

Impact of COVID-19 Symptoms on Patients’ Health-Related Quality of Life

Vicky W. Li, Kyla S. Finlayson, Halley Costantino

Cerner Enviza, an Oracle company, Kansas City, MO, USA

Cerner Enviza
an Oracle company

PCR184

Introduction

- The impact of COVID-19 on individuals tends to vary based on factors including, though not limited to, symptoms experienced, existing medical conditions, and social determinants of health (SDoH; such as socioeconomic status and access to care).^{1,2}

Objective

- To examine the humanistic burden of COVID-19 in a large population of US adults through health-related quality of life (HRQoL) outcomes, using symptoms, comorbidities, sociodemographic, and SDoH factors as predictors in a machine-learning eXtreme Gradient Boosting (XGBoost) model.

Methods

Data Source

- This study used cross-sectional data from the 2022 National Health and Wellness Survey (NHWS). It is an annual, self-administered, internet-based, nationwide survey comprised of ~75,000 US adults (age 18 or older) each year. Participants are recruited through an existing, general-purpose, web-based consumer panel. The final sample matches the demographic composition of the US on age, gender, and racial/ethnic groups, based on data from the Current Population Survey of the US Census.
- In 2022, there were a total of 75,261 participants in the NHWS, with 4,706 of them currently experiencing symptoms of COVID-19 at the time of survey participation.

COVID-19 Symptoms and Variables

- The survey included 26 symptoms of COVID-19 and duration of each symptom in weeks.
- COVID-19-specific healthcare resource use (HRCU), vaccination rate, COVID-19 syndrome ("long COVID") diagnosis, and self-reported severity were also examined.

Social Determinants of Health Variables

- Analysis included sociodemographic variables (including education and household income), being a caregiver of an adult relative, having lack of reliable transportation, and the level of social support available (which is measured through the modified Medical Outcomes Study Social Support Survey [mMOS-SS]) were examined.³

Comorbidities and HCRU

- Charlson comorbidity index (CCI) and a selection of individual comorbidities ever diagnosed by a doctor and/or experienced in the past 12 months were examined, as well as overall HCRU in the past 6 months (not condition-specific).⁴

Outcome Measures

- HRQoL at the time of the survey was measured by the RAND 36-Item Health Status Inventory (HSI).⁵ Specifically, the Physical Health Composite (PHC) score and the Mental Health Composite (MHC) score were outcomes of interest.

Analysis Methods

- Descriptive statistics were used to describe COVID-19 participants. Participants not experiencing COVID-19 symptoms were also shown for reference.
- Spearman correlation tests and heatmaps were used to examine symptoms and duration of symptoms in correlation with PHC and MHC scores.
- All study variables were entered into an XGBoost regression model to select top features for predicting PHC and MHC scores among COVID-19 participants. Dataset was split into 60% training, 20% validation, and 20% test data. Models were built separately for PHC and MHC scores. Squared error was specified for the objective loss function. Hyperparameters were tuned based on the Root Mean Squared Error (RMSE) of the validation data. SHAP values were calculated to select top features from the final XGBoost models.

Results

- Descriptive results of COVID-19 participants and the non-COVID-19 general population are shown in **Tables 1-4**.
 - On the RAND-36 HSI scale, COVID-19 participants had an average PHC T-score of 37.78 and MHC T-score of 36.11, both of which were lower than those from the non-COVID-19 participants (**Table 4**).
 - Doctor visits, emergency room (ER) visits, and hospitalizations were all higher in the COVID-19 group (**Table 4**).
- Descriptive results of COVID-19-specific variables are shown in **Tables 5-6**.
 - The most common symptoms reported were cough and fatigue/tiredness, but symptoms with the longest duration were changes in skin color (i.e., pale, gray, or blue-colored skin, lips, or nail beds), anxiety/depression, pink eye, and difficulty breathing or shortness of breath (**Table 6**).
- Spearman correlation results showed that duration of COVID-19 symptoms were more strongly correlated with PHC and MHC scores than the type of symptoms experienced (**Figures 1 and 2**). Statistics below are not shown in figures for brevity.
 - Duration of sore throat, congestion or runny nose, and cough were most strongly correlated with lower PHC scores (Spearman rho = -0.49, -0.45, and -0.39; all $p < 0.001$).
 - Duration of rash, sore throat, and congestion or runny nose were most strongly correlated with lower MHC scores (Spearman rho = -0.58, -0.37, -0.32, -0.30; all $p < 0.001$).

Results, continued

Table 1. Sociodemographic Characteristics for US 2022 NHWS Participants Currently Experiencing Symptoms for COVID-19

Sociodemographics Variables	Experiencing Symptoms for COVID-19	Not Experiencing Symptoms for COVID-19
	N=4,706	N=70,555
	n (%) / Mean \pm SD	n (%) / Mean \pm SD
Age (years)	43.61 \pm 15.56	47.64 \pm 17.78
Sex		
Male	2,092 (44.5%)	33,920 (48.1%)
Female	2,614 (55.5%)	36,635 (51.9%)
Education		
High school or less	923 (19.6%)	12,922 (18.3%)
Some college/associate's degree	1,348 (28.6%)	20,403 (28.9%)
College degree	1,292 (27.5%)	21,211 (30.1%)
Graduate degree	1,143 (24.3%)	16,019 (22.7%)
Has Health Insurance	4,236 (90.0%)	57,041 (80.8%)
Employment Status		
Unemployed/retired/student	1,268 (26.9%)	26,726 (37.9%)
Employed full-time	2,693 (57.2%)	33,969 (48.1%)
Self-employed	299 (6.4%)	4,091 (5.8%)
Employed part-time	446 (9.5%)	5,769 (8.2%)
Marital Status		
Single	935 (19.9%)	15,481 (21.9%)
Married/living with partner	3,173 (67.4%)	44,579 (63.2%)
Divorced/separated/widowed/unknown	598 (12.7%)	10,495 (14.9%)
Annual Household Income		
<\$25,000 or declined to answer	673 (14.3%)	11,574 (16.4%)
\$25,000 to <\$50,000	773 (16.4%)	11,546 (16.4%)
\$50,000 to <\$75,000	639 (13.6%)	10,145 (14.4%)
\$75,000 to <\$100,000	792 (16.8%)	12,380 (17.3%)
\$100,000 to <\$150,000	1,126 (23.9%)	15,241 (21.6%)
\$150,000 to <\$200,000	380 (8.1%)	5,337 (7.6%)
\$200,000 or more	323 (6.9%)	4,532 (6.4%)
Number of Children Living in Same Household		
0	2,134 (45.3%)	42,008 (59.5%)
1 or 2	2,261 (48.0%)	25,625 (36.3%)
3+	311 (6.6%)	2,922 (4.1%)
Caregiver of an Adult Relative	2,285 (48.5%)	14,850 (20.8%)
Lack of Reliable Transportation Has Kept from Attending Medical Appointments, Meetings, Work, or Daily Needs	1,810 (38.5%)	9,639 (13.7%)

Table 2. mMOS-SS Scale for US 2022 NHWS Participants Currently Experiencing Symptoms for COVID-19

mMOS-SS Variables	Experiencing Symptoms for COVID-19	Not Experiencing Symptoms for COVID-19
	N=4,706	N=70,555
	n (%) / Mean \pm SD	n (%) / