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Project: Predictive analysis on factors contributing to uptake of HIN1 and Seasonal Flu vaccine

Overview

Vaccination,remains a key public health measure used to fight infectious diseases. Vaccines provide immunization for individuals, and enough immunization in a community can further reduce the spread of diseases through "herd immunity"

Beginning in spring 2009, a pandemic caused by the H1N1 influenza virus, colloquially named "swine flu," swept across the world. Researchers estimate that in the first year, it was responsible for between 151,000 to 575,000 deaths globally.

A vaccine for the H1N1 flu virus became publicly available in October 2009. In late 2009 and early 2010, the United States conducted the National 2009 H1N1 Flu Survey. This phone survey asked respondents whether they had received the H1N1 and seasonal flu vaccines, in conjunction with questions about themselves. These additional questions covered their social, economic, and demographic background, opinions on risks of illness and vaccine effectiveness, and behaviors towards mitigating transmission.

A better understanding of how these characteristics are associated with personal vaccination patterns can provide guidance for future public health efforts.

This project aims to analyze factors that influence individuals' decision-making processes regarding getting vaccinated against H1N1 and seasonal flu. By gaining insights into these factors,healthcare department can develop targeted strategies and interventions to increase vaccination rates and improve public health outcomes during pandemics

Problem Statement

The world has recently experienced the impact of major flu outbreaks like the COVID-19, Swine Flu (H1N1) and the Avian Flu(H5N1). The effect of any flu outbreak depends on the type of flu and its respective variants, the population demographics like age, and other underlying health conditions of the individual and vaccination status of the population.Seasonal flu places a substantial burden on the health of people each year. CDC estimates that flu has resulted in 9 million – 41 million illnesses, 140,000 – 710,000

hospitalizations and 12,000 – 52,000 deaths annually between 2010 and 2020.Despite the availability and effectiveness of flu vaccines, there are still significant portions of the population who choose not to get vaccinated.

To address this problem, it is crucial to investigate the reasons behind these decisions and identify the key factors driving individuals' opinions, perceptions, and behaviors related to flu vaccination and develop startegic interventions to target different cohort and improve vaccine uptake

Objectives

1. Determine demographic factors (age,gender,occupation) that determine vaccine upatek
2. Determine Knowledge, Opinions(Attitude) and Behavoiurs (Practices) that influence vaccine uptake
3. Predict how likely individuals are to receive their H1N1 and seasonal flu vaccines
4. Evaluate AUC & ROC performace of predictive models used

Data Understanding

We will use data sets from phone survey where respondents were asked whether they had received the H1N1 and seasonal flu vaccines, in conjunction with questions about themselves. These additional questions covered their social, economic, and demographic background, opinions on risks of illness and vaccine effectiveness, and behaviors towards mitigating transmission.from Predict H1N1 and Seasonal Flu Vaccines

Loading libraries

In [1]:
```
#Loading libraries
import pandas as pd
import numpy as np
import seaborn as sns
import matplotlib.pyplot as plt
import warnings
warnings.filterwarnings("ignore")
```

In [2]:
```
#Loading dataset with variables assessed
flu_dataset_1 = pd.read_csv("training_set_features.csv", index_col="respondent_id",
flu_dataset_1.head()
```

Out[2]:

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

5 rows × 35 columns

In [3]:
```
#Loading the second dataframe that contains a binary classification of whether the
vaccination_status = pd.read_csv('training_set_labels.csv',index_col="respondent_id
vaccination_status.head()
```

Out[3]:

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

Merging two data sets containing responses and vaccination status

In [4]:
```
#We merge dataframes on respondent_id to merge all variable in one
flu_merged = pd.merge(flu_dataset_1, vaccination_status, on='respondent_id', how='l
flu_merged.head()
```

Out[4]:

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

5 rows × 37 columns

Loading description data for better understanding

In [5]:
```
#Showing a description of how data has been coded for better understanding
data_description_df= pd.read_csv('H1N1- Flu Data Description.csv', encoding="latin1
data_description_df
```

Out[5]:

	Col_name	Description
0	seasonal_vaccine	Whether respondent received seasonal flu vacci...
1	h1n1_vaccine	Whether respondent received H1N1 flu vaccine. ...
2	respondent_id	Unique and random identifier.
3	h1n1_concern	Level of concern about the H1N1 flu.(0 = Not ...
4	h1n1_knowledge	Level of knowledge about H1N1 flu.(0 = No kno...
5	behavioral_antiviral_meds	Has taken antiviral medications. (binary)
6	behavioral_avoidance	Has avoided close contact with others with fl...
7	behavioral_face_mask	Has bought a face mask. (binary)
8	behavioral_wash_hands	Has frequently washed hands or used hand sani...
9	behavioral_large_gatherings	Has reduced time at large gatherings. (binary)
10	behavioral_outside_home	Has reduced contact with people outside of ow...
11	behavioral_touch_face	Has avoided touching eyes, nose, or mouth. (b...
12	doctor_recc_h1n1	H1N1 flu vaccine was recommended by doctor. (...
13	doctor_recc_seasonal	Seasonal flu vaccine was recommended by docto...
14	chronic_med_condition	Has any of the following chronic medical cond...
15	child_under_6_months	Has regular close contact with a child under ...
16	health_worker	Is a healthcare worker. (binary)
17	health_insurance	Has health insurance. (binary)
18	opinion_h1n1_vacc_effective	Respondent's opinion about H1N1 vaccine effec...
19	opinion_h1n1_risk	Respondent's opinion about risk of getting si...
20	opinion_h1n1_sick_from_vacc	Respondent's worry of getting sick from takin...
21	opinion_seas_vacc_effective	Respondent's opinion about seasonal flu vacci...
22	opinion_seas_risk	Respondent's opinion about risk of getting si...
23	opinion_seas_sick_from_vacc	Respondent's worry of getting sick from takin...
24	age_group	Age group of respondent.
25	education	Self-reported education level.
26	race	Race of respondent.
27	sex	Sex of respondent.
28	income_poverty	Household annual income of respondent with re...
29	marital_status	Marital status of respondent.

	Col_name	Description
30	rent_or_own	Housing situation of respondent.
31	employment_status	Employment status of respondent.
32	hhs_geo_region	Respondent's residence using a 10 region geog...
33	census_msa	Respondent's residence within metropolitan st...
34	household_adults	Number of other adults in household, top-code...
35	household_children	Number of children in household, top-coded to 3.
36	employment_industry	Type of industry respondent is employed in. V...
37	employment_occupation	Type of occupation of respondent. Values are ...

Data Cleaning

In [6]:
```
#Checking column names for data understanding
flu_merged.columns
```

Out[6]:
```
Index(['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_risk',
       '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', 'h1n1_vaccine', 'seasonal_vaccine'],
      dtype='object')
```

In [7]:
```
# Decoding the coded information of Respondent's opinion about H1N1 vaccine effecti
flu_merged.h1n1_concern=flu_merged.h1n1_concern.replace({0 :"Not at all concerned",
                                                         3 : "Very concerend"})
flu_merged.h1n1_knowledge=flu_merged.h1n1_knowledge.replace({0 :"No Knowledge", 1 :

flu_merged.opinion_h1n1_vacc_effective=flu_merged.opinion_h1n1_vacc_effective.repla
                                                        4 :"Somewhat effective
#Respondent's opinion about risk of getting sick with H1N1 flu without vaccine.
flu_merged.opinion_h1n1_risk=flu_merged.opinion_h1n1_risk.replace({1 :"Very Low", 2
                                                          4 : "Somewhat high",
#Respondent's opinion about seasonal flu vaccine effectiveness.
flu_merged.opinion_seas_vacc_effective=flu_merged.opinion_seas_vacc_effective.repla
                                                        4 :"Somewhat effective
#Respondent's opinion about seasonal flu vaccine effectiveness.
flu_merged.opinion_h1n1_sick_from_vacc= flu_merged.opinion_h1n1_sick_from_vacc.repl
                                                                             4
#Respondent's opinion about risk of getting sick with seasonal flu without vaccine.
flu_merged.opinion_seas_risk=flu_merged.opinion_seas_risk.replace({1 :"Very Low", 2
```

```
                                                                    4 : "Somewhat high",
#Respondent's worry of getting sick from taking seasonal flu vaccine
flu_merged.opinion_seas_sick_from_vacc= flu_merged.opinion_seas_sick_from_vacc.repl
                                                                                   4
```

In [8]:
```
#Ensuring decoding above has applied
flu_merged.head()
```

Out[8]:

respondent_id	h1n1_concern	h1n1_knowledge	behavioral_antiviral_meds	behavioral_avoida
0	Not very concerned	No Knowledge	0.0	
1	Very concerend	Alot of knowledge	0.0	
2	Not very concerned	A little knowledge	0.0	
3	Not very concerned	A little knowledge	0.0	
4	Somewhat concerend	A little knowledge	0.0	

5 rows × 37 columns

In [9]:
```
#checking shape od data before removing missing values
flu_merged.shape
```

Out[9]:
```
(26707, 37)
```

In [10]:
```
#checking missing values of data
#missing_values_sum = df.isnull().sum()
#print(missing_values_sum)
missing_values_percentage = (flu_merged.isnull().sum() / len(flu_merged)) * 100
print(missing_values_percentage)
```

```
h1n1_concern                  0.344479
h1n1_knowledge                0.434343
behavioral_antiviral_meds     0.265848
behavioral_avoidance          0.778822
behavioral_face_mask          0.071142
behavioral_wash_hands         0.157262
behavioral_large_gatherings   0.325757
behavioral_outside_home       0.307036
behavioral_touch_face         0.479275
doctor_recc_h1n1              8.087767
doctor_recc_seasonal          8.087767
chronic_med_condition         3.635751
child_under_6_months          3.070356
health_worker                 3.010447
health_insurance             45.957989
opinion_h1n1_vacc_effective    1.464036
opinion_h1n1_risk              1.452803
opinion_h1n1_sick_from_vacc    1.479013
opinion_seas_vacc_effective    1.729884
opinion_seas_risk              1.924589
opinion_seas_sick_from_vacc    2.010709
age_group                      0.000000
education                      5.268282
race                           0.000000
sex                            0.000000
income_poverty                16.561201
marital_status                 5.272026
rent_or_own                    7.645936
employment_status              5.477965
hhs_geo_region                 0.000000
census_msa                     0.000000
household_adults               0.932340
household_children             0.932340
employment_industry           49.912008
employment_occupation         50.436215
h1n1_vaccine                   0.000000
seasonal_vaccine               0.000000
dtype: float64
```

In [11]:
```
#drop columns with high percentage of missing values
#dropping health insurance and employment_occupation
flu_merged.drop(['health_insurance','employment_industry','employment_occupation'],
```

In [12]:
```
#checking shape of data to confirm if changes have applied
flu_merged.shape
```

Out[12]: (26707, 34)

In [13]:
```
#Checking for Duplicates
duplicates = flu_merged.duplicated()
#filtered rows of the duplicates
duplicated_rows= flu_merged[duplicates]
print(duplicated_rows)
```

```
Empty DataFrame
Columns: [h1n1_concern, h1n1_knowledge, behavioral_antiviral_meds, behavioral_avoida
nce, behavioral_face_mask, behavioral_wash_hands, behavioral_large_gatherings, behav
ioral_outside_home, behavioral_touch_face, doctor_recc_h1n1, doctor_recc_seasonal, c
hronic_med_condition, child_under_6_months, health_worker, opinion_h1n1_vacc_effecti
ve, opinion_h1n1_risk, opinion_h1n1_sick_from_vacc, opinion_seas_vacc_effective, opi
nion_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_ms
a, household_adults, household_children, h1n1_vaccine, seasonal_vaccine]
Index: []

[0 rows x 34 columns]
```

Data has no dulpicated rows present

In [14]:
```
#checking columns with nal values
flu_merged.isnull().sum()
```

Out[14]:
```
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
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
h1n1_vaccine                    0
seasonal_vaccine                0
dtype: int64
```

In [15]:
```
#dropping null values from the data set
flu_merged = flu_merged.dropna()
```

```
flu_merged.isnull().sum()
```

Out[15]:
```
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
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
hhs_geo_region               0
census_msa                   0
household_adults             0
household_children           0
h1n1_vaccine                 0
seasonal_vaccine             0
dtype: int64
```

In [16]:
```
#confirming data is clean
flu_merged.info()
```

```
<class 'pandas.core.frame.DataFrame'>
Index: 19642 entries, 0 to 26706
Data columns (total 34 columns):
 #   Column                       Non-Null Count  Dtype  
---  ------                       --------------  -----  
 0   h1n1_concern                 19642 non-null  object 
 1   h1n1_knowledge               19642 non-null  object 
 2   behavioral_antiviral_meds    19642 non-null  float64
 3   behavioral_avoidance         19642 non-null  float64
 4   behavioral_face_mask         19642 non-null  float64
 5   behavioral_wash_hands        19642 non-null  float64
 6   behavioral_large_gatherings  19642 non-null  float64
 7   behavioral_outside_home      19642 non-null  float64
 8   behavioral_touch_face        19642 non-null  float64
 9   doctor_recc_h1n1             19642 non-null  float64
 10  doctor_recc_seasonal         19642 non-null  float64
 11  chronic_med_condition        19642 non-null  float64
 12  child_under_6_months         19642 non-null  float64
 13  health_worker                19642 non-null  float64
 14  opinion_h1n1_vacc_effective  19642 non-null  object 
 15  opinion_h1n1_risk            19642 non-null  object 
 16  opinion_h1n1_sick_from_vacc  19642 non-null  object 
 17  opinion_seas_vacc_effective  19642 non-null  object 
 18  opinion_seas_risk            19642 non-null  object 
 19  opinion_seas_sick_from_vacc  19642 non-null  object 
 20  age_group                    19642 non-null  object 
 21  education                    19642 non-null  object 
 22  race                         19642 non-null  object 
 23  sex                          19642 non-null  object 
 24  income_poverty               19642 non-null  object 
 25  marital_status               19642 non-null  object 
 26  rent_or_own                  19642 non-null  object 
 27  employment_status            19642 non-null  object 
 28  hhs_geo_region               19642 non-null  object 
 29  census_msa                   19642 non-null  object 
 30  household_adults             19642 non-null  float64
 31  household_children           19642 non-null  float64
 32  h1n1_vaccine                 19642 non-null  int64  
 33  seasonal_vaccine             19642 non-null  int64  
dtypes: float64(14), int64(2), object(18)
memory usage: 5.2+ MB
```

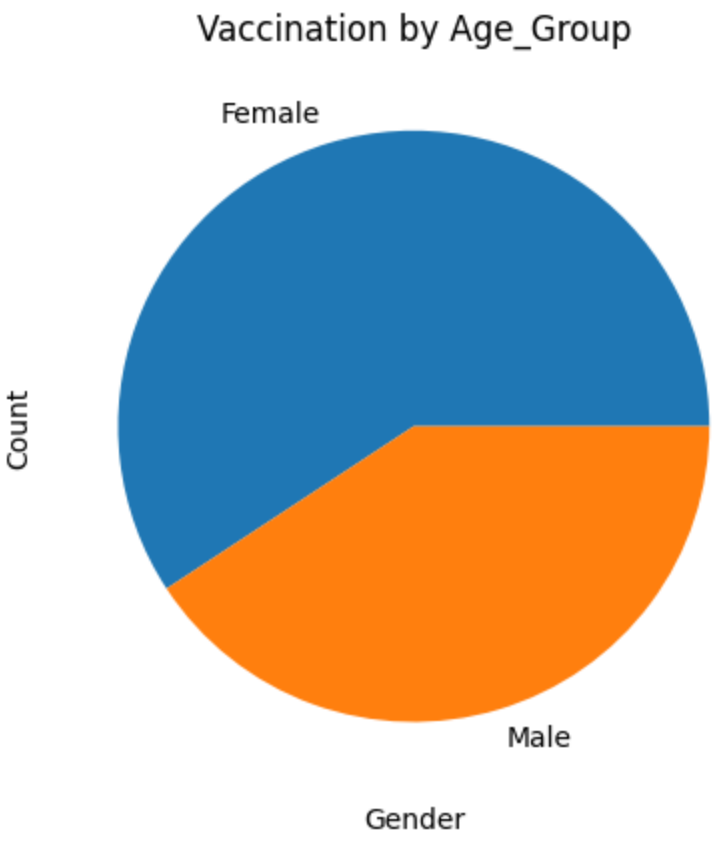
Exploratory Data Analysis

Univariate analysis

In [17]:
```
# Viweing columns for ease of viewing columns for analysis
flu_merged.columns
```

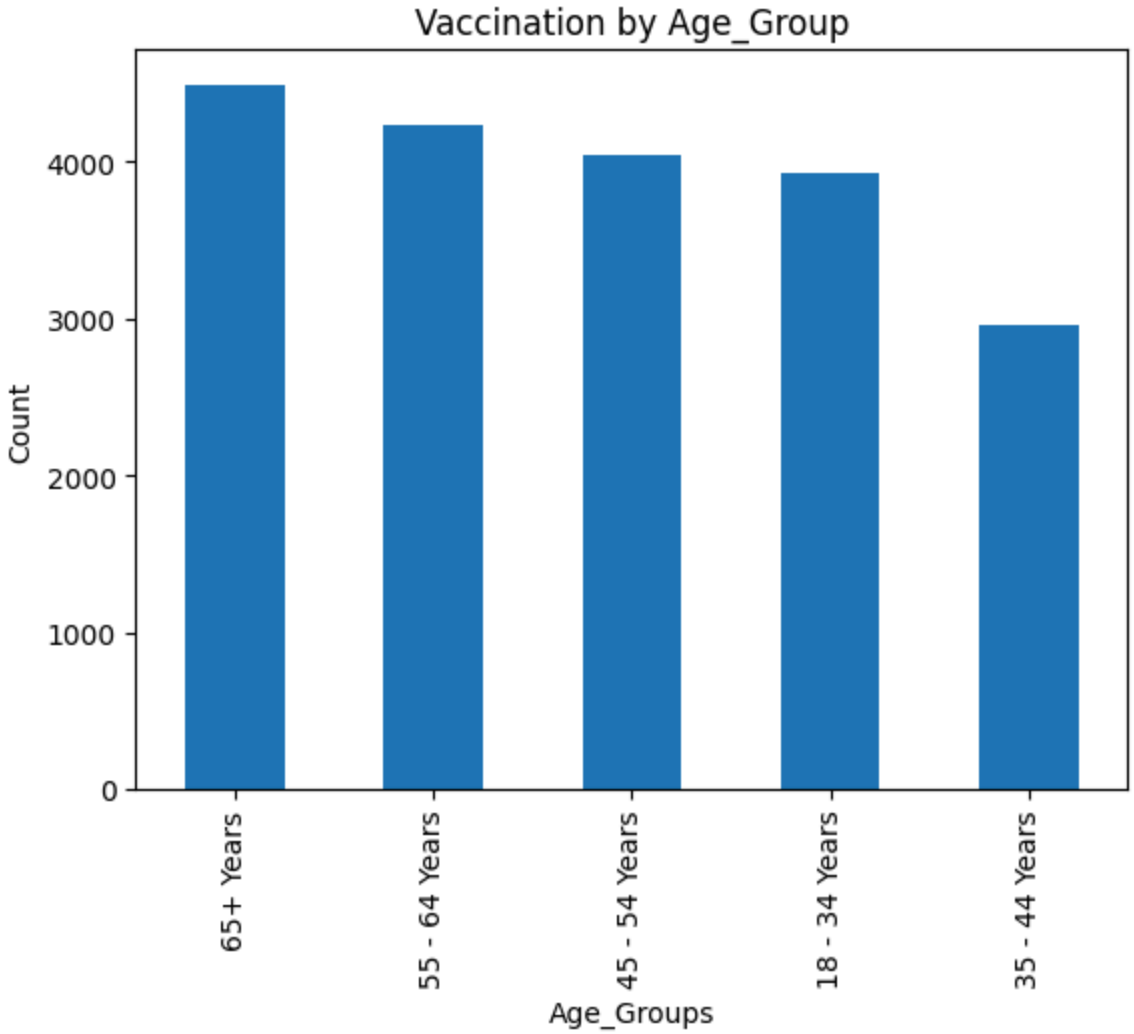
Out[17]:
```
Index(['h1n1_concern', 'h1n1_knowledge', 'behavioral_antiviral_meds',
       'behavioral_avoidance', 'behavioral_face_mask', 'behavioral_wash_hands',
       'behavioral_large_gatherings', 'behavioral_outside_home',
       'behavioral_touch_face', 'doctor_recc_h1n1', 'doctor_recc_seasonal',
       'chronic_med_condition', 'child_under_6_months', 'health_worker',
       'opinion_h1n1_vacc_effective', 'opinion_h1n1_risk',
       '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', 'h1n1_vaccine',
       'seasonal_vaccine'],
      dtype='object')
```

In [18]:
```
#showing data by gender
gender_category_count = flu_merged['sex'].value_counts()
gender_category_count.plot(kind = 'pie', title = 'Vaccination by Age_Group')
plt.xlabel ('Gender')
plt.ylabel ('Count')
plt.show()
```



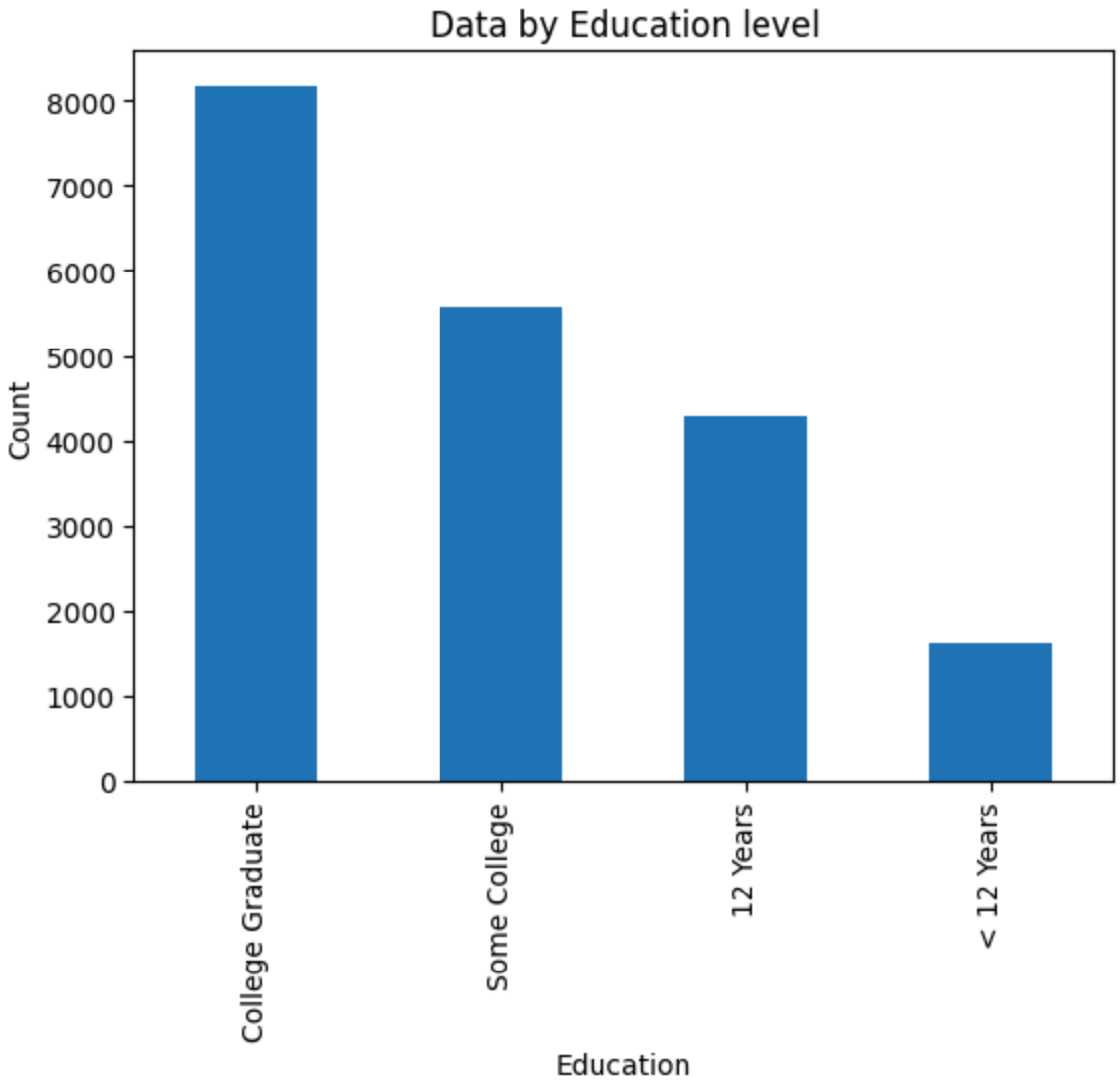
Majority of respondents were female

In [19]:
```
#showing data by age groups
age_category_count = flu_merged['age_group'].value_counts()
age_category_count.plot(kind = 'bar', title = 'Vaccination by Age_Group')
plt.xlabel ('Age_Groups')
plt.ylabel ('Count')
plt.show()
```



Majority of the respondents were 65 years and above and least were between the age group of 35 -44 years

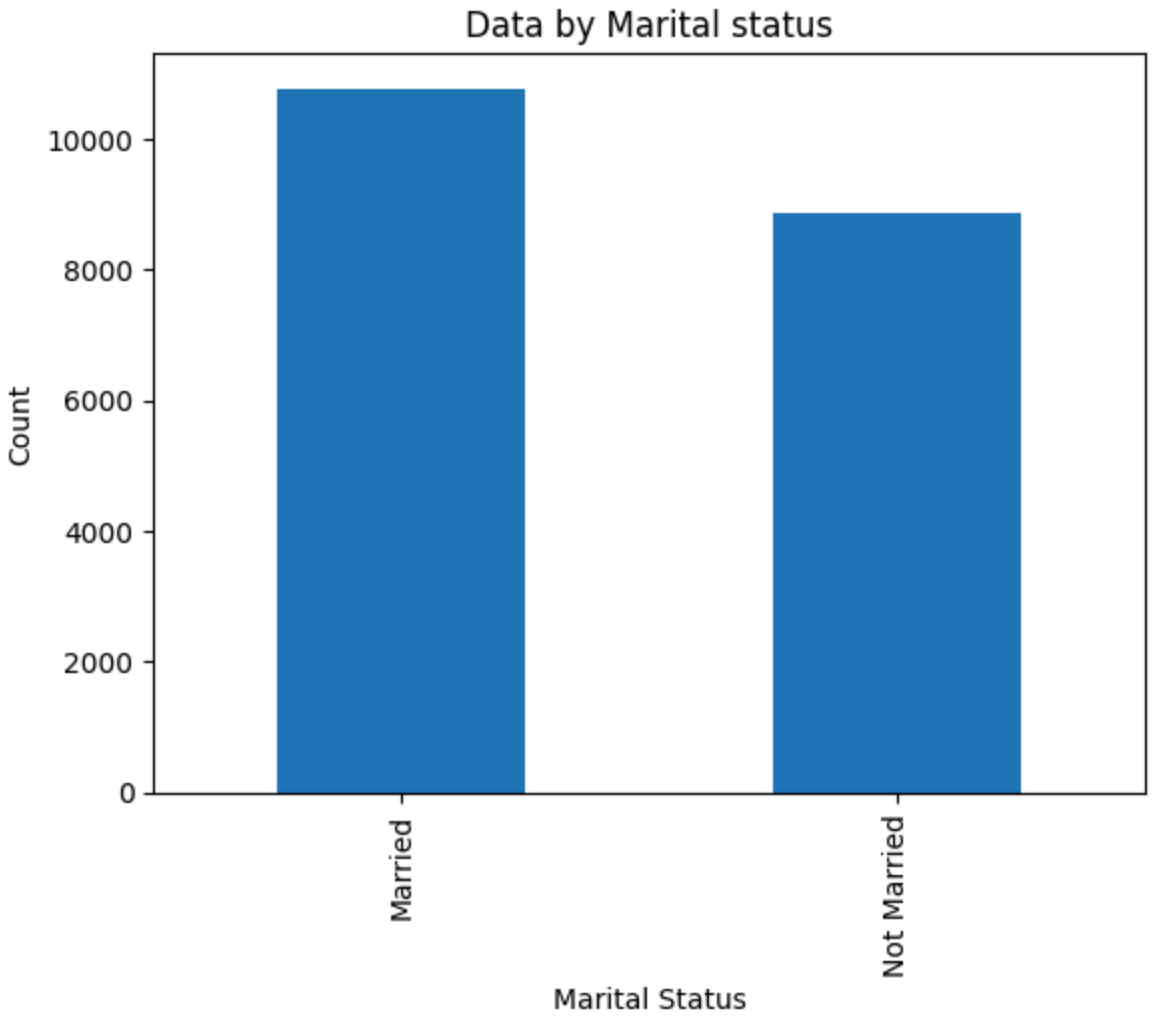
In [20]:
```
#showing data by education
education_category_count = flu_merged['education'].value_counts()
education_category_count.plot(kind = 'bar', title = 'Data by Education level')
plt.xlabel ('Education')
plt.ylabel ('Count')
plt.show()
```



Majority of respondents were college graduates with least being school goes of less than 12 years

In [21]:

```
#showing data by marital status
marital_category_count = flu_merged['marital_status'].value_counts()
marital_category_count .plot(kind = 'bar', title = 'Data by Marital status')
plt.xlabel ('Marital Status')
plt.ylabel ('Count')
plt.show()
```



Most respondents were married

In [22]:
```
#displaying frquencies and percenatges of non numeric columns
non_numeric_columns = flu_merged.select_dtypes(exclude='number')

#creating count and percentage table
for col in non_numeric_columns.columns:
    counts = flu_merged[col].value_counts(dropna=False)
    percentage = flu_merged[col].value_counts(normalize=True, dropna= False)* 100
    summary = pd.DataFrame({'Count': counts, 'Percentage (%)' : percentage.round(2)
    print(summary)
```

```
                     Count  Percentage (%)
h1n1_concern
Somewhat concerend     7989           40.67
Not very concerned     6229           31.71
Very concerend         3175           16.16
Not at all concerned   2249           11.45
                    Count  Percentage (%)
h1n1_knowledge
A little knowledge  10861           55.29
Alot of knowledge    7362           37.48
No Knowledge         1419            7.22
                             Count  Percentage (%)
opinion_h1n1_vacc_effective
Somewhat effective            9172           46.70
Very effective                5715           29.10
Don't know                    2838           14.45
Not very effective            1347            6.86
Not at all effective           570            2.90
                   Count  Percentage (%)
opinion_h1n1_risk
Somewhat low        7691           39.16
Very Low            5881           29.94
Somewhat high       4184           21.30
Very high           1348            6.86
Don't know           538            2.74
                             Count  Percentage (%)
opinion_h1n1_sick_from_vacc
Not very worried              6956           35.41
Not at all worried            6684           34.03
Somewhat worried              4390           22.35
Very worried                  1560            7.94
Don't know                      52            0.26
                             Count  Percentage (%)
opinion_seas_vacc_effective
Somewhat effective            8906           45.34
Very effective                7603           38.71
Not very effective            1638            8.34
Not at all effective           822            4.18
Don't know                     673            3.43
                   Count  Percentage (%)
opinion_seas_risk
Somewhat low        6811           34.68
Somewhat high       5984           30.47
Very Low            4258           21.68
Very high           2286           11.64
Don't know           303            1.54
                             Count  Percentage (%)
opinion_seas_sick_from_vacc
Not at all worried            8996           45.80
Not very worried              5713           29.09
Somewhat worried              3683           18.75
Very worried                  1221            6.22
Don't know                      29            0.15
               Count  Percentage (%)
age_group
65+ Years       4491           22.86
```

```
55 - 64 Years   4234           21.56
45 - 54 Years   4038           20.56
18 - 34 Years   3925           19.98
35 - 44 Years   2954           15.04
                  Count  Percentage (%)
education
College Graduate   8165           41.57
Some College       5570           28.36
12 Years           4287           21.83
< 12 Years         1620            8.25
                   Count  Percentage (%)
race
White              15745           80.16
Black               1474            7.50
Hispanic            1295            6.59
Other or Multiple   1128            5.74
        Count  Percentage (%)
sex
Female  11638           59.25
Male     8004           40.75
                          Count  Percentage (%)
income_poverty
<= $75,000, Above Poverty  11185           56.94
> $75,000                   6159           31.36
Below Poverty               2298           11.70
                Count  Percentage (%)
marital_status
Married         10768           54.82
Not Married      8874           45.18
             Count  Percentage (%)
rent_or_own
Own          14980           76.27
Rent          4662           23.73
                     Count  Percentage (%)
employment_status
Employed            11093           56.48
Not in Labor Force   7417           37.76
Unemployed           1132            5.76
                Count  Percentage (%)
hhs_geo_region
lzgpxyit         3098           15.77
fpwskwrf         2328           11.85
qufhixun         2309           11.76
oxchjgsf         2171           11.05
bhuqouqj         2138           10.88
kbazzjca         2062           10.50
mlyzmhmf         1658            8.44
lrircsnp         1541            7.85
atmpeygn         1521            7.74
dqpwygqj          816            4.15
                         Count  Percentage (%)
census_msa
MSA, Not Principle  City   8571           43.64
MSA, Principle City        5717           29.11
Non-MSA                    5354           27.26
```

From the table generated we can oberve that

1. majority of respondent were Somewhat concerend of HIN1 at 40.67%
2. Respondent stated that HINI vaccine was Somewhat effective at 46.70
3. Were aware that H1N1 vaccintion provided Somewhat low riks after vaccination 39.16

In [23]:
```
#show numeric data summary
flu_merged.describe()
```

Out[23]:

	behavioral_antiviral_meds	behavioral_avoidance	behavioral_face_mask	behavioral_wa
count	19642.000000	19642.000000	19642.000000	196
mean	0.049435	0.740454	0.067712	
std	0.216780	0.438397	0.251258	
min	0.000000	0.000000	0.000000	
25%	0.000000	0.000000	0.000000	
50%	0.000000	1.000000	0.000000	
75%	0.000000	1.000000	0.000000	
max	1.000000	1.000000	1.000000	

Bivariate Analysis

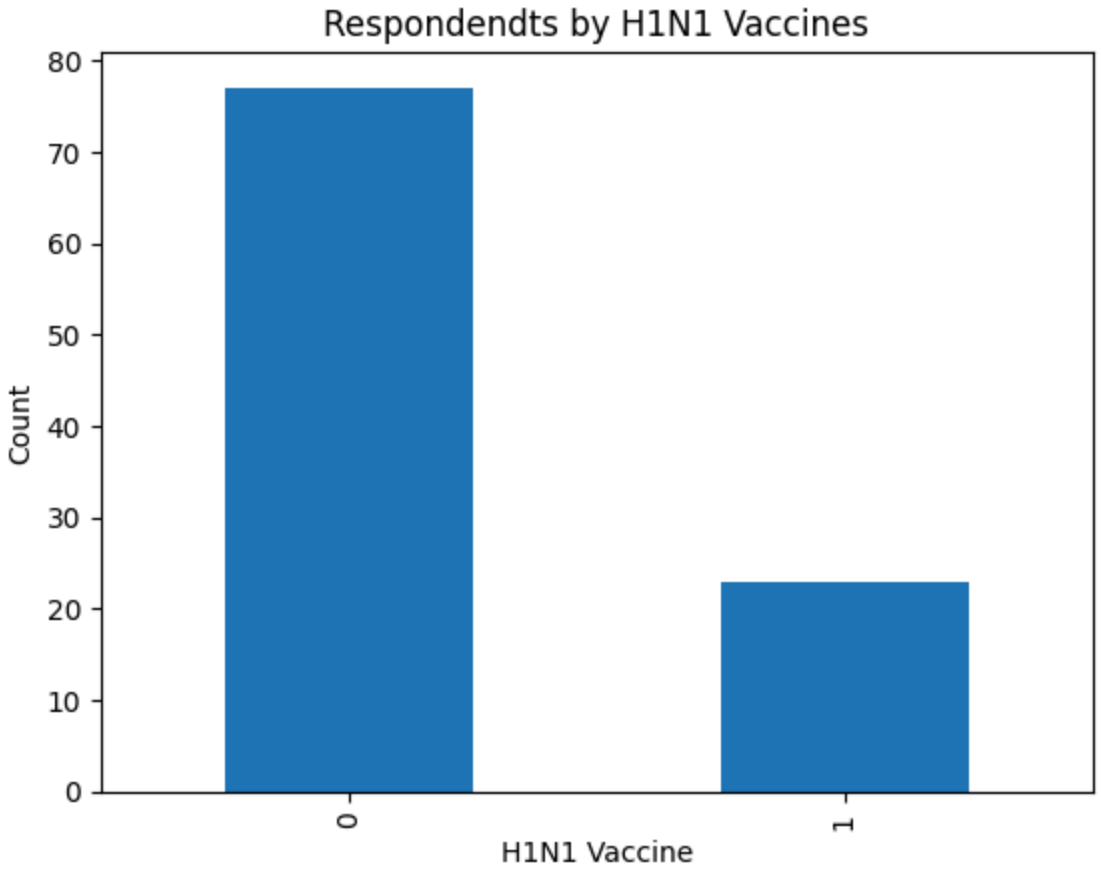
Analysis of demographic, behavioral and opinions by vaccination status

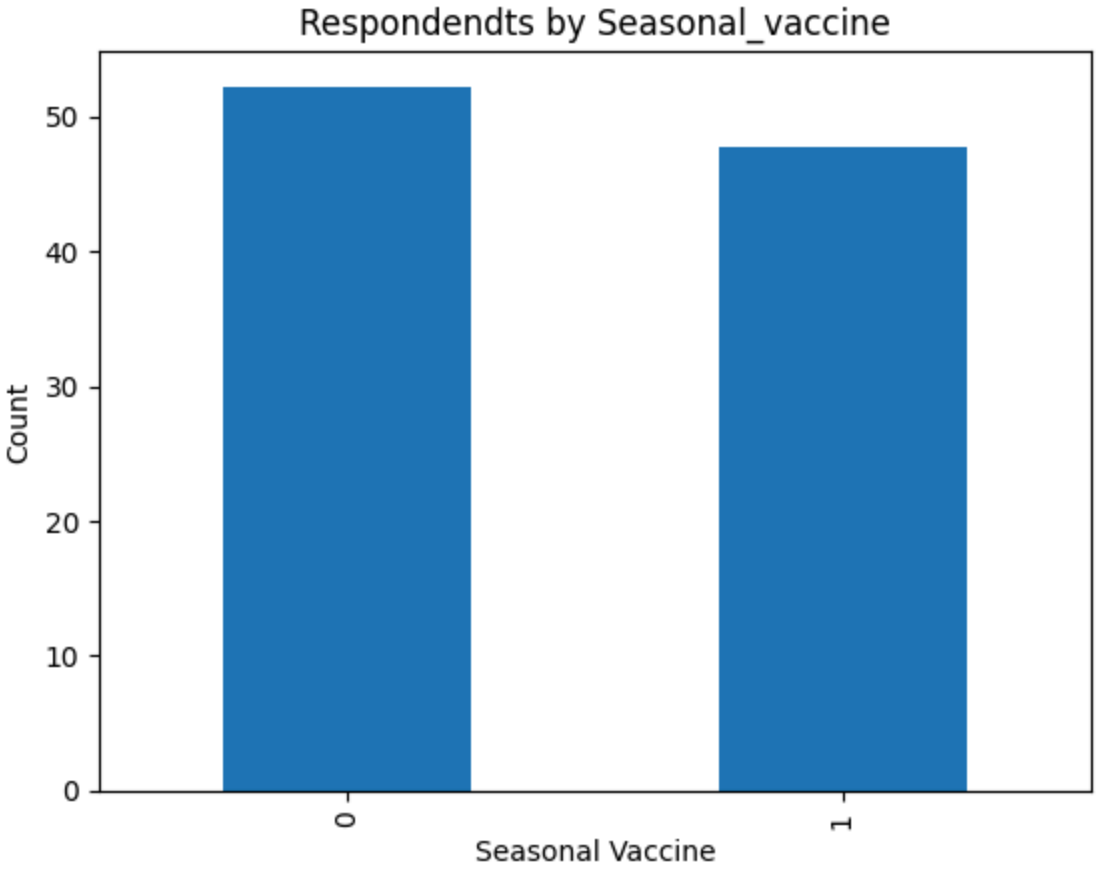
Vaccinated = '1'

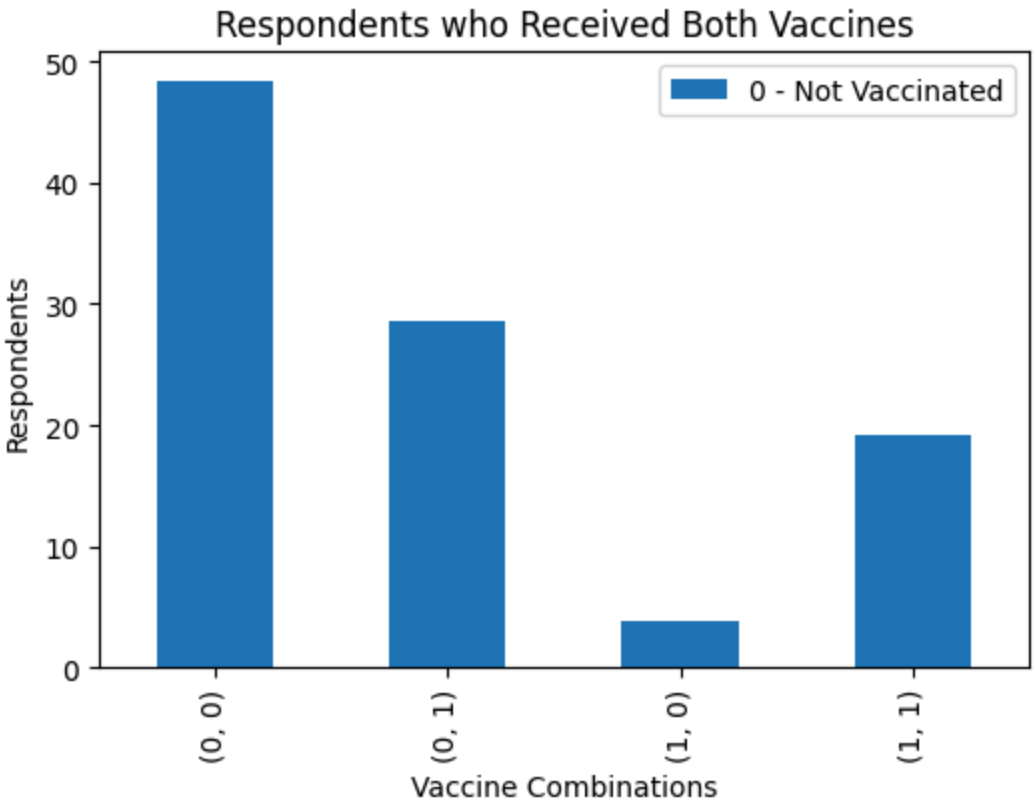
Not Vaccinate = '0'

In [24]:
```
#Show respondents by vaccine type
#H1N1 Vaccine
HIN1_vaccine = flu_merged['h1n1_vaccine'].value_counts() / len(flu_merged['h1n1_vac
HIN1_vaccine.plot (kind = 'bar', title = 'Respondendts by H1N1 Vaccines')
plt.xlabel ('H1N1 Vaccine')
plt.ylabel ('Count')
plt.show()

#Seasonal vaccine
Seasonal_vaccine = flu_merged['seasonal_vaccine'].value_counts() / len(flu_merged['
Seasonal_vaccine.plot (kind = 'bar', title = 'Respondendts by Seasonal_vaccine')
plt.xlabel ('Seasonal Vaccine')
plt.ylabel ('Count')
plt.show()
```

```
# Both vaccines
# Calculate the count of participants who took each combination of vaccines
vaccine_counts = flu_merged.groupby(['h1n1_vaccine', 'seasonal_vaccine']).size() /

#Bar graph for the vaccine combinations
plt.figure(figsize=(6, 4))
vaccine_counts.plot.bar()
plt.xlabel('Vaccine Combinations')
plt.ylabel('Respondents')
plt.title('Respondents who Received Both Vaccines')
plt.legend(['0 - Not Vaccinated', '1 - Vaccinated'])
plt.show()
```







Observation Percentage of respondents who received only H1N1: 21% Percentage of respondents who received only Seasonal Vaccine: 46% Percentage of respondents who

received both vaccines about 18% Percentage of respondents who received one of the vaccines about 48%

Plotting vaccination status by:

1. Demogrphic variables, we will use age group, gender , marital status, race, employment status
2. By opinions (Attitude) we will use :opinion_h1n1_vacc_effective', 'opinion_h1n1_risk','opinion_h1n1_sick_from_vacc', 'opinion_seas_vacc_effective','opinion_seas_risk'
3. By behaviour(practices) we will use 'behavioral_face_mask', 'behavioral_wash_hands','behavioral_large_gatherings'

In [25]:
```
#Introdcuing a new column by combining vaccination columns to show vaccination stat
flu_merged['vaccination_status'] = flu_merged['h1n1_vaccine'] + flu_merged['seasona
flu_merged['vaccination_status'] = flu_merged['vaccination_status'].map({2: 'both',
flu_merged.tail()
```

Out[25]:

respondent_id	h1n1_concern	h1n1_knowledge	behavioral_antiviral_meds	behavioral_avoida
26700	Very concerend	A little knowledge	0.0	
26701	Somewhat concerend	Alot of knowledge	0.0	
26702	Somewhat concerend	No Knowledge	0.0	
26703	Not very concerned	Alot of knowledge	0.0	
26706	Not at all concerned	No Knowledge	0.0	

5 rows × 35 columns

Demographic variables

In [26]:
```
#selecting the data to plot only for demographic variables and vaccination status
demographic_data = flu_merged[['age_group', 'race', 'sex','marital_status', 'employ
                               'h1n1_vaccine', 'seasonal_vaccine']]
demographic_data
```

Out[26]:

respondent_id	age_group	race	sex	marital_status	employment_status	race	vaccin
0	55 - 64 Years	White	Female	Not Married	Not in Labor Force	White	
1	35 - 44 Years	White	Male	Not Married	Employed	White	
3	65+ Years	White	Female	Not Married	Not in Labor Force	White	
4	45 - 54 Years	White	Female	Married	Employed	White	
5	65+ Years	White	Male	Married	Employed	White	
...	...	...	...	...	...	...	
26700	55 - 64 Years	White	Female	Married	Not in Labor Force	White	
26701	18 - 34 Years	White	Female	Not Married	Not in Labor Force	White	
26702	65+ Years	White	Female	Not Married	Not in Labor Force	White	
26703	18 - 34 Years	White	Male	Not Married	Employed	White	
26706	65+ Years	White	Male	Married	Not in Labor Force	White	

19642 rows × 9 columns

Chi -squared test for association

Using combine vaccination status column as outcome

In [27]:
```
#conducting test of association between demographics assessed and vaccination statu
from scipy import stats
demographic_data = flu_merged[['age_group', 'race', 'sex','marital_status', 'employ
results = []
for col in demographic_data:
    contingency = pd.crosstab(flu_merged[col], flu_merged['vaccination_status'])

    chi2, p, _, _ = stats.chi2_contingency(contingency)
    results.append({
        'variable': col,
        'Test': 'Chi-squared',
        'p-value': round (p, 50),
        'Contingency Shape': contingency.shape
    })
```

```
summary_demographics = pd.DataFrame(results)
print(summary_demographics)
```

```
            variable         Test       p-value Contingency Shape
0          age_group  Chi-squared  0.000000e+00            (5, 3)
1               race  Chi-squared  2.405942e-37            (4, 3)
2                sex  Chi-squared  2.293237e-25            (2, 3)
3     marital_status  Chi-squared  4.226012e-19            (2, 3)
4  employment_status  Chi-squared  0.000000e+00            (3, 3)
5               race  Chi-squared  2.405942e-37            (4, 3)
6  vaccination_status  Chi-squared  0.000000e+00            (3, 3)
7       h1n1_vaccine  Chi-squared  0.000000e+00            (2, 3)
8    seasonal_vaccine  Chi-squared  0.000000e+00            (2, 3)
```

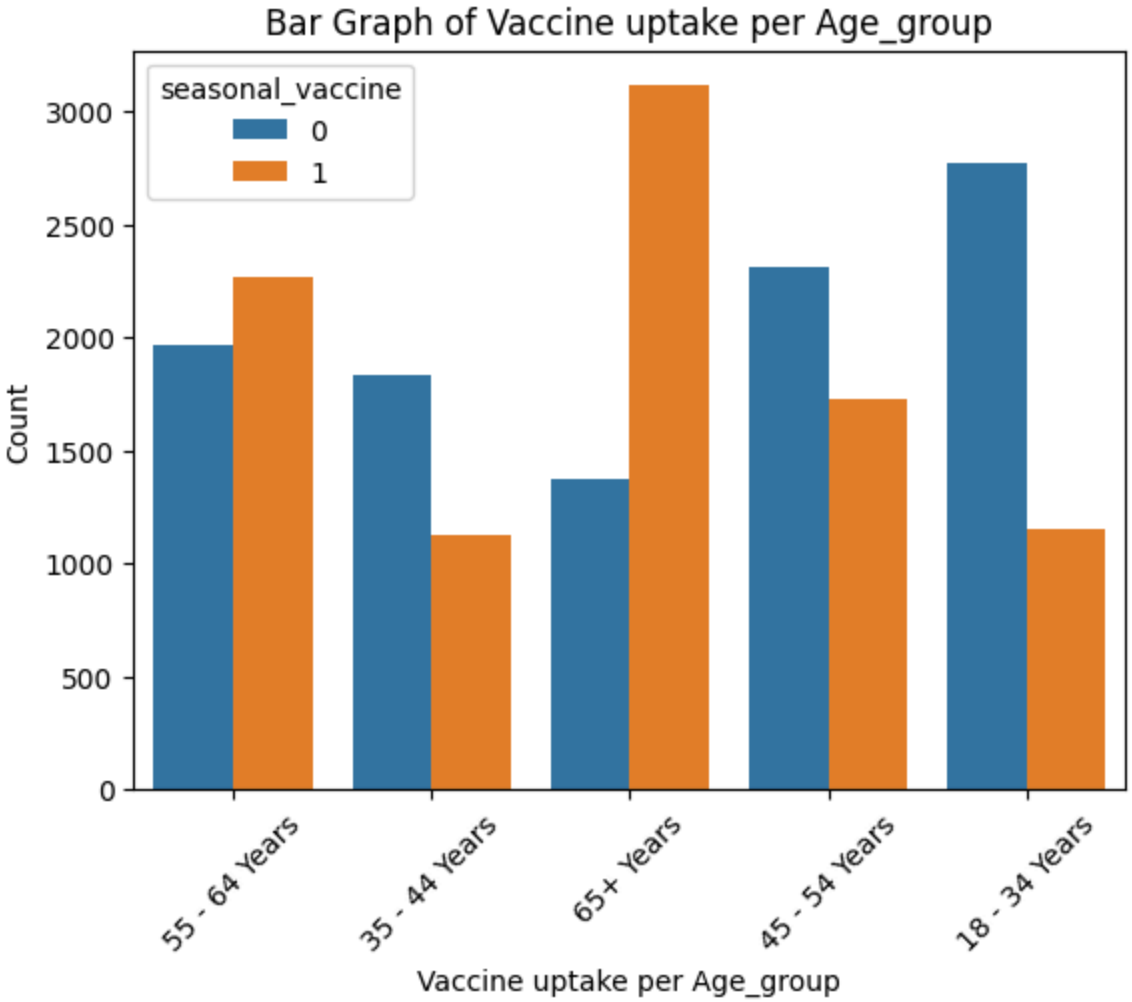
P values of< 0.05 in all variables inidcate that all demograghic variables assessed are determinats of vaccination

In [28]:
```
#conducting test of association between opinions assessed and vaccination status
opinions_data = flu_merged[['opinion_h1n1_vacc_effective', 'opinion_h1n1_risk', 'op
                        'opinion_h1n1_sick_from_vacc', 'opinion_seas_risk', 'opinion
results = []
for col in opinions_data:
    contingency = pd.crosstab(opinions_data[col],opinions_data['vaccination_status'
    chi2, p, _ , _ = stats.chi2_contingency(contingency)
    results.append({
        'variable': col,
        'Test': 'Chi-squared',
        'p-value': round (p, 50),
        'Contingency Shape': contingency.shape
    })

summary_opinions = pd.DataFrame(results)
print(summary_opinions)
```

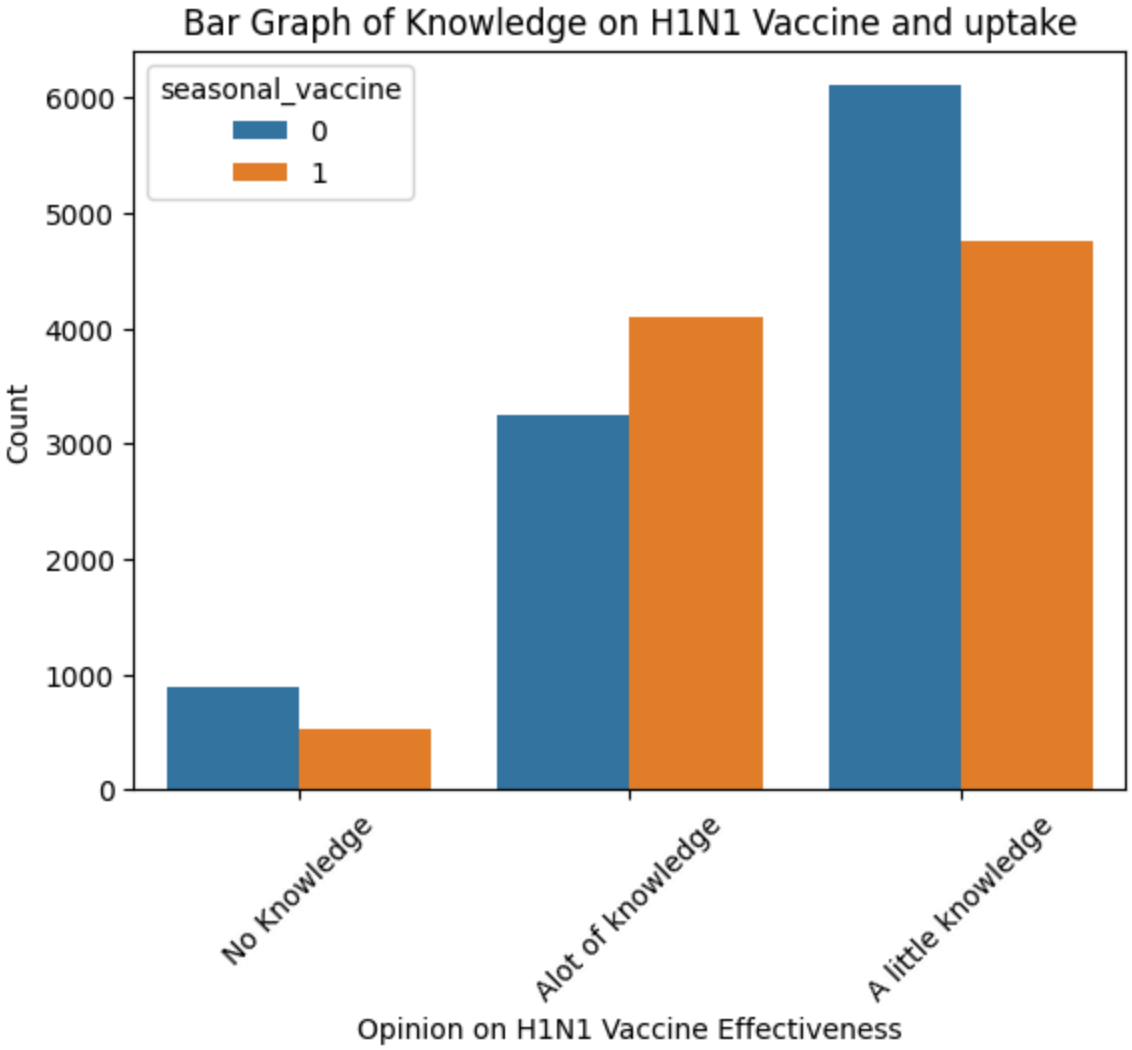
```
                     variable         Test       p-value Contingency Shape
0  opinion_h1n1_vacc_effective  Chi-squared  0.000000e+00            (5, 3)
1           opinion_h1n1_risk  Chi-squared  0.000000e+00            (5, 3)
2  opinion_seas_vacc_effective  Chi-squared  0.000000e+00            (5, 3)
3  opinion_h1n1_sick_from_vacc  Chi-squared  2.175112e-44            (5, 3)
4           opinion_seas_risk  Chi-squared  0.000000e+00            (5, 3)
5  opinion_seas_sick_from_vacc  Chi-squared  1.881035e-35            (5, 3)
6          vaccination_status  Chi-squared  0.000000e+00            (3, 3)
7               h1n1_vaccine  Chi-squared  0.000000e+00            (2, 3)
8             seasonal_vaccine  Chi-squared  0.000000e+00            (2, 3)
```

P values of <0.05 in all variables inidcate that all opinions assessed are determinats of vaccination

In [29]:
```
#create a plot to show association between knowledge and vaccination of Seasonal va
sns.countplot ( data = flu_merged, x = 'age_group', hue = 'seasonal_vaccine')
plt.xlabel('Vaccine uptake per Age_group')
plt.ylabel('Count')
plt.title('Bar Graph of Vaccine uptake per Age_group')
plt.xticks(rotation=45)
plt.show()
```

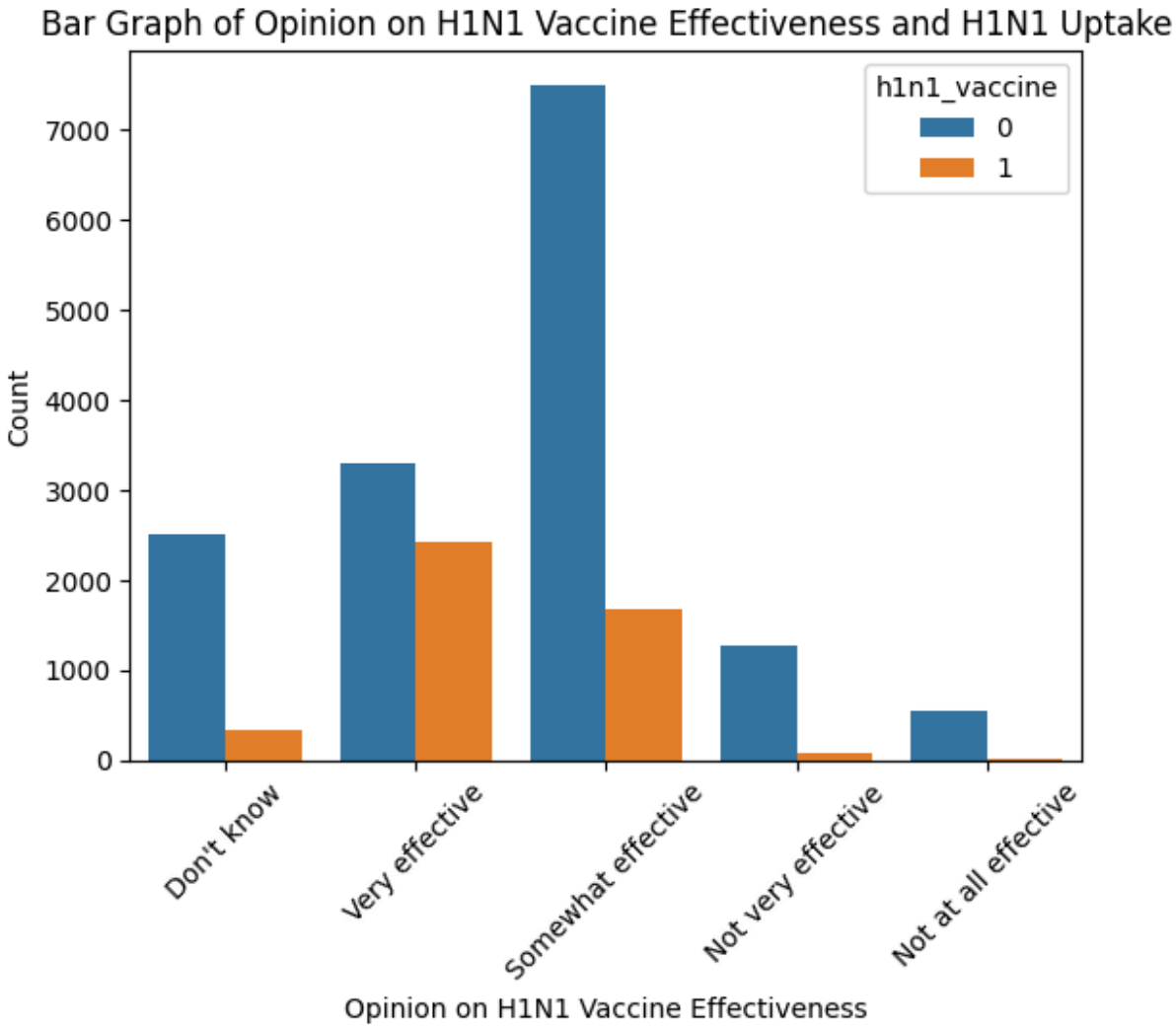


In [30]:
```
#create a plot to show association between knowledge and vaccination of Seasonal va
sns.countplot ( data = flu_merged, x = 'h1n1_knowledge', hue = 'seasonal_vaccine')
plt.xlabel('Opinion on H1N1 Vaccine Effectiveness')
plt.ylabel('Count')
plt.title('Bar Graph of Knowledge on H1N1 Vaccine and uptake')
plt.xticks(rotation=45)
plt.show()
```



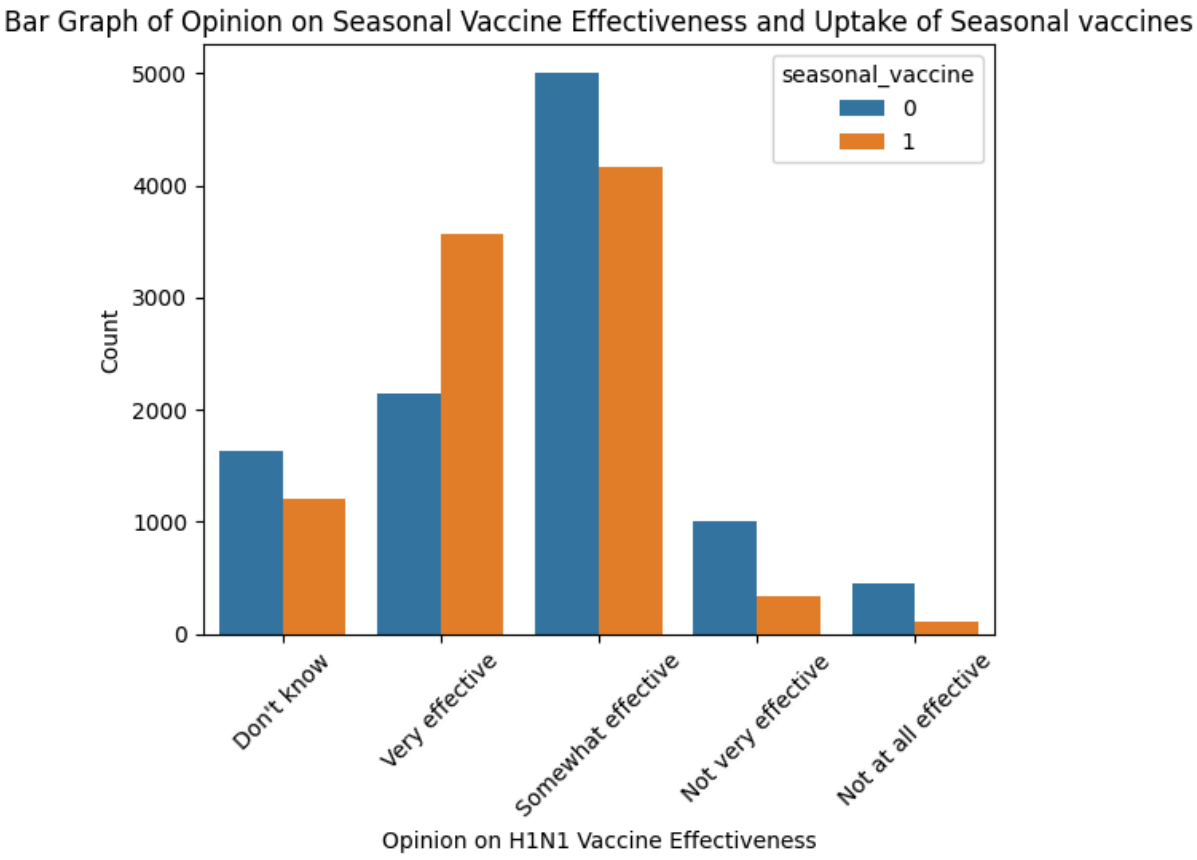
Increased uptake with increase in knowlege on H1N1 vaccine

