-null float64
opinion_h1n1_sick_from_vacc  26312 non-null float64
opinion_seas_vacc_effective  26245 non-null float64
opinion_seas_risk            26193 non-null float64
opinion_seas_sick_from_vacc  26170 non-null float64
age_group                    26707 non-null object
education                    25300 non-null object
race                         26707 non-null object
sex                          26707 non-null object
income_poverty               22284 non-null object
marital_status               25299 non-null object
rent_or_own                  24665 non-null object
employment_status            25244 non-null object
hhs_geo_region               26707 non-null object
census_msa                   26707 non-null object
household_adults             26458 non-null float64
household_children           26458 non-null float64
employment_industry          13377 non-null object
employment_occupation        13237 non-null object
dtypes: float64(23), int64(1), object(12)
memory usage: 7.3+ MB
```

In [39]:

```
#Displaying the columns
train_var.columns
```

Out[39]:

```
Index(['respondent_id', 'h1n1_concern', 'h1n1_knowledge',
       'behavioral_antiviral_meds', 'behavioral_avoidance',
       'behavioral_face_mask', 'behavioral_wash_hands',
       'behavioral_large_gatherings', 'behavioral_outside_home',
       'behavioral_touch_face', 'doctor_recc_h1n1', 'doctor_recc_seasonal',
       'chronic_med_condition', 'child_under_6_months', 'health_worker',
       'health_insurance', 'opinion_h1n1_vacc_effective', 'opinion_h1n1_ris
k',
       'opinion_h1n1_sick_from_vacc', 'opinion_seas_vacc_effective',
       'opinion_seas_risk', 'opinion_seas_sick_from_vacc', 'age_group',
       'education', 'race', 'sex', 'income_poverty', 'marital_status',
       'rent_or_own', 'employment_status', 'hhs_geo_region', 'census_msa',
       'household_adults', 'household_children', 'employment_industry',
       'employment_occupation'],
      dtype='object')
```

In [40]:

```
train_var.shape
```

Out[40]:

```
(26707, 36)
```

In [41]:

```
#Looking for NULL values, as they might require NA Imputation
train_var.isnull().sum()
```

Out[41]:

```
respondent_id                    0
h1n1_concern                    92
h1n1_knowledge                 116
behavioral_antiviral_meds       71
behavioral_avoidance           208
behavioral_face_mask            19
behavioral_wash_hands           42
behavioral_large_gatherings     87
behavioral_outside_home         82
behavioral_touch_face          128
doctor_recc_h1n1              2160
doctor_recc_seasonal          2160
chronic_med_condition          971
child_under_6_months           820
health_worker                  804
health_insurance             12274
opinion_h1n1_vacc_effective    391
opinion_h1n1_risk              388
opinion_h1n1_sick_from_vacc    395
opinion_seas_vacc_effective    462
opinion_seas_risk              514
opinion_seas_sick_from_vacc    537
age_group                        0
education                     1407
race                             0
sex                              0
income_poverty                4423
marital_status                1408
rent_or_own                   2042
employment_status             1463
hhs_geo_region                   0
census_msa                       0
household_adults               249
household_children             249
employment_industry          13330
employment_occupation        13470
dtype: int64
```

In [42]:

```
#Checking for NULL values in the labels
train_labels.isnull().sum()
```

Out[42]:

```
respondent_id       0
h1n1_vaccine        0
seasonal_vaccine    0
dtype: int64
```

In [43]:

```
train_var.shape
#therefore the dataset has 26707 respondents (rows) and 36 features (columns)
```

Out[43]:

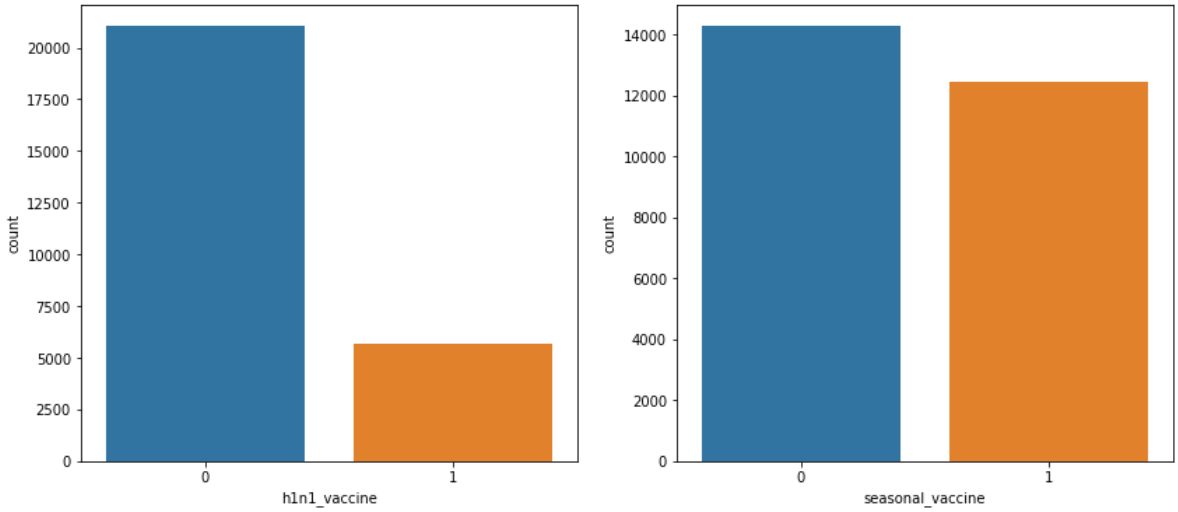
```
(26707, 36)
```

In [44]:

```
# visualising the labels
f, axes = plt.subplots(1,2 ,figsize=(14,6))
sb.countplot(x = "h1n1_vaccine", data = train_labels, ax = axes[0])
sb.countplot(x = "seasonal_vaccine", data = train_labels, ax = axes[1])
```

Out[44]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2d43ce899e8>
```



Presence of unbalanced classes, for both the labels especially h1n1_vaccine. h1n1_vaccine is in the ratio 1:4 which is highly unbalanced while seasonal vaccine is roughly in the ratio of 1:1.

In [45]:

```
#Dropping the respondent's id variable from the dataset containing the features as it is a
#provide much insights
train_var = train_var.drop(["respondent_id"], axis = 1)
```

In [46]:

```
train_var.head()
#to confirm that the respondent's id has been removed as now there are only 35 variables (c
```

Out[46]:

	h1n1_concern	h1n1_knowledge	behavioral_antiviral_meds	behavioral_avoidance	behavioral_
0	1.0	0.0	0.0	0.0	
1	3.0	2.0	0.0	1.0	
2	1.0	1.0	0.0	1.0	
3	1.0	1.0	0.0	1.0	
4	2.0	1.0	0.0	1.0	

5 rows × 35 columns

In [17]:

```
#Dropping the respondent's id from the labels dataset
train_dep = train_labels.drop(["respondent_id"], axis=1)
```

Finidng the number of people who have and have not taken the H1N1 Vaccine

In [18]:

```
#Extract the feature h1n1_vaccine from the dataset
h1n1_vaccine = train_labels["h1n1_vaccine"]
```

In [47]:

```
#A count loop that tells us the number of data points for each class for Fun!!!
#this can be replaced with df.value_counts()
count_1 = 0
count_0 = 0
for i in h1n1_vaccine:
    if i == 0:
        count_0 += 1
    elif i == 1:
        count_1 += 1
    else:
        pass
print("count_0 = ", count_0)
print("count_1 = ", count_1)
```

```
count_0 =  21033
count_1 =  5674
```

In [50]:

```
#Cross-checking for loop with df.value_counts()
h1n1_vaccine.value_counts()
```

Out[50]:

```
0    21033
1     5674
Name: h1n1_vaccine, dtype: int64
```

Finding the number of people who have and have not taken the Seasonal Flu Vaccine

In [20]:

```
#Extracting the saesonal_vaccine column from the dataset
seasonal_vaccine = train_labels["seasonal_vaccine"]
```

In [21]:

```
#A for loop to find the count of data points for each class
count_0 = 0
count_1 = 0
for i in seasonal_vaccine:
    if i == 0:
        count_0 += 1
    elif i == 1:
        count_1 += 1
    else:
        pass
print("count_0 = ",count_0)
print("count_1 = ", count_1)
```

```
count_0 =  14272
count_1 =  12435
```

In [51]:

```
seasonal_vaccine.value_counts()
```

Out[51]:

```
0    14272
1    12435
Name: seasonal_vaccine, dtype: int64
```

Exploring the Data

In [22]:

```
#To gain statistical summary for the numeric variables
train_var.describe()
```

Out[22]:

al_large_gatherings	behavioral_outside_home	behavioral_touch_face	doctor_recc_h1n1	...	health
26620.00000	26625.000000	26579.000000	24547.000000	...	2590
0.35864	0.337315	0.677264	0.220312	...	
0.47961	0.472802	0.467531	0.414466	...	
0.00000	0.000000	0.000000	0.000000	...	
0.00000	0.000000	0.000000	0.000000	...	
0.00000	0.000000	1.000000	0.000000	...	
1.00000	1.000000	1.000000	0.000000	...	
1.00000	1.000000	1.000000	1.000000	...	

H1N1 Features

1. h1n1_concern = Level of concern about the H1N1 flu.

```
    0 = Not at all concerned; 1 = Not very concerned; 2 = Somewhat concerned; 3 =
Very concerned.
```

2. h1n1_knowledge = Level of knowledge about H1N1 flu.

```
    0 = No knowledge; 1 = A little knowledge; 2 = A lot of knowledge.
```

Before exploring:

- Was expecting a strong correlation between concern and knowledge as practically, if a person is concerned about a disease it is logic for him to gain more knowledge about it from internet or other reliable sources.
- Was expecting a strong correlation between h1n1_concern and h1n1_vaccine OR h1n1_knowledge and h1n1_vaccines

However, I do acknowledge the fact that since the classes of each varaible, hln1_concern and h1n1_knowledge are different, h1n1_concern has 3 classes and h1n1_knowledge has 2 classes. Co-relation between the 2 features might not be that strong theoretically.

Finding the Relationship between h1n1_concern and h1n1_knowledge

In [52]:

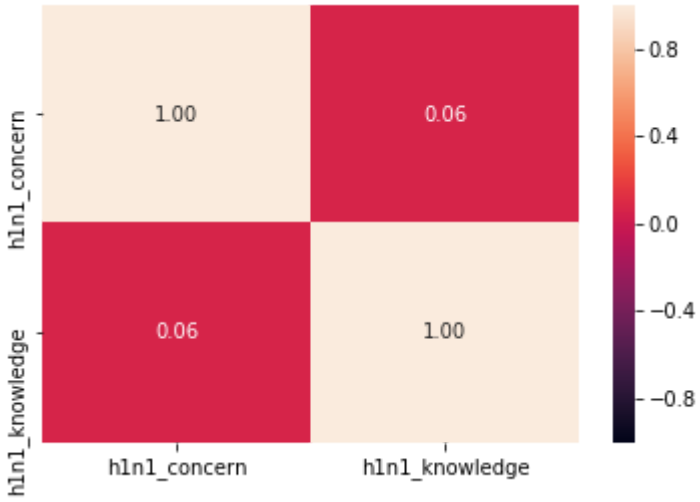
```
#Extracting the features h1n1_concern and h1n1_knowledge
h1n1 = train_var[["h1n1_concern", "h1n1_knowledge"]]
```

In [24]:

```
#To check and visualise the correlation between h1n1_concern and h1n1_knowledge
sb.heatmap(data=h1n1.corr(), vmin = -1, vmax = 1, annot = True, fmt = ".2f")
```

Out[24]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2d43b5163c8>
```



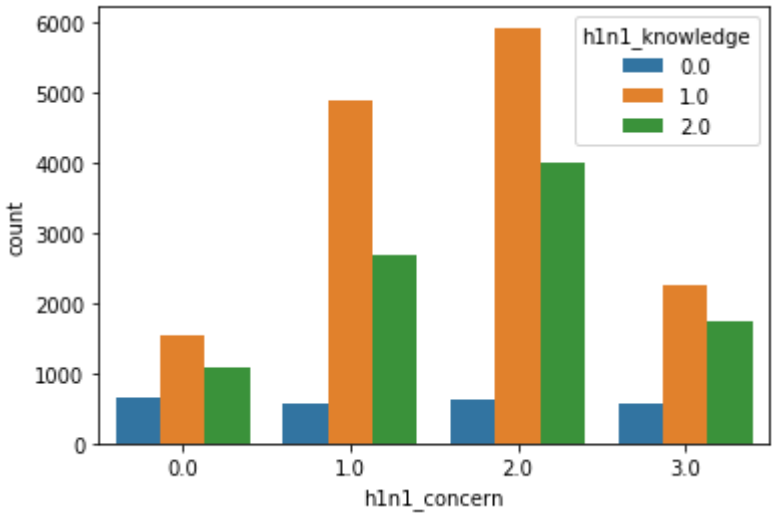
The correlation between h1n1_concern and h1n1_knowledge is 0.06, which is very low. This is different from the value expected maybe because of the fact that the number of classes of the two variables are different. Therefore, this shows us that concern is not strongly related to knowledge.

In [25]:

```
#visualising the relationship between h1n1_concern and h1n1_knowledge
sb.countplot(x='h1n1_concern', data=h1n1, hue='h1n1_knowledge')
```

Out[25]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2d43b704dd8>
```



Majority of the respondents are somewhat concerned about H1N1 (2) and have a little knowledge about H1N1 (1). With a somewhat conerned attitude and little knwoledge of the H1N1 Flu, it makes sense that not many people took the H1N1 Vaccine. This is in line with the labels, Where the number of people who have taken the H1N1 Vaccine is 5674, which is very low.

In [26]:

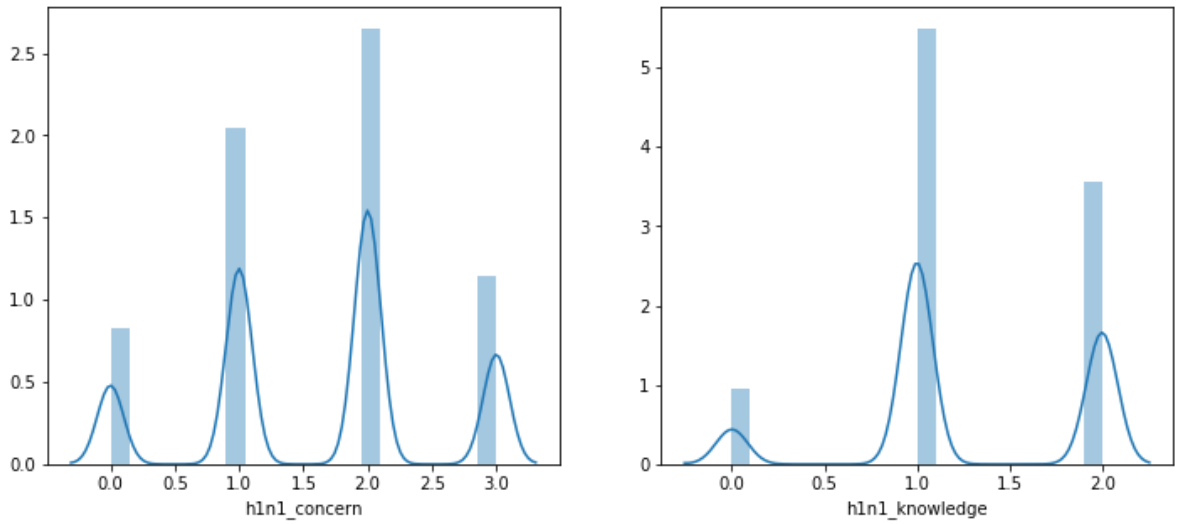
```
#Plotting Histograms to see the majority class
#Plotting KDE to see where the density lies

f, axes = plt.subplots(1,2 ,figsize=(12,5))
sb.distplot(h1n1["h1n1_concern"], bins=20,  kde=True, ax = axes[0])
sb.distplot(h1n1["h1n1_knowledge"], bins=20, kde=True, ax = axes[1])
```

```
C:\ProgramData\Anaconda3\lib\site-packages\numpy\lib\histograms.py:824: Runt
imeWarning: invalid value encountered in greater_equal
  keep = (tmp_a >= first_edge)
C:\ProgramData\Anaconda3\lib\site-packages\numpy\lib\histograms.py:825: Runt
imeWarning: invalid value encountered in less_equal
  keep &= (tmp_a <= last_edge)
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\nonparametric\kde.py:
447: RuntimeWarning: invalid value encountered in greater
  X = X[np.logical_and(X > clip[0], X < clip[1])] # won't work for two colum
ns.
C:\ProgramData\Anaconda3\lib\site-packages\statsmodels\nonparametric\kde.py:
447: RuntimeWarning: invalid value encountered in less
  X = X[np.logical_and(X > clip[0], X < clip[1])] # won't work for two colum
ns.
```

Out[26]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2d43b6834a8>
```



- Majority of the respondents are somewhat concerned about H1N1.
- Majority of the respondents have a little knowledge about H1N1.

Finding the relationship between h1n1_concern, h1n1_knowledge and h1n1_vaccine and seasonal_vaccine

In [27]:

```
#Concatenating the labels and the h1n1 features into one data frame
h1n1_labels = pd.concat([h1n1, train_dep], axis = 1)
```

In [28]:

```
h1n1_labels.head()
```

Out[28]:

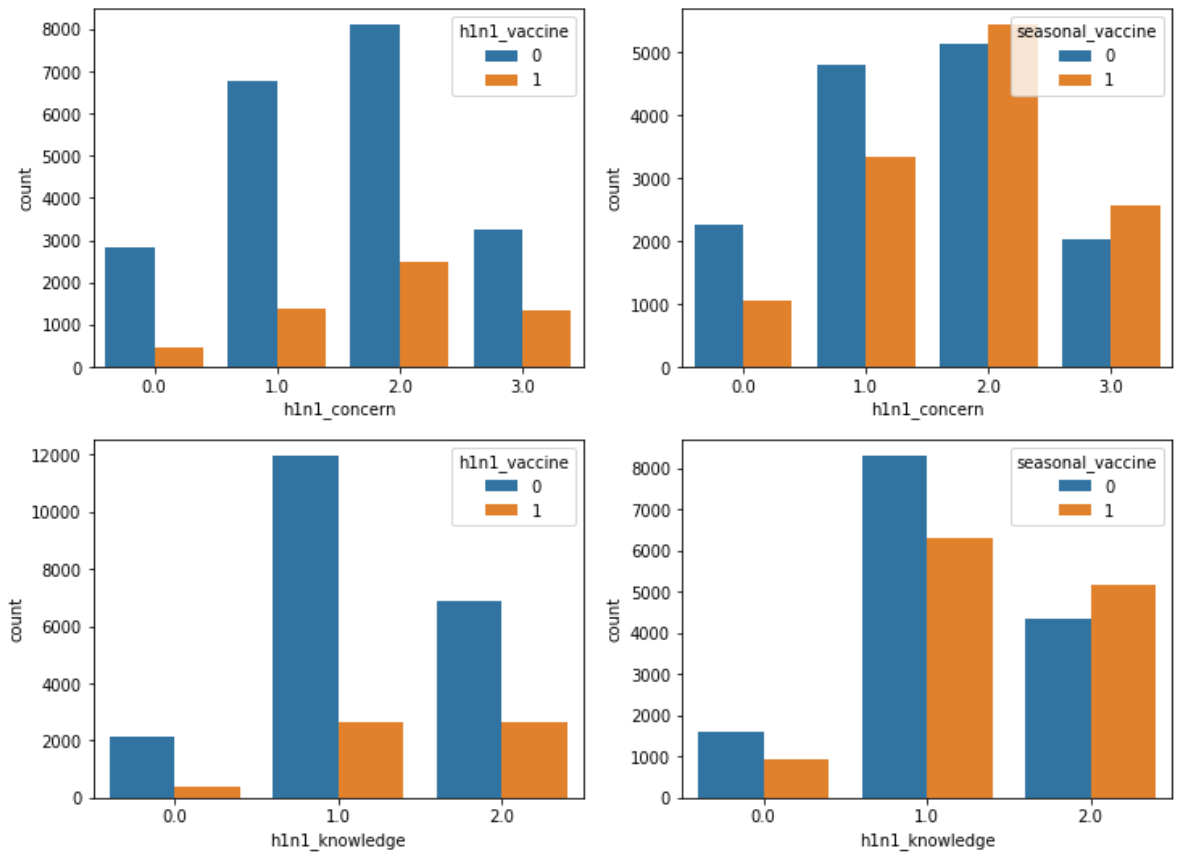
	h1n1_concern	h1n1_knowledge	h1n1_vaccine	seasonal_vaccine
0	1.0	0.0	0	0
1	3.0	2.0	0	1
2	1.0	1.0	0	0
3	1.0	1.0	0	1
4	2.0	1.0	0	0

In [29]:

```
#Visualising the relationships
f, axes = plt.subplots(2,2 ,figsize=(12,9))
sb.countplot(x='h1n1_concern', data=h1n1_labels, hue='h1n1_vaccine', ax = axes[0,0])
sb.countplot(x='h1n1_concern', data=h1n1_labels, hue='seasonal_vaccine', ax = axes[0,1])
sb.countplot(x='h1n1_knowledge', data=h1n1_labels, hue='h1n1_vaccine', ax = axes[1,0])
sb.countplot(x='h1n1_knowledge', data=h1n1_labels, hue='seasonal_vaccine', ax = axes[1,1])
```

Out[29]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2d43c610a20>
```



Graph 1 => h1n1_concern VS h1n1_vaccine

- For each category, the number of people who have not taken the H1N1 vaccine is greater than those who have taken the H1N1 Vaccine
- Despite being very concerned (3) about H1N1, the number of people who have taken the vaccine is very low around 1500.

Graph 2 => h1n1_knowledge VS h1n1_vaccine

- Most people have a little knowledge (1) about H1N1 and have not taken the H1N1 Vaccine.

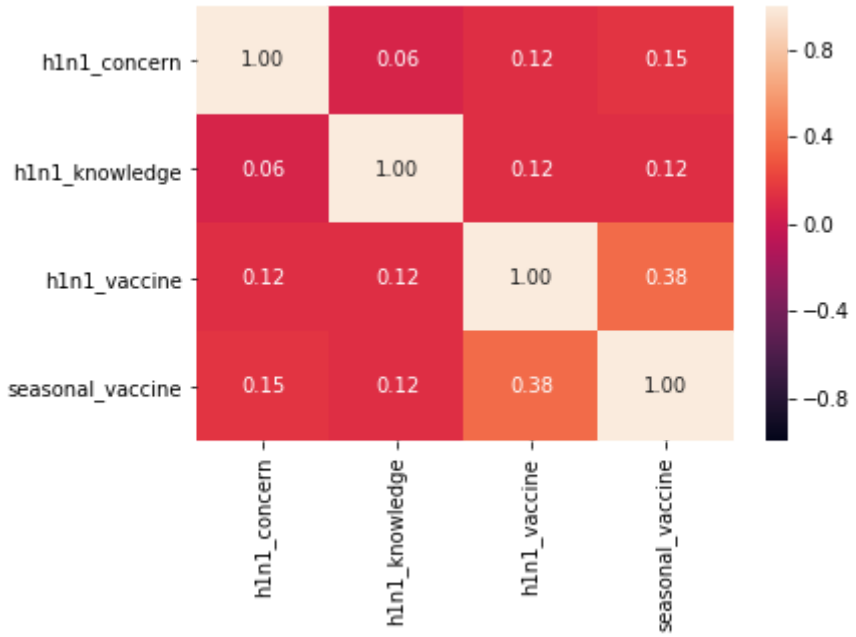
Out of the people who have taken the H1N1 Vaccine, most seem to have taken the Vaccine out of concern and not out of knowledge.

In [30]:

```
#finding the relationship between the h1n1_concern and h1n1_knowledge with h1n1_vaccine and
sb.heatmap(data=h1n1_labels.corr(), vmin = -1, vmax = 1, annot = True, fmt = ".2f")
```

Out[30]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x2d43c9a59e8>
```



h1n1_concern

Correlation between h1n1_concern and h1n1_vaccine = 0.12
Correlation between h1n1_knowledge and h1n1_vaccine = 0.12

h1n1_knowledge

Correlation between h1n1_concern and seasonal_vaccine = 0.15
Correlation between h1n1_knowledge and seasonal_vaccine = 0.12

Surprisingly, the correlation between h1n1_concern and seasonal_vaccine is stronger than h1n1_concern and h1n1_vaccine.

Behavioural Features

1. behavioral_antiviral_meds = Has taken antiviral medications. (binary)

2. behavioral_avoidance = Has avoided close contact with others with flu-like symptoms. (binary)

3. behavioral_face_mask = Has bought a face mask. (binary)

4. behavioral_wash_hands = Has frequently washed hands or used hand sanitizer. (binary)

5. behavioral_large_gatherings = Has reduced time at large gatherings. (binary)

6. behavioral_outside_home = Has reduced contact with people outside of own household. (binary)

7. behavioral_touch_face = Has avoided touching eyes, nose, or mouth. (binary)

In [29]:

```
#Extracting all the behavioural_X features
behaviour = train_var[["behavioral_antiviral_meds", "behavioral_avoidance", "behavioral_fac
```

In [30]:

```
behaviour.head()
```

Out[30]:

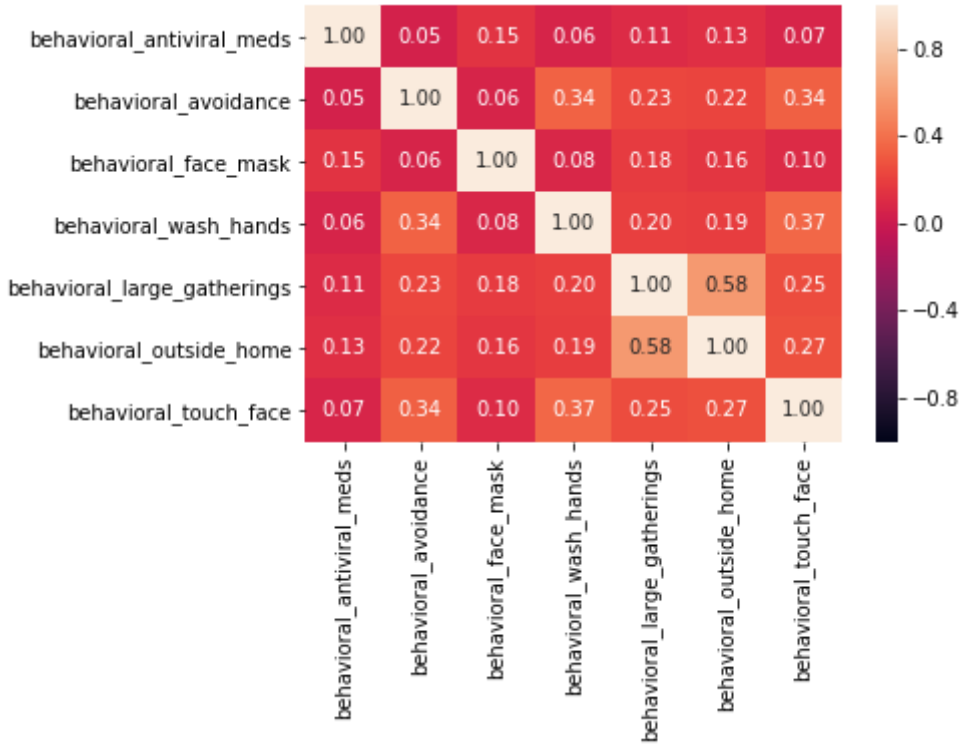
	behavioral_antiviral_meds	behavioral_avoidance	behavioral_face_mask	behavioral_wash_hand
0	0.0	0.0	0.0	0.
1	0.0	1.0	0.0	1.
2	0.0	1.0	0.0	0.
3	0.0	1.0	0.0	1.
4	0.0	1.0	0.0	1.

In [31]:

```
#Visualising the correlation between the various behavioural features
sb.heatmap(data=behaviour.corr(), vmin = -1, vmax = 1, annot = True, fmt = ".2f")
```

Out[31]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1ffca1dd710>
```



In [32]:

```
#Appending the label dataframe into the behaviour dataframe
behaviour_labels = pd.concat([behaviour, train_dep], axis = 1)
```

In [33]:

```
behaviour_labels.head()
```

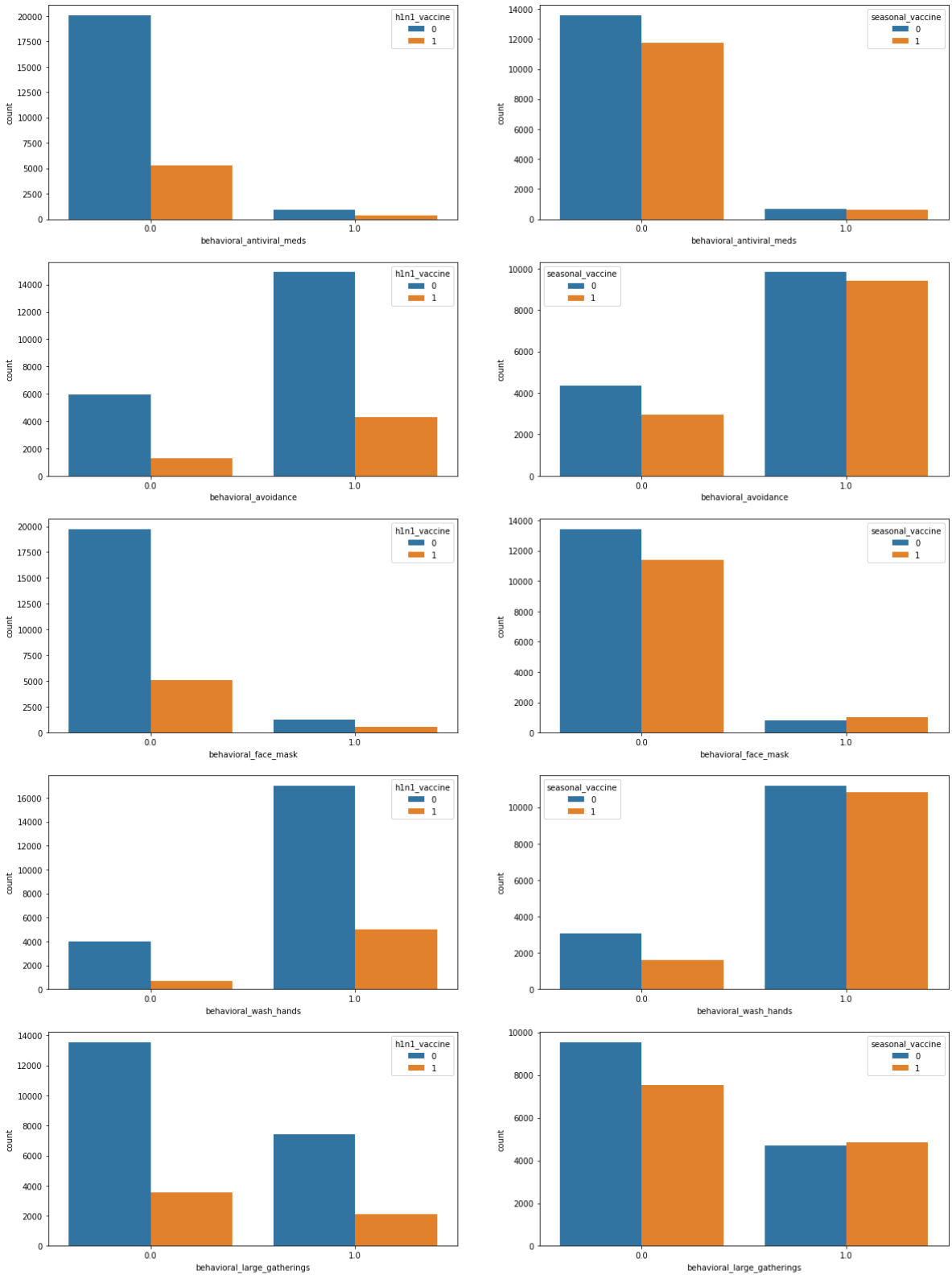
Out[33]:

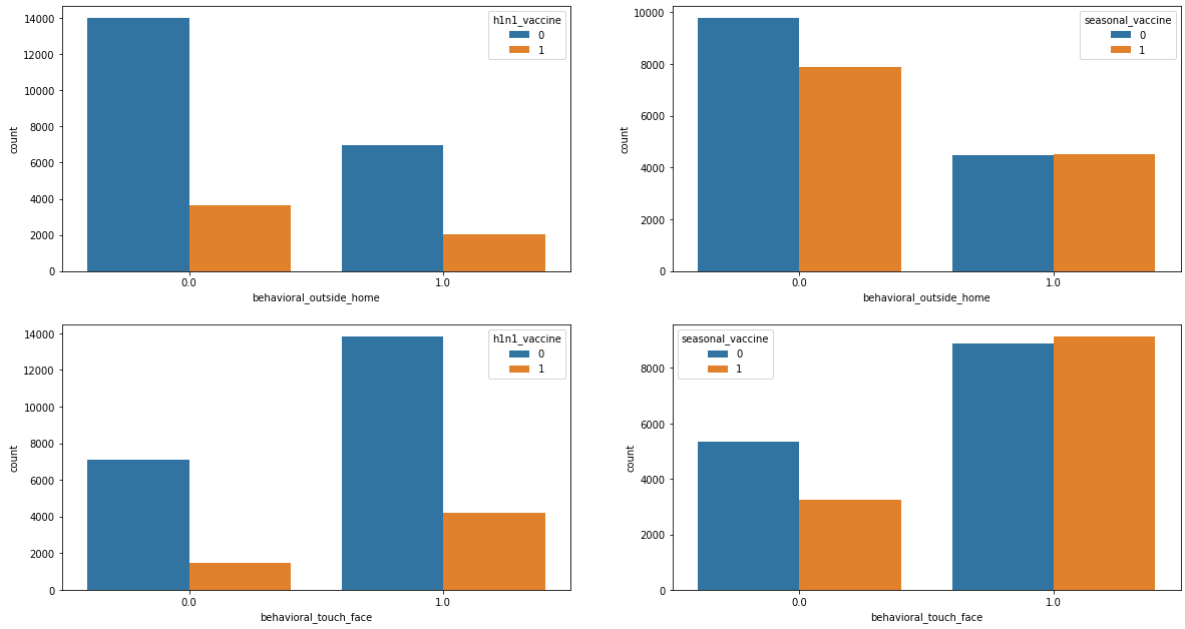
	behavioral_antiviral_meds	behavioral_avoidance	behavioral_face_mask	behavioral_wash_hand
0	0.0	0.0	0.0	0.
1	0.0	1.0	0.0	1.
2	0.0	1.0	0.0	0.
3	0.0	1.0	0.0	1.
4	0.0	1.0	0.0	1.

In [34]:

```
#Visualising h1n1_vaccine and seasonal_vaccine with respect to the behavioural features

f, axes = plt.subplots(7, 2, figsize=(20,40))
count = 0
for i in behaviour_labels:
    if count <= 6:
        sb.countplot(x=behaviour_labels[i], data=behaviour_labels, hue='h1n1_vaccine', ax =
        sb.countplot(x=behaviour_labels[i], data=behaviour_labels, hue='seasonal_vaccine',
        count+=1
    else:
        break
```





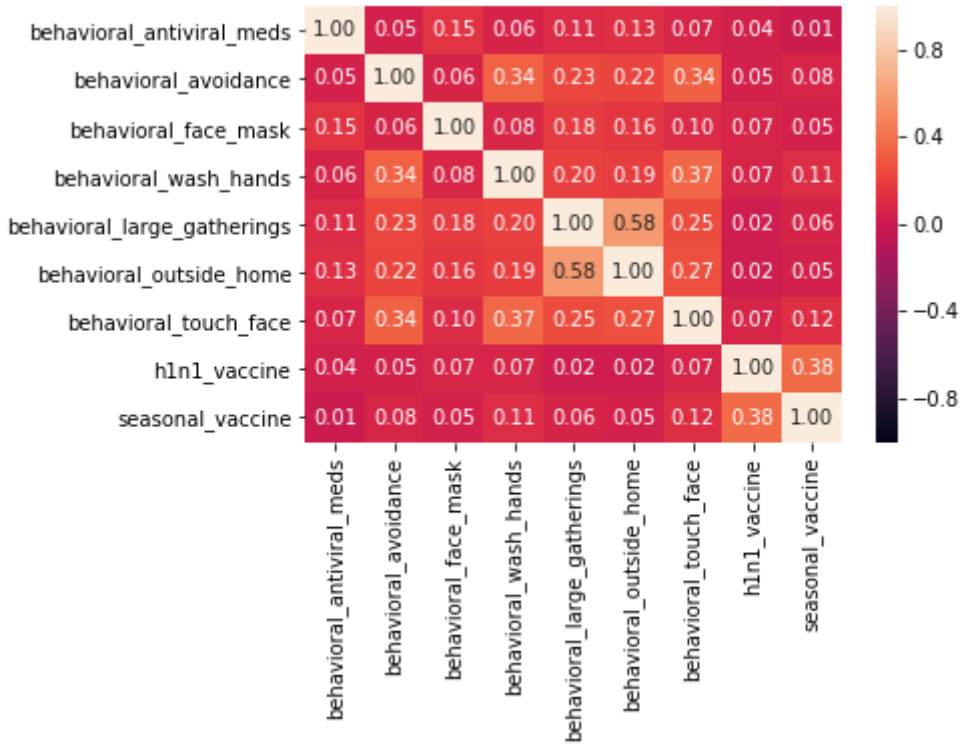
The graphs on the left, are in terms of h1n1_vaccine while the graphs on the right are in terms of seasonal_vaccine

In [35]:

```
#Visualising the correlation between the behavioural features
sb.heatmap(data=behaviour_labels.corr(), vmin = -1, vmax = 1, annot = True, fmt = ".2f")
```

Out[35]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1ffcaca8128>
```



The highest correlation is in between behavioural_large_gatherings and behavioural_outside_home of 0.58.

The feature with the highest correlation to h1n1_vaccine is

Opinion Features

1. opinion_h1n1_vacc_effective

- Respondent's opinion about H1N1 vaccine effectiveness.
- 1 = Not at all effective; 2 = Not very effective; 3 = Don't know; 4 = Somewhat effective; 5 = Very effective.

2. opinion_h1n1_risk

- Respondent's opinion about risk of getting sick with H1N1 flu without vaccine.
- 1 = Very Low; 2 = Somewhat low; 3 = Don't know; 4 = Somewhat high; 5 = Very high.

3. opinion_h1n1_sick_from_vacc

- Respondent's worry of getting sick from taking H1N1 vaccine.
- 1 = Not at all worried; 2 = Not very worried; 3 = Don't know; 4 = Somewhat worried; 5 = Very worried.

4. opinion_seas_vacc_effective

- Respondent's opinion about seasonal flu vaccine effectiveness.
- 1 = Not at all effective; 2 = Not very effective; 3 = Don't know; 4 = Somewhat effective; 5 = Very effective.

5. opinion_seas_risk

- Respondent's opinion about risk of getting sick with seasonal flu without vaccine.
- 1 = Very Low; 2 = Somewhat low; 3 = Don't know; 4 = Somewhat high; 5 = Very high.

6. opinion_seas_sick_from_vacc

- Respondent's worry of getting sick from taking seasonal flu vaccine.
- 1 = Not at all worried; 2 = Not very worried; 3 = Don't know; 4 = Somewhat worried; 5 = Very worried.

In [36]:

```
opinion = train_var[["opinion_h1n1_vacc_effective", "opinion_h1n1_risk", "opinion_h1n1_sick
```

In [37]:

```
opinion.head()
```

Out[37]:

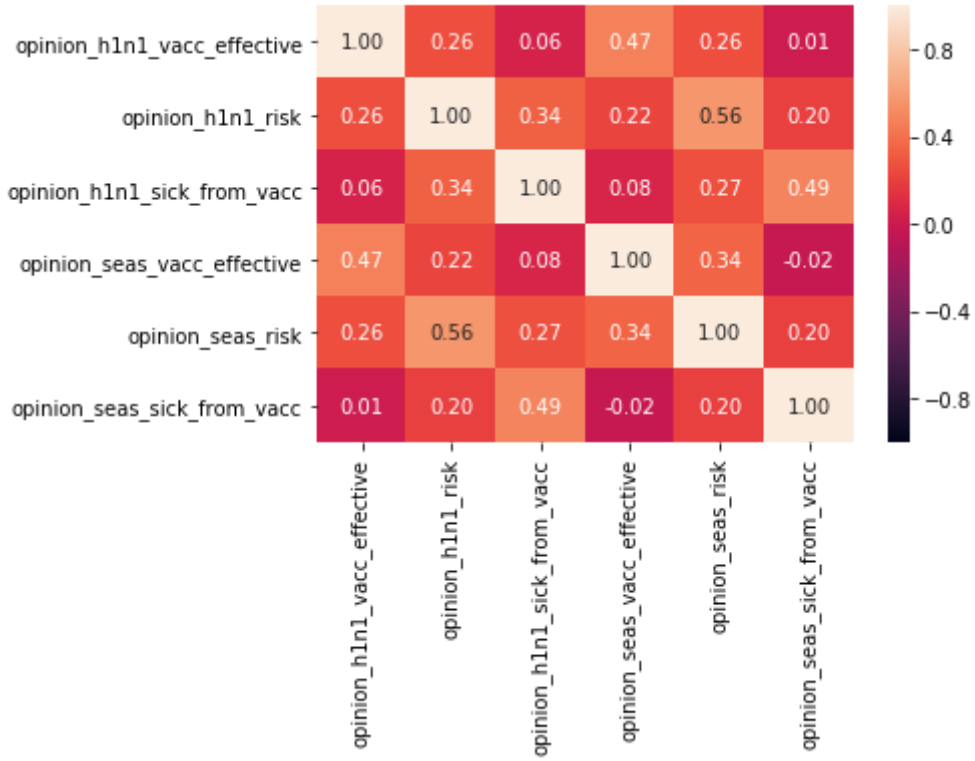
	opinion_h1n1_vacc_effective	opinion_h1n1_risk	opinion_h1n1_sick_from_vacc	opinion_seas_v
0	3.0	1.0	2.0	
1	5.0	4.0	4.0	
2	3.0	1.0	1.0	
3	3.0	3.0	5.0	
4	3.0	3.0	2.0	

In [38]:

```
sb.heatmap(data=opinion.corr(), vmin = -1, vmax = 1, annot = True, fmt = ".2f")
```

Out[38]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1ffcadaa2e8>
```



In [39]:

```
#Appending the label dataframe into the opinion dataframe
opinion_labels = pd.concat([opinion, train_dep], axis = 1)
```

In [40]:

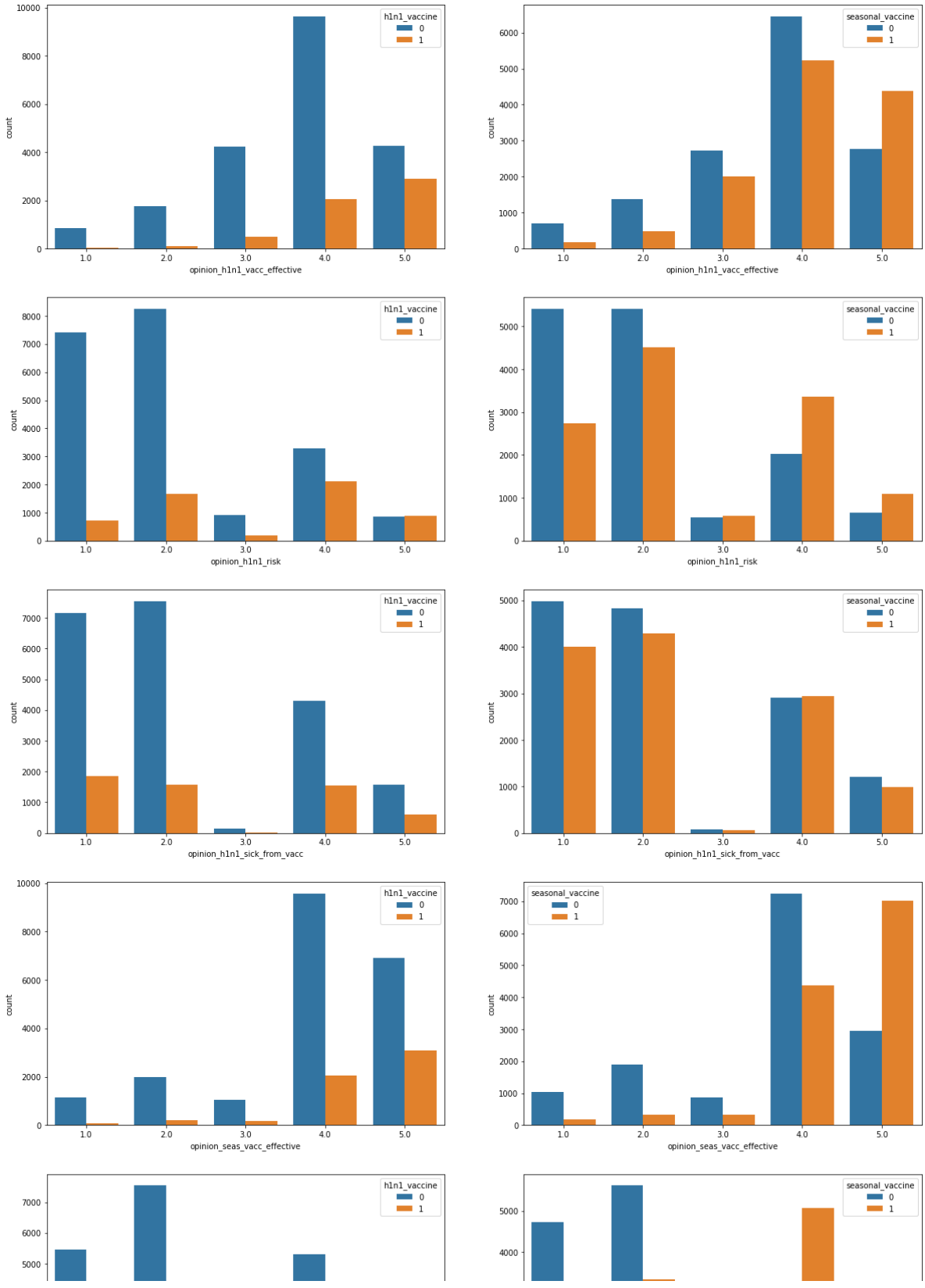
```
opinion_labels.head()
```

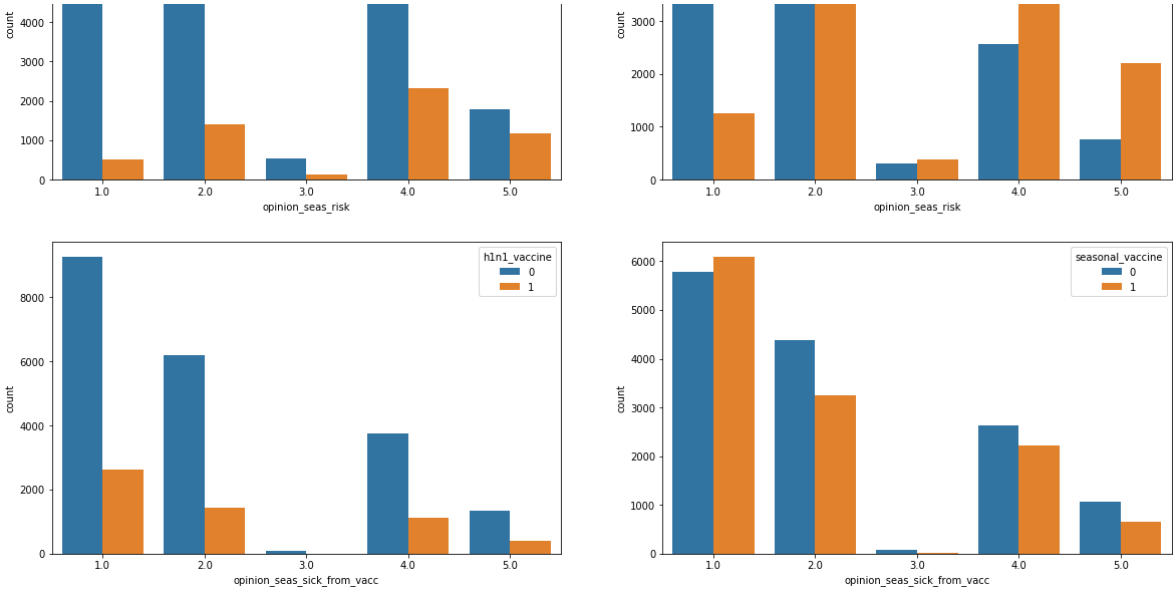
Out[40]:

	opinion_h1n1_vacc_effective	opinion_h1n1_risk	opinion_h1n1_sick_from_vacc	opinion_seas_v
0	3.0	1.0	2.0	
1	5.0	4.0	4.0	
2	3.0	1.0	1.0	
3	3.0	3.0	5.0	
4	3.0	3.0	2.0	

In [41]:

```
f, axes = plt.subplots(6, 2, figsize=(20,40))
count = 0
for i in opinion_labels:
    if count <= 5:
        sb.countplot(x=opinion_labels[i], data=opinion_labels, hue='h1n1_vaccine', ax = axe
        sb.countplot(x=opinion_labels[i], data=opinion_labels, hue='seasonal_vaccine', ax =
        count+=1
    else:
        break
```



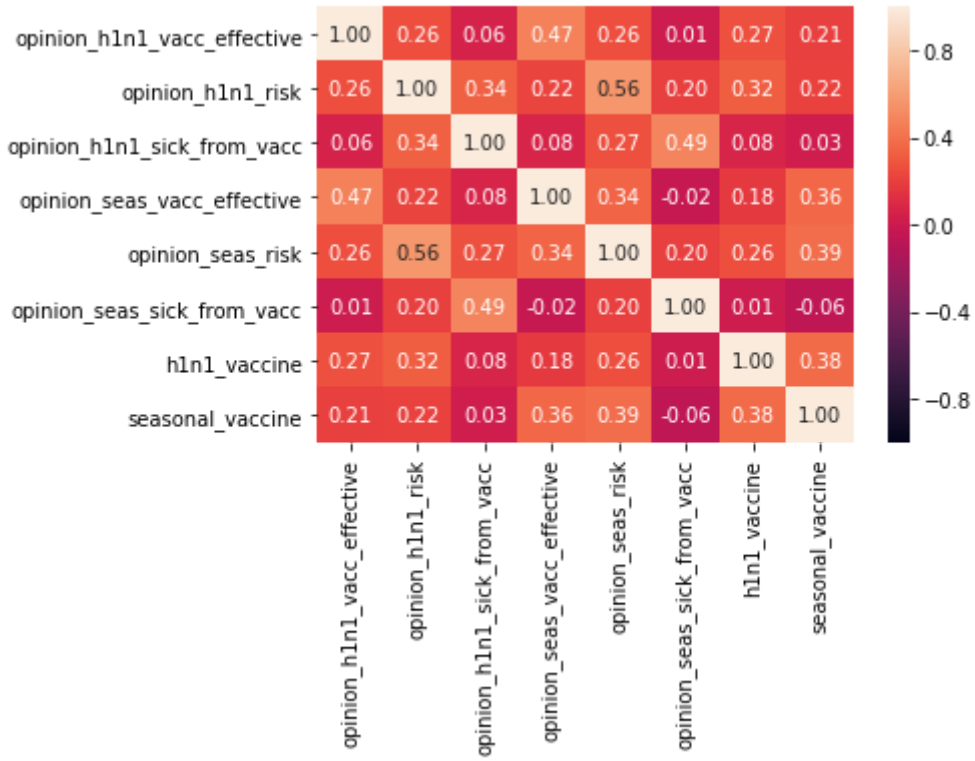


In [42]:

```
sb.heatmap(data=opinion_labels.corr(), vmin = -1, vmax = 1, annot = True, fmt = ".2f")
```

Out[42]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1ffcb3904e0>
```



Health Workers and Insurance

1. health_worker

- Is a healthcare worker. (binary)

2. health_insurance

- Has health insurance. (binary)

In [43]:

```
health = train_var[["health_worker", "health_insurance"]]
```

In [44]:

```
health.head()
```

Out[44]:

	health_worker	health_insurance
0	0.0	1.0
1	0.0	1.0
2	0.0	NaN
3	0.0	NaN
4	0.0	NaN

In [45]:

```
health.isnull().sum()
```

Out[45]:

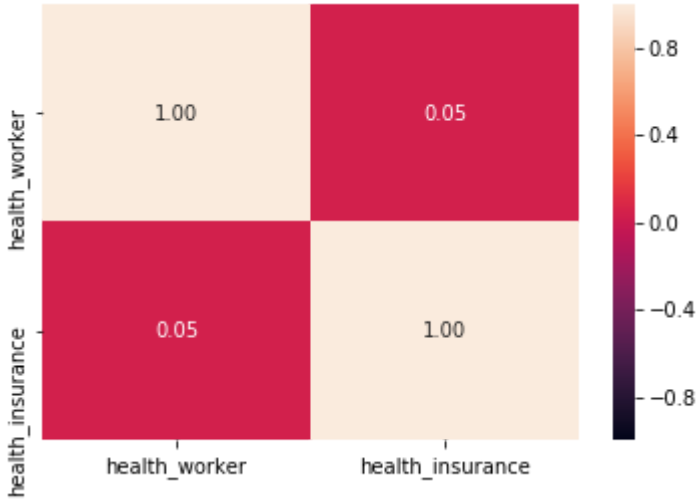
```
health_worker         804
health_insurance    12274
dtype: int64
```

In [46]:

```
sb.heatmap(data=health.corr(), vmin = -1, vmax = 1, annot = True, fmt = ".2f")
```

Out[46]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1ffcb7b3ba8>
```



In [47]:

```
health_labels = pd.concat([health, train_dep], axis = 1)
```

In [48]:

```
health_labels.head()
```

Out[48]:

	health_worker	health_insurance	h1n1_vaccine	seasonal_vaccine
0	0.0	1.0	0	0
1	0.0	1.0	0	1
2	0.0	NaN	0	0
3	0.0	NaN	0	1
4	0.0	NaN	0	0

In [49]:

```
health_labels.isnull().sum()
```

Out[49]:

```
health_worker         804
health_insurance    12274
h1n1_vaccine            0
seasonal_vaccine        0
dtype: int64
```

In [50]:

```
#health_labels = health_labels.dropna(how="any")
```

In [51]:

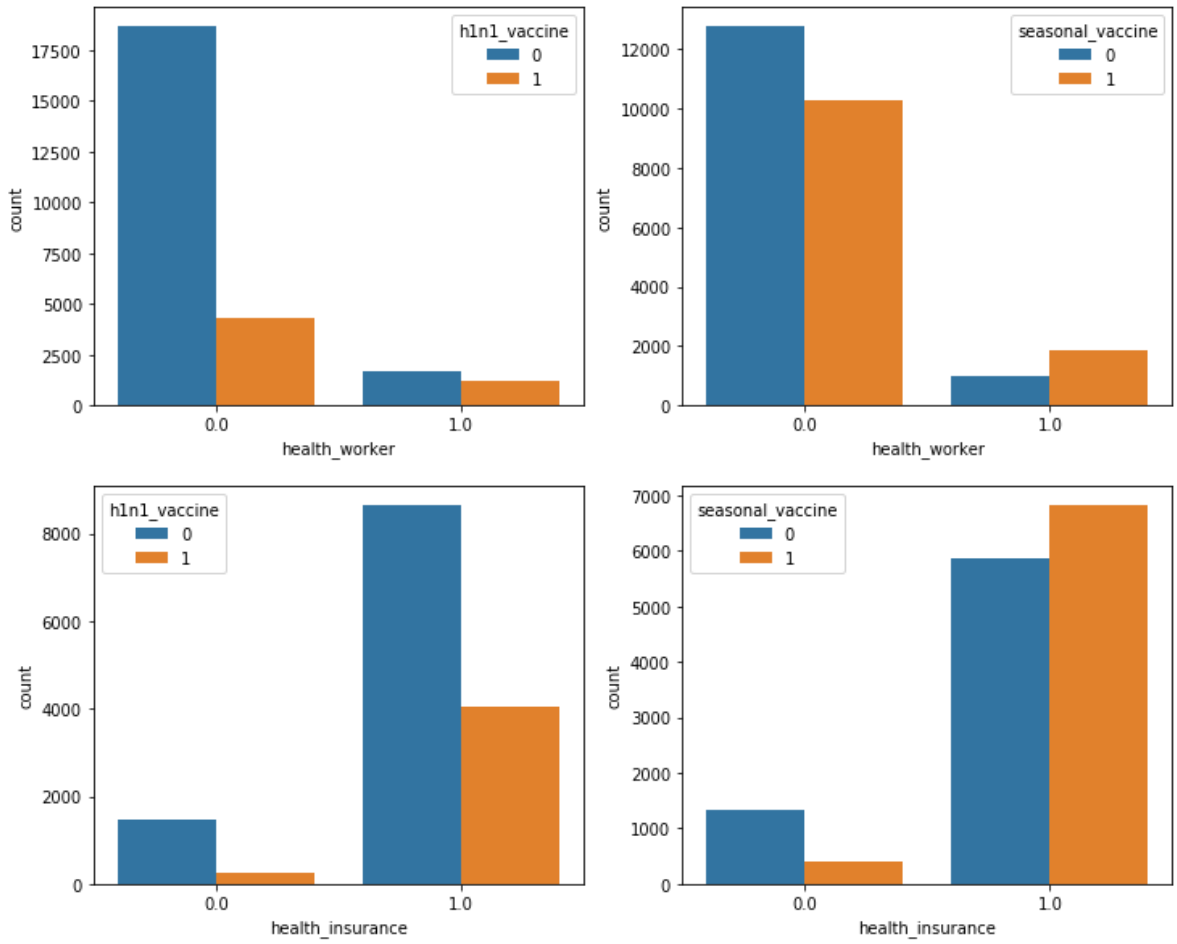
```
health_labels.shape
```

Out[51]:

```
(26707, 4)
```

In [52]:

```
f, axes = plt.subplots(2, 2, figsize=(12,10))
count = 0
for i in health_labels:
    if count <= 1:
        sb.countplot(x=health_labels[i], data=health_labels, hue='h1n1_vaccine', ax = axes[
        sb.countplot(x=health_labels[i], data=health_labels, hue='seasonal_vaccine', ax = a
        count+=1
    else:
        break
```

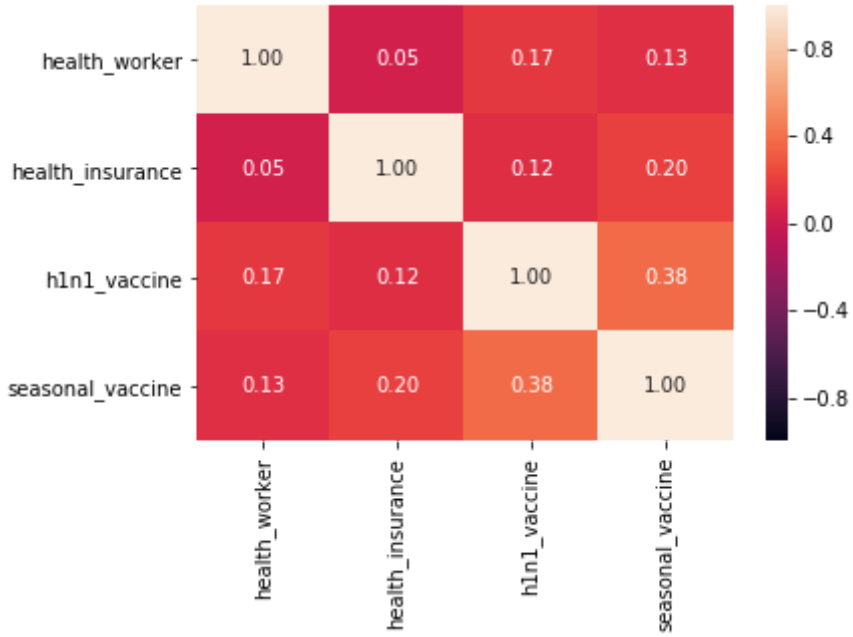


In [53]:

```
sb.heatmap(data=health_labels.corr(), vmin = -1, vmax = 1, annot = True, fmt = ".2f")
```

Out[53]:

```
<matplotlib.axes._subplots.AxesSubplot at 0x1ffcbc222e8>
```



One-Hot Encoding

In [54]:

```
#Finding out the categorical variables of the data type object
train_var.select_dtypes(['object']).columns
```

Out[54]:

```
Index(['age_group', 'education', 'race', 'sex', 'income_poverty',
       'marital_status', 'rent_or_own', 'employment_status', 'hhs_geo_regio
n',
       'census_msa', 'employment_industry', 'employment_occupation'],
      dtype='object')
```

In [55]:

```
#Getting the 1s and 0s
dummies = pd.get_dummies(train_var[['age_group', 'education', 'race', 'sex', 'income_povert
       'marital_status', 'rent_or_own', 'employment_status', 'hhs_geo_region',
       'census_msa', 'employment_industry', 'employment_occupation']], drop_first=False)
```

In [56]:

```
#Viewing the dummies
dummies.head()
```

Out[56]:

	age_group_18 - 34 Years	age_group_35 - 44 Years	age_group_45 - 54 Years	age_group_55 - 64 Years	age_group_65+ Years	education_12 Years	e
0	0	0	0	1	0	0	
1	0	1	0	0	0	1	
2	1	0	0	0	0	0	
3	0	0	0	0	1	1	
4	0	0	1	0	0	0	

5 rows × 82 columns

In [57]:

```
#Dropping the original object data type features to make way for the new ones
train_var = train_var.drop(['age_group', 'education', 'race', 'sex', 'income_poverty',
       'marital_status', 'rent_or_own', 'employment_status', 'hhs_geo_region',
       'census_msa', 'employment_industry', 'employment_occupation'], axis=1)
```

In [58]:

```
#Concatenating the dummies and the original dataset
train_var = pd.concat([train_var, dummies], axis=1)
```

In [59]:

```
train_var.head()
```

Out[59]:

	h1n1_concern	h1n1_knowledge	behavioral_antiviral_meds	behavioral_avoidance	behavioral_
0	1.0	0.0	0.0	0.0	
1	3.0	2.0	0.0	1.0	
2	1.0	1.0	0.0	1.0	
3	1.0	1.0	0.0	1.0	
4	2.0	1.0	0.0	1.0	

5 rows × 105 columns

In [60]:

```
#26707 rows with 105 features
train_var.shape
```

Out[60]:

```
(26707, 105)
```

NA Imputation

In [61]:

```
from sklearn.preprocessing import StandardScaler
from sklearn.impute import SimpleImputer
from sklearn.compose import ColumnTransformer

from sklearn.linear_model import LogisticRegression
from sklearn.multioutput import MultiOutputClassifier

from sklearn.pipeline import Pipeline

from sklearn.model_selection import train_test_split

from sklearn.metrics import roc_curve, roc_auc_score

RANDOM_SEED = 6    # Set a random seed for reproducibility!
```

In [62]:

```
train_var.isnull().sum()
```

Out[62]:

```
h1n1_concern                        92
h1n1_knowledge                     116
behavioral_antiviral_meds           71
behavioral_avoidance               208
behavioral_face_mask                19
behavioral_wash_hands               42
behavioral_large_gatherings         87
behavioral_outside_home             82
behavioral_touch_face              128
doctor_recc_h1n1                  2160
doctor_recc_seasonal              2160
chronic_med_condition              971
child_under_6_months               820
health_worker                      804
health_insurance                 12274
opinion_h1n1_vacc_effective        391
opinion_h1n1_risk                  388
opinion_h1n1_sick_from_vacc        395
opinion_seas_vacc_effective        462
opinion_seas_risk                  514
opinion_seas_sick_from_vacc        537
household_adults                   249
household_children                 249
age_group_18 - 34 Years              0
age_group_35 - 44 Years              0
age_group_45 - 54 Years              0
age_group_55 - 64 Years              0
age_group_65+ Years                  0
education_12 Years                   0
education_< 12 Years                 0
                                  ...
employment_industry_rucpziij         0
employment_industry_saaquncn         0
employment_industry_vjjrobsf         0
employment_industry_wlfvacwt         0
employment_industry_wxleyezf         0
employment_industry_xicduogh         0
employment_industry_xqicxuve         0
employment_occupation_bxpfxfdn       0
employment_occupation_ccgxvspp       0
employment_occupation_cmhcxjea       0
employment_occupation_dcjcmpih       0
employment_occupation_dlvbwzss       0
employment_occupation_emcorrxb       0
employment_occupation_haliazsg       0
employment_occupation_hfxkjkmi       0
employment_occupation_hodpvpew       0
employment_occupation_kldqjyjy       0
employment_occupation_mxkfnird       0
employment_occupation_oijqvulv       0
employment_occupation_pvmttkik       0
employment_occupation_qxajmpny       0
employment_occupation_rcertsgn       0
employment_occupation_tfqavkke       0
employment_occupation_ukymxvdu       0
```

```
employment_occupation_uqqtjvyb        0
employment_occupation_vlluhbov        0
employment_occupation_xgwztkwe        0
employment_occupation_xqwwgdyp        0
employment_occupation_xtkaffoo        0
employment_occupation_xzmlyyjv        0
Length: 105, dtype: int64
```

In [63]:

```
#Show those features which ARE of the data type - object
train_var.dtypes!="object"
```

Out[63]:

```
h1n1_concern                        True
h1n1_knowledge                      True
behavioral_antiviral_meds           True
behavioral_avoidance                True
behavioral_face_mask                True
behavioral_wash_hands               True
behavioral_large_gatherings         True
behavioral_outside_home             True
behavioral_touch_face               True
doctor_recc_h1n1                    True
doctor_recc_seasonal                True
chronic_med_condition               True
child_under_6_months                True
health_worker                       True
health_insurance                    True
opinion_h1n1_vacc_effective         True
opinion_h1n1_risk                   True
opinion_h1n1_sick_from_vacc         True
opinion_seas_vacc_effective         True
opinion_seas_risk                   True
opinion_seas_sick_from_vacc         True
household_adults                    True
household_children                  True
age_group_18 - 34 Years             True
age_group_35 - 44 Years             True
age_group_45 - 54 Years             True
age_group_55 - 64 Years             True
age_group_65+ Years                 True
education_12 Years                  True
education_< 12 Years                True
                                    ...
employment_industry_rucpziij        True
employment_industry_saaquncn        True
employment_industry_vjjrobsf        True
employment_industry_wlfvacwt        True
employment_industry_wxleyezf        True
employment_industry_xicduogh        True
employment_industry_xqicxuve        True
employment_occupation_bxpfxfdn      True
employment_occupation_ccgxvspp      True
employment_occupation_cmhcxjea      True
employment_occupation_dcjcmpih      True
employment_occupation_dlvbwzss      True
employment_occupation_emcorrxb      True
employment_occupation_haliazsg      True
employment_occupation_hfxkjkmi      True
employment_occupation_hodpvpew      True
employment_occupation_kldqjyjy      True
employment_occupation_mxkfnird      True
employment_occupation_oijqvulv      True
employment_occupation_pvmttkik      True
employment_occupation_qxajmpny      True
employment_occupation_rcertsgn      True
employment_occupation_tfqavkke      True
```

```
employment_occupation_ukymxvdu    True
employment_occupation_uqqtjvyb    True
employment_occupation_vlluhbov    True
employment_occupation_xgwztkwe    True
employment_occupation_xqwwgdyp    True
employment_occupation_xtkaffoo    True
employment_occupation_xzmlyyjv    True
Length: 105, dtype: bool
```

