PREDICTING HEALTH STATUS: A GRAPHICAL MODEL–BASED APPROACH

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ABSTRACT

The project is aimed to help family doctors choose whether to perform a COVID swab.
Given some information about the patients, the developed tool consists in querying the adopted graphical model in order to get as output a probability for each of the considered health status.
Probably the execution of the swab is more suitable for elderly patients, not vaccinated against influence and with feverish symptoms.

INTRODUCTION

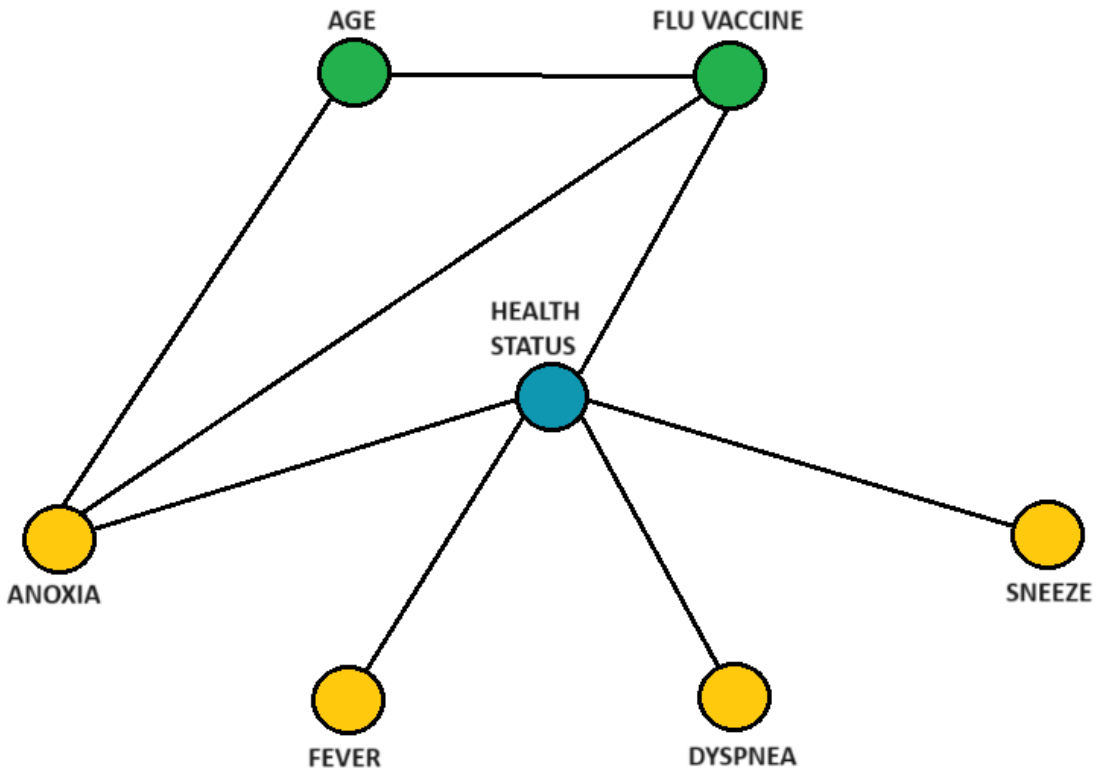
The available data refer to seven variables:

- **Health status**, i.e. a summary of the patient health status (Covid, flu, healthy or other);
- **Age**, with respect to the patient age;
- **Flu vaccine**, indicating whether the patient got the flu vaccine;
- **Anoxia, Dyspnea, Sneeze and Fever**, indicating the symptoms manifested by the patient.

In order to model the relationship among these variables, highlighting the conditional independence structure, an undirected graphical model was adopted.
By the mean of this model, it is possible to help doctors decide whether to perform a swab, considering the information available, even if it is partial.

GRAPHICAL MODEL

One of the main advantages of the model used is that the result can be represented graphically.
The following plot shows in a simple and intuitive way the structure of the selected model, i.e. the model that "best" fits data without overfitting them.



Some considerations can be made:

- Getting the flu vaccine is not independent on the patient age.
  In fact, as age increases, the proportion of people who got the vaccine increases too (only the 9% of people with an age <25 got it);
- The only symptom that has a relationship with age seems to be anoxia;
- Each of the considered symptoms (dyspnea, sneeze, fever, anoxia) is associated with the health status. Moreover, they are pairwise independent conditional on it. As instance, knowing that a person was infected by COVID the onset of fever doesn't influence the onset of dyspnea;
- The relationship between the presence of anoxia and the flu vaccine exists, but it changes with age or health status;
- The health status of a person is not independent on the flu vaccine, but this relationship appears to be influenced by the presence of the anoxia symptom;
- Age and health status seem to be conditional independent with respect to the flu vaccine or to the presence of anoxia. This means that, for example, knowing that a patient has a specific age may be informative with respect to the health status only when no other information is available about flu vaccine and anoxia. On the contrary, when these variables are observed, age is no longer informative.

PREDICTIONS

As an output of this analysis a diagnostic tool was obtained. In order to do a functional test, it was used to predict the health status of a sample of five patients of a selected family doctor.
The aforementioned tool works by considering the conditional distribution of the health status variable with respect to all the information available about the patient, that represent his profile. These results depend not only on the specific patient profile, but also on the information available. In fact, in real cases there may be only partial information.

1. In the following table, the conditional distribution for a 70 years old patient and with a temperature of 39 °C was highlighted. Given the patient profile, the most probable health status seems to be COVID, so a swab is highly recommended.

AGE	<25			[25, 40)		
HEALTH STATUS\FEVER	<37	[37, 38)	>=38	<37	[37, 38)	>=38
Covid	0,0%	2,3%	62,9%	0,0%	3,8%	71,3%
Flu	0,8%	71,9%	10,2%	0,8%	69,0%	6,9%
Healthy	98,1%	13,0%	0,0%	97,8%	12,4%	0,0%
Other	1,2%	12,7%	26,9%	1,4%	14,8%	21,8%
AGE	[40, 60)			>=60		
HEALTH STATUS\FEVER	<37	[37, 38)	>=38	<37	[37, 38)	>=38
Covid	0,0%	6,9%	82,3%	0,0%	19,2%	91,9%
Flu	1,7%	73,4%	4,6%	1,2%	56,7%	1,4%
Healthy	95,4%	5,7%	0,0%	95,7%	6,6%	0,0%
Other	2,9%	14,0%	13,1%	3,1%	17,5%	6,6%

2. Sometimes the situation may be not so clear like in the previous case. The second patient is a 30 years old, who got the flu vaccine and manifests anoxia and a temperature of 37.5 °C.
   Flu appears to be more likely, but since there is just a slight difference in probabilities with COVID, the doctor may decide to perform a swab anyway.

Age [25, 40), Anoxia=Yes, Fever [37, 38), Flue Vaccine=Yes

Covid	Flu	Healthy	Other
33,3%	52,0%	0,3%	14,4%

3. The third middle-aged patient manifested both dyspnea and a 38.9 °C fever. No information about whether he got a flu vaccine shot in the past is available, so is very likely that he has flu.

Age [40, 60) , Dyspnea=Yes, Fever [37, 38)

Covid	Flu	Healthy	Other
10,2%	83,5%	0,1%	6,3%

4. For an old man who sneeze the tool would suggest to perform a swab.

Age>60 , Sneeze= Yes

Covid	Flue	Healthy	Other
62,4%	9,4%	22,9%	5,3%

5. Even without flu vaccine, a young person with the symptom of sneeze will be classified as healthy, so no swab seems to be needed.

Age<25, Sneeze=Yes, Flu Vaccine=No

Covid	Flu	Healthy	Other
7,4%	18,8%	68,2%	5,6%

CONCLUSIONS

To sum up it is possible to conclude that the resulting diagnostic tool will indeed help family doctors in deciding whether to perform a COVID swab to their patients.
However, there may be difficult situations in which the human opinion is needed.