In [31]:
```
#create a plot to show association between opinion and vaccination of H1N1
sns.countplot ( data = flu_merged, x = 'opinion_h1n1_vacc_effective', hue = 'h1n1_v
plt.xlabel('Opinion on H1N1 Vaccine Effectiveness')
plt.ylabel('Count')
plt.title('Bar Graph of Opinion on H1N1 Vaccine Effectiveness and H1N1 Uptake')
plt.xticks(rotation=45)
plt.show()
```



H1N1 Vaccine effectiveness: Majority of the vaccinated reported the vaccine to be very effective while majority of unvaccinated decalred it as somewhat effective

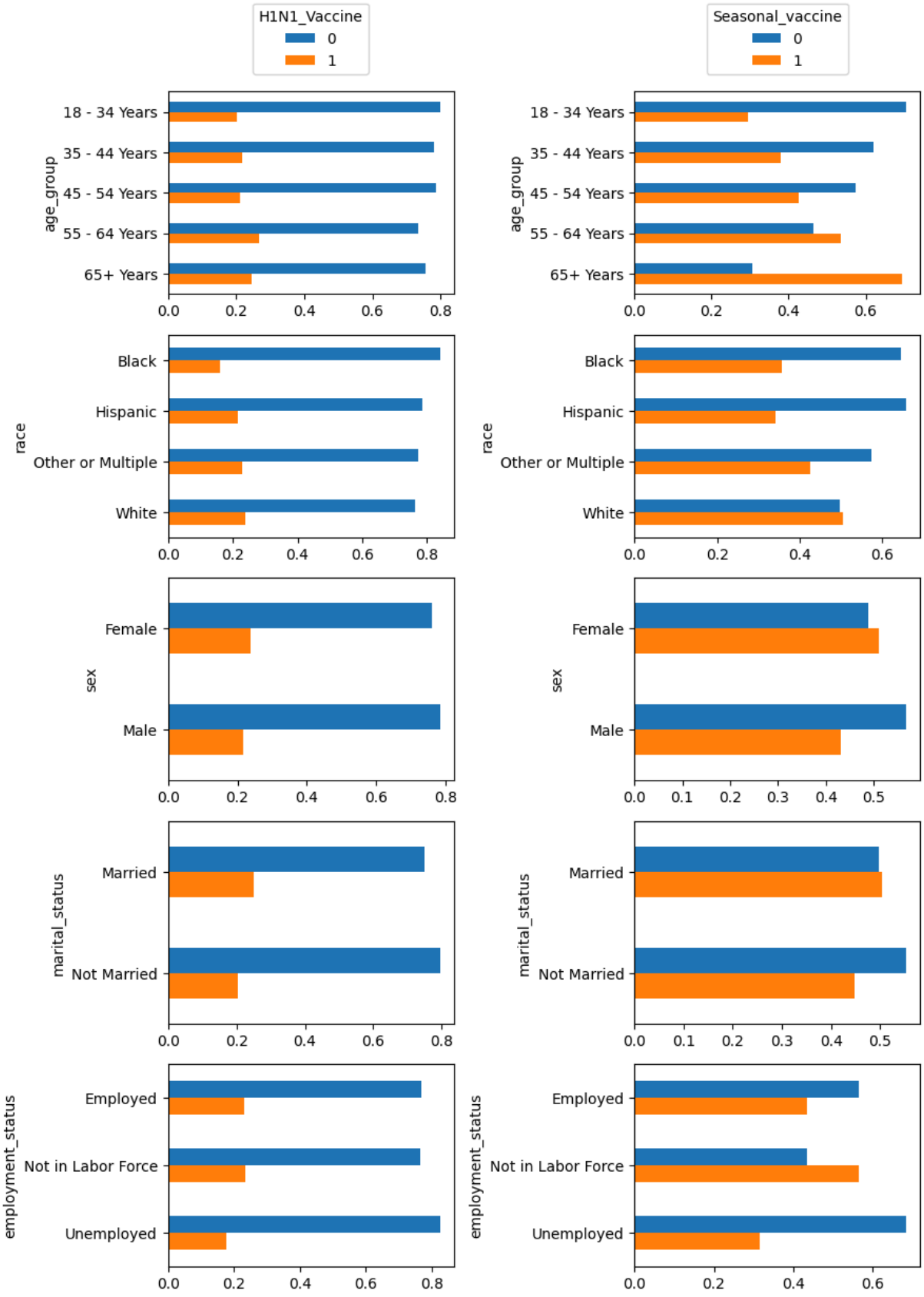
In [32]:
```
#create a plot to show association between opinion and vaccination of Seasonal vacc
sns.countplot ( data = flu_merged, x = 'opinion_h1n1_vacc_effective', hue = 'season
plt.xlabel('Opinion on H1N1 Vaccine Effectiveness')
plt.ylabel('Count')
plt.title('Bar Graph of Opinion on Seasonal Vaccine Effectiveness and Uptake of Sea
plt.xticks(rotation=45)
plt.show()
```



Seasonal Vaccine effectiveness: Majority of the vaccinated and unvaccinated reported the vaccine to be somewhat effective while few of the vaccinated also reported the vaccine to be not effective at all

In [33]:
```
#plotting a group bar chart sgowing association between demographics and vaccine up

def vaccination_rate_plot(col, target, flu_merged, ax=None):
    """Stacked bar chart of vaccination rate for `target` against
    `col`.

    Args:
        col (string): column name of feature variable
        target (string): column name of target variable
        df (pandas DataFrame): dataframe that contains columns
            `col` and `target`
        ax (matplotlib axes object, optional): matplotlib axes
            object to attach plot to
    """
    counts = (flu_merged[[target, col]]
                  .groupby([target, col])
                  .size()
                  .unstack(target)
              )
    group_counts = counts.sum(axis='columns')
    props = counts.div(group_counts, axis='index')

    props.plot(kind='barh', stacked=False, ax=ax)
    ax.invert_yaxis()
    ax.legend().remove()
```

```
cols_to_plot = ['age_group', 'race', 'sex','marital_status', 'employment_status']

fig, ax = plt.subplots(len(cols_to_plot), 2, figsize=(9, len(cols_to_plot) * 2.5))
for idx, col in enumerate(cols_to_plot):
    vaccination_rate_plot(col, 'h1n1_vaccine', flu_merged, ax=ax[idx, 0])
    vaccination_rate_plot(col, 'seasonal_vaccine', flu_merged, ax=ax[idx, 1])

ax[0, 0].legend(loc='lower center', bbox_to_anchor=(0.5, 1.05), title='H1N1_Vaccine
ax[0, 1].legend(loc='lower center', bbox_to_anchor=(0.5, 1.05), title='Seasonal_vac
fig.tight_layout()
plt.show();
```



Observations

Age group

1. H1N1 Vaccine, had almost equal distribution across the age groups however the age group between 55-64 recorded the highest
2. Seasonal vaccine,uptake increased with increas in age group with the highest uptake recorded in age group 65

Race

3. White race recorded hghest uptake for both Seasonal vaccine and H1N1 vaccine compared to all other races while blacks recorded lowest uptake for both vaccines

Sex

4. Almost equal proportion of men and women received H1N1 vaccine, however women recieved slightly more vaccines as compared to men for both strains

Marital Status

5. Higher uptake recorded among married couples for both vaccines

Education

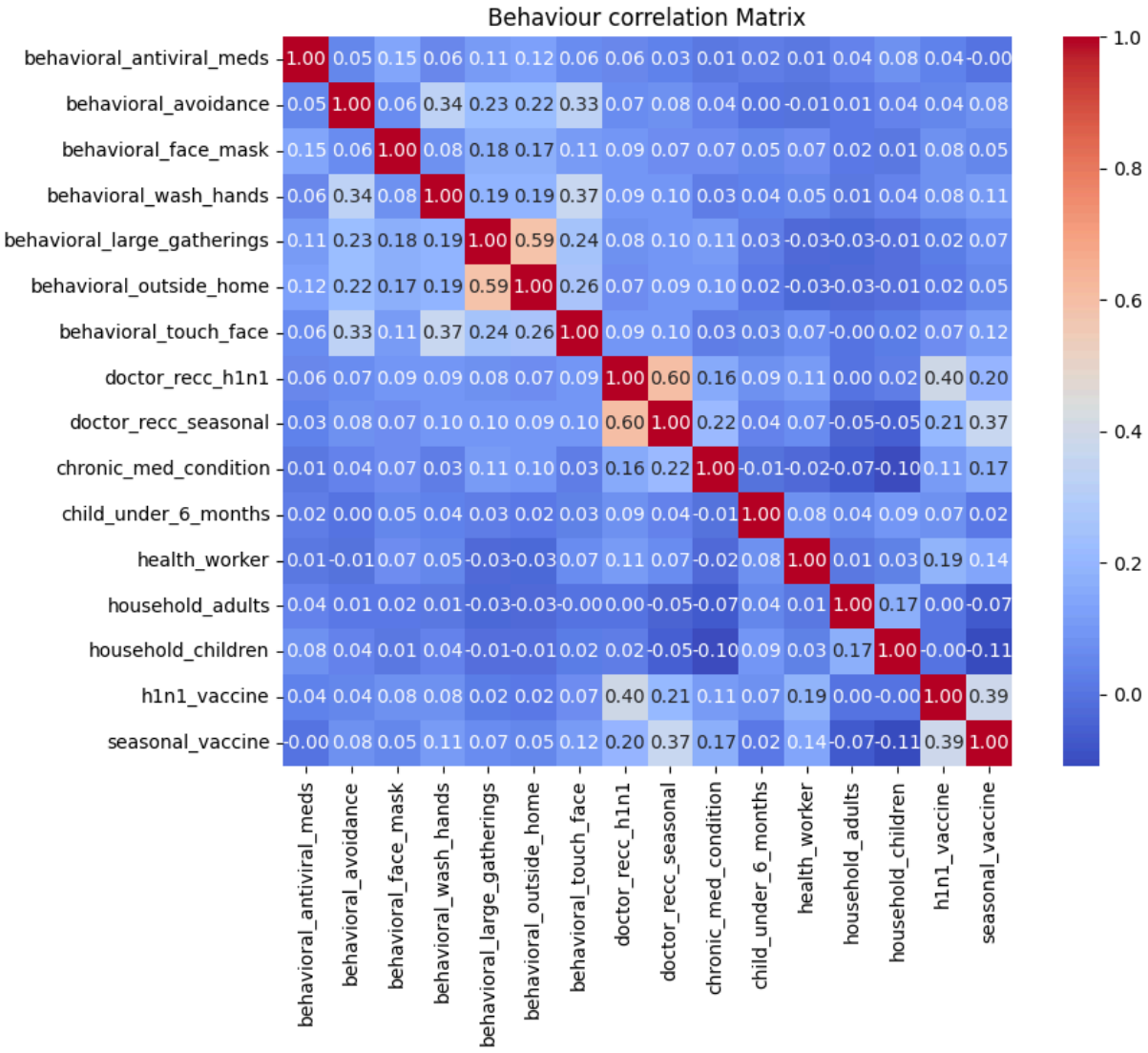
6. College graduates made the majority of those who received both H1N1 Vaccine and Seasonal vaccine

Employment status

7. Workers not in labour force were the highest vaccinated group for both H1N1 and Seasonal vaccines with unemployed recording lowest numbers for both vaccines

Correlation matrix for behaviour/practice in regard to vaccination status

In [34]:
```
numeric_df = flu_merged.select_dtypes(include = 'number')


corr_matrix = numeric_df.corr()
plt.figure(figsize=(10,8))
sns.heatmap(corr_matrix, annot = True, fmt = ".2f", cmap = 'coolwarm', square = Tru
plt.title('Behaviour correlation Matrix')
plt.tight_layout()
plt.show()
```



Behavioural Factors that influence vaccination

1. High correlation between Doctor_reccomendation for vaccination for both h1n1 (0.40) and seasonal flu vaccine (0.21) and taking the actual vaccines.This highlights the critical role of healthcare professionals in influencing vaccine decisions.

2. Seasonal_vaccine (0.37) and h1n1_vaccine (0.40). Respondents who took the seasonal flu vaccine are also more likely to take the H1N1 vaccine, suggesting general vaccine receptiveness.

3. Doctor_recc_seasonal (0.21): Recommendations for seasonal flu vaccination also correlate positively, though less strongly than for H1N1-specific recommendations.

4. Repondents with chronic show increased uptake of vaccine , more so seasonal vaccine (0.17) as compared to (0.11) H1N1 vaccine

5. There is moderate correlation between being a healthcare workers and taking both seasonal vaccine (0.14) and H1N1 vaccines (0.19)

6. low correlation is observed between having a face mask (0.12), frequently washing hands (0.11) and taking the seasonal flu vaccine uptake.

7. Most behavioral variables such as mask-wearing, hand-washing, or avoiding close contact with others, reduced time at large gatherings, using face mask, and reduced contact with people outsde home show near-zero correlations, indicating minimal direct relationship with H1N1 vaccine

Multivariate Analysis

Modelling data

Models used

1. Logistic regression model
2. Decision tree model

In [35]:
```
import pickle, sklearn
from sklearn.model_selection import train_test_split
from sklearn.preprocessing import StandardScaler
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, roc_curve, roc_auc_score
from numbers import Number
```

In [36]:
```
#loading original data set with numerical data
flu_dataset_2 = pd.read_csv("training_set_features_original.csv", index_col="respon

#droping non numeric
#flu_dataset_2_numeric = flu_dataset_2.apply (pd.to_numeric, errors = 'coerce')


#flu_dataset_2_cleaned = flu_dataset_2_numeric.dropna()

flu_dataset_2_numeric = flu_dataset_2.select_dtypes(include = ['number'])



flu_dataset_2_numeric.head()
```

Out[36]:

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

5 rows × 23 columns

In [37]:
```
#We merge dataframes on respondent_id to merge all variable in one
flu_merged_2 = pd.merge(flu_dataset_2_numeric, vaccination_status, on='respondent_i
flu_merged_2.head()
```

Out[37]:

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

5 rows × 25 columns

In [38]:
```
#dropping missing values
flu_merged_2 = flu_merged_2.dropna()
```

In [39]:
```
#combine y vaccine variables to have one outcome
flu_merged_2 ['Combined_vaccine_status'] = flu_merged_2['h1n1_vaccine'] + flu_merge
flu_merged_2['Combined_vaccine_status'] = flu_merged_2['Combined_vaccine_status'].m
flu_merged_2.tail()
```

Out[39]:

respondent_id	h1n1_concern	h1n1_knowledge	behavioral_antiviral_meds	behavioral_avoida
26697	1.0	1.0	0.0	
26699	2.0	2.0	0.0	
26701	2.0	2.0	0.0	
26703	1.0	2.0	0.0	
26706	0.0	0.0	0.0	

5 rows × 26 columns

In [40]:
```
X = flu_merged_2
y = flu_merged_2['Combined_vaccine_status']
```

In [41]:
```
#splitting the data set
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.2,random_state =42
```

In [42]:
```
X_train.head()
```

Out[42]:

respondent_id	h1n1_concern	h1n1_knowledge	behavioral_antiviral_meds	behavioral_avoida
8530	3.0	1.0	0.0	
26289	1.0	1.0	0.0	
11056	1.0	1.0	0.0	
8303	0.0	1.0	0.0	
4880	2.0	2.0	0.0	

5 rows × 26 columns

In [43]:
```
X_test.head()
```

Out[43]:

respondent_id	h1n1_concern	h1n1_knowledge	behavioral_antiviral_meds	behavioral_avoida
8066	2.0	1.0	0.0	
18432	2.0	2.0	0.0	
6895	2.0	1.0	0.0	
4428	1.0	1.0	0.0	
12108	2.0	1.0	0.0	

5 rows × 26 columns

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

Out[44]:
```
respondent_id
8530     1
26289    1
11056    0
8303     0
4880     0
Name: Combined_vaccine_status, dtype: int64
```

In [45]:
```
y_test.head()
```

Out[45]:
```
respondent_id
8066     1
18432    2
6895     0
4428     0
12108    0
Name: Combined_vaccine_status, dtype: int64
```

In [46]:
```
print(f'y_train shape: {y_train.shape}')
print(f'y_test shape: {y_test.shape}')
print(f'X_train shape: {X_train.shape}')
print(f'X_test shape: {X_test.shape}')
```

```
y_train shape: (10804,)
y_test shape: (2702,)
X_train shape: (10804, 26)
X_test shape: (2702, 26)
```

Scaling the model

In [47]:
```
# Import StandardScaler
from sklearn.preprocessing import StandardScaler

# Instantiate a scaler object
scaler = StandardScaler()
```

```
# Fit the scaler on X_train and transform X_train
X_train_scaled = scaler.fit_transform(X_train)

# Transform X_test
X_test_scaled = scaler.transform(X_test)
```

Building a logistic regression model and decision tree model to compare ROC and AUC of the the two models

Logistic Regression

In [48]:
```
#logistic regression model
from sklearn.linear_model import LogisticRegression
from sklearn.metrics import accuracy_score, classification_report

# training the model
model = LogisticRegression()
model.fit(X_train_scaled, y_train)
```

Out[48]:
```
LogisticRegression()
```

In [49]:
```
#predicting and evaluating the model
y_pred = model.predict(X_test_scaled)
accuracy = accuracy_score(y_test, y_pred)

print("Accuarcy", accuracy)
print("Classification Report:\n", classification_report(y_test, y_pred))
```

```
Accuarcy 1.0
Classification Report:
              precision    recall  f1-score   support

           0       1.00      1.00      1.00      1255
           1       1.00      1.00      1.00       793
           2       1.00      1.00      1.00       654

    accuracy                           1.00      2702
   macro avg       1.00      1.00      1.00      2702
weighted avg       1.00      1.00      1.00      2702
```

In [50]:
```
#cross validation of model
from sklearn.model_selection import cross_val_score
score = cross_val_score(model, X, y ,cv=5, scoring = 'accuracy')
print('Cross_Validated accuracy scores:' , score)
print('Mean accuracy:', score.mean())
```

```
Cross_Validated accuracy scores: [1. 1. 1. 1. 1.]
Mean accuracy: 1.0
```

Model is accuartely predicting

Model 2 will be a decison tree model to comapre with logistic model

In [51]:
```
from sklearn.tree import DecisionTreeClassifier
from sklearn.model_selection import train_test_split
from sklearn.metrics import accuracy_score

#Data set
X = flu_merged_2
y = flu_merged_2['Combined_vaccine_status']

#splitting data set into train and test
X_train,X_test,y_train,y_test = train_test_split(X,y,test_size=0.3,random_state =42

#initailizing and training the decision tree model
model = DecisionTreeClassifier()
model.fit(X_train, y_train)

#predicting
y_pred = model.predict(X_test)

#evaluating the models accuracy
accuracy = accuracy_score(y_test, y_pred)
print(f"Accuracy:{accuracy:.2f}")
```

```
Accuracy:1.00
```

Both models accurately predicting vaccine uptake

Conclusion

The results of this study ascertain certain vaccine uptake factors such as opinions/knowledge and demographic factors provide an understanding and influence vaccination decision.This factors may provide guidance on better approaches by groups intending to accelaret vaccine uptake in similar settings.

1. Low vaccine uptake among younger population, people of black race, and unemployed individuals
2. Tertiary education was found to be a strong predictor of vaccination, those with tertiary and secondary level of education being more inclined to get the vaccine
3. Increased uptake of seasonal flu vaccines as compared to H1N1 vaccine

4. Those who perceived vaccination as a way of preventing disease and were at risk of infection without the vaccine were more likely to be vaccinated

5. Respondent who had reccomendations from health care workers to get vaccinated understood that vaccination plays a crucial line of defence from infections

Reccomendation

From this study, the following suggestions may be made to improve h1n1 and seasonal vaccination uptake in the Counrty,and other places:

1. There is a need to tailor educational intervention programs for specific target groups targeting the low-income groups,African americans and unemployed in vaccination drives/accelartion camapigns.

2. Use of information, Education and communication (IEC) materials such as visula Aids, posters, flyers and media to effectively communicate and educate public on role of vaccination Considering that education level affected vaccine uptake

3. Continuos advocacy and socila mobilization with context specific tailored messaging such as effectiveness of vaccines ,percieved risks of opting out of vaccinnation drives and, clarifying misconceptions, and creating awareness on flu symptoms and prevention measures

4. Creating awareness about diseases of like nature such as seasonal flu and H1N1 should also be targeted alongside promoting inoculation to increase vaccine acceptance.Considering that seasonal flu had more acceptance than H1N1

5. The importance of position of health workers in reinforcing vaccine uptake has been highlighted,therefore healthcare workers should be prepared and knowledgeable as to participate in a discussion on vaccination together with the patient, in their daily health check-ups and Introduction of vaccination at service delivery points especially for adult targeted vaccines such as flu and h1n1 vaccines, which will in turnlead to reduced missed opportunities for vaccination