In [64]:

```
train_var.isnull().sum()
```

Out[64]:

```
h1n1_concern                          92
h1n1_knowledge                       116
behavioral_antiviral_meds             71
behavioral_avoidance                 208
behavioral_face_mask                  19
behavioral_wash_hands                 42
behavioral_large_gatherings           87
behavioral_outside_home               82
behavioral_touch_face                128
doctor_recc_h1n1                    2160
doctor_recc_seasonal                2160
chronic_med_condition                971
child_under_6_months                 820
health_worker                        804
health_insurance                   12274
opinion_h1n1_vacc_effective          391
opinion_h1n1_risk                    388
opinion_h1n1_sick_from_vacc          395
opinion_seas_vacc_effective          462
opinion_seas_risk                    514
opinion_seas_sick_from_vacc          537
household_adults                     249
household_children                   249
age_group_18 - 34 Years                0
age_group_35 - 44 Years                0
age_group_45 - 54 Years                0
age_group_55 - 64 Years                0
age_group_65+ Years                    0
education_12 Years                     0
education_< 12 Years                   0
                                    ...
employment_industry_rucpziij           0
employment_industry_saaquncn           0
employment_industry_vjjrobsf           0
employment_industry_wlfvacwt           0
employment_industry_wxleyezf           0
employment_industry_xicduogh           0
employment_industry_xqicxuve           0
employment_occupation_bxpfxfdn         0
employment_occupation_ccgxvspp         0
employment_occupation_cmhcxjea         0
employment_occupation_dcjcmpih         0
employment_occupation_dlvbwzss         0
employment_occupation_emcorrxb         0
employment_occupation_haliazsg         0
employment_occupation_hfxkjkmi         0
employment_occupation_hodpvpew         0
employment_occupation_kldqjyjy         0
employment_occupation_mxkfnird         0
employment_occupation_oijqvulv         0
employment_occupation_pvmttkik         0
employment_occupation_qxajmpny         0
employment_occupation_rcertsgn         0
employment_occupation_tfqavkke         0
employment_occupation_ukymxvdu         0
```

```
employment_occupation_uqqtjvyb        0
employment_occupation_vlluhbov        0
employment_occupation_xgwztkwe        0
employment_occupation_xqwwgdyp        0
employment_occupation_xtkaffoo        0
employment_occupation_xzmlyyjv        0
Length: 105, dtype: int64
```

In [104]:

```
imp = SimpleImputer(missing_values=np.nan, strategy='most_frequent')
```

In [105]:

```
#first fit then transfor, or you can d fit_transform
imp.fit(train_var)

#transformation
train_var = imp.fit_transform(train_var)
```

In [106]:

```
train_var = pd.DataFrame(data=train_var)
```

In [107]:

```
train_var.shape
```

Out[107]:

```
(26707, 105)
```

In [108]:

```
train_var.head()
```

Out[108]:

	0	1	2	3	4	5	6	7	8	9	...	95	96	97	98	99	100	101	102	10
0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.(
1	3.0	2.0	0.0	1.0	0.0	1.0	0.0	1.0	1.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	1.0	0.0	0.(
2	1.0	1.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.(
3	1.0	1.0	0.0	1.0	0.0	1.0	1.0	0.0	0.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.(
4	2.0	1.0	0.0	1.0	0.0	1.0	1.0	0.0	1.0	0.0	...	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.(

5 rows × 105 columns

In [109]:

```
#Therefore, now there are no NaN va;ues in train_var
train_var.isnull().sum()
```

Out[109]:

```
0      0
1      0
2      0
3      0
4      0
5      0
6      0
7      0
8      0
9      0
10     0
11     0
12     0
13     0
14     0
15     0
16     0
17     0
18     0
19     0
20     0
21     0
22     0
23     0
24     0
25     0
26     0
27     0
28     0
29     0
      ..
75     0
76     0
77     0
78     0
79     0
80     0
81     0
82     0
83     0
84     0
85     0
86     0
87     0
88     0
89     0
90     0
91     0
92     0
93     0
94     0
95     0
96     0
97     0
```

```
98     0
99     0
100    0
101    0
102    0
103    0
104    0
Length: 105, dtype: int64
```

Scaling

In [90]:

```
from sklearn.preprocessing import MinMaxScaler
```

In [91]:

```
X_train, X_test, y_train, y_test = train_test_split(
    train_var,
    train_dep,
    test_size=0.2,
    shuffle=True,
    stratify=train_dep,
    random_state=RANDOM_SEED
)
```

In [92]:

```
scaler = MinMaxScaler()
```

In [93]:

```
X_train = scaler.fit_transform(X_train)
```

In [94]:

```
X_test = scaler.fit_transform(X_test)
```

In [95]:

```
y_train = scaler.fit_transform(y_train)
```

In [113]:

```
y_test = scaler.fit_transform(y_test)
```

In [97]:

```
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score
```

In [98]:

```
clf = MultiOutputClassifier(LogisticRegression(penalty="l2", C=1))
```

In [99]:

```
clf.fit(X_train,y_train)
```

```
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\_logistic.p
y:940: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

Increase the number of iterations (max_iter) or scale the data as shown in:
    https://scikit-learn.org/stable/modules/preprocessing.html (https://scik
it-learn.org/stable/modules/preprocessing.html)
Please also refer to the documentation for alternative solver options:
    https://scikit-learn.org/stable/modules/linear_model.html#logistic-regre
ssion (https://scikit-learn.org/stable/modules/linear_model.html#logistic-re
gression)
  extra_warning_msg=_LOGISTIC_SOLVER_CONVERGENCE_MSG)
C:\ProgramData\Anaconda3\lib\site-packages\sklearn\linear_model\_logistic.p
y:940: ConvergenceWarning: lbfgs failed to converge (status=1):
STOP: TOTAL NO. of ITERATIONS REACHED LIMIT.

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

Out[99]:

```
MultiOutputClassifier(estimator=LogisticRegression(C=1, class_weight=None,
                                                   dual=False,
                                                   fit_intercept=True,
                                                   intercept_scaling=1,
                                                   l1_ratio=None, max_iter=1
00,
                                                   multi_class='auto',
                                                   n_jobs=None, penalty='l
2',
                                                   random_state=None,
                                                   solver='lbfgs', tol=0.000
1,
                                                   verbose=0,
                                                   warm_start=False),
                      n_jobs=None)
```

In [100]:

```
prediction = clf.predict_proba(X_test)
```

In [101]:

```
prediction
#The probabilities are for Class 0 and CLass 1 respectively, we need to get
# the second column as that tells us the probabilities of taking the vaccines
```

Out[101]:

```
[array([[0.86336798, 0.13663202],
        [0.93534235, 0.06465765],
        [0.87676219, 0.12323781],
        ...,
        [0.54020494, 0.45979506],
        [0.57945078, 0.42054922],
        [0.97176849, 0.02823151]]), array([[0.48144218, 0.51855782],
        [0.91664352, 0.08335648],
        [0.4338987 , 0.5661013 ],
        ...,
        [0.3060185 , 0.6939815 ],
        [0.12780318, 0.87219682],
        [0.90080166, 0.09919834]])]
```

In [102]:

```
print("There are 2 arrays, one for 0 and one for 1 ")
print("array for 0 shape ", prediction[0].shape)
print("array for 1 shape ", prediction[1].shape)
```

```
There are 2 arrays, one for 0 and one for 1
array for 0 shape  (5342, 2)
array for 1 shape  (5342, 2)
```

In [116]:

```
X_train = pd.DataFrame(data=X_train)
X_test = pd.DataFrame(data=X_test)
y_train = pd.DataFrame(data=y_train)
y_test = pd.DataFrame(data=y_test)
```

In [117]:

```
y_preds = pd.DataFrame(
    {
        "h1n1_vaccine": prediction[0][:, 1],
        "seasonal_vaccine": prediction[1][:, 1],
    },
    index = y_test.index
)
print("y_preds.shape:", y_preds.shape)
y_preds.head()
```

```
y_preds.shape: (5342, 2)
```

Out[117]:

	h1n1_vaccine	seasonal_vaccine
0	0.136632	0.518558
1	0.064658	0.083356
2	0.123238	0.566101
3	0.057037	0.296145
4	0.081375	0.843715

Plot

In [118]:

```
def plot_roc(y_true, y_score, label_name, ax):
    fpr, tpr, thresholds = roc_curve(y_true, y_score)
    ax.plot(fpr, tpr)
    ax.plot([0, 1], [0, 1], color='grey', linestyle='--')
    ax.set_ylabel('TPR')
    ax.set_xlabel('FPR')
    ax.set_title(
        f"{label_name}: AUC = {roc_auc_score(y_true, y_score):.4f}"
    )
```

In [119]:

```
y_test.head()
```

Out[119]:

	0	1
0	0.0	1.0
1	0.0	0.0
2	1.0	1.0
3	0.0	0.0
4	1.0	1.0

In [120]:

```
y_preds.head()
```

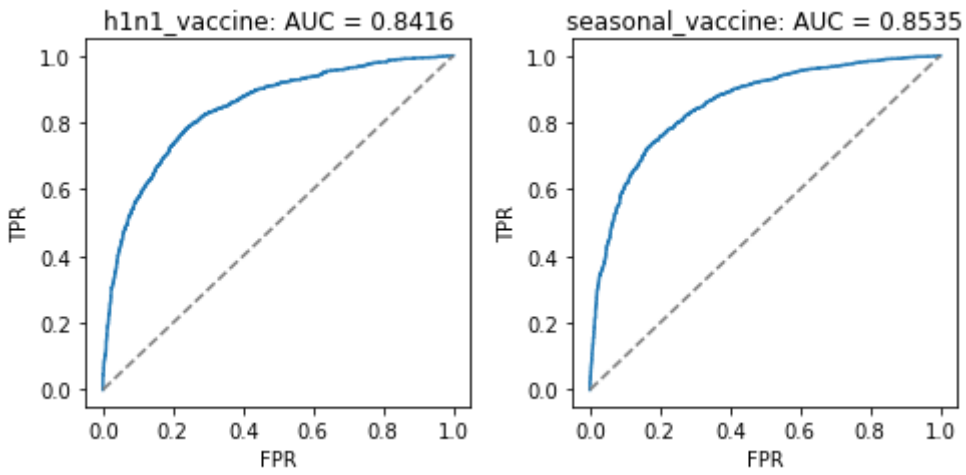
Out[120]:

	h1n1_vaccine	seasonal_vaccine
0	0.136632	0.518558
1	0.064658	0.083356
2	0.123238	0.566101
3	0.057037	0.296145
4	0.081375	0.843715

In [121]:

```
fig, ax = plt.subplots(1, 2, figsize=(7, 3.5))

plot_roc(
    y_test[0],
    y_preds['h1n1_vaccine'],
    'h1n1_vaccine',
    ax=ax[0]
)
plot_roc(
    y_test[1],
    y_preds['seasonal_vaccine'],
    'seasonal_vaccine',
    ax=ax[1]
)
fig.tight_layout()
```



In [122]:

```
roc_auc_score(y_test, y_preds)
```

Out[122]:

```
0.8475430958270868
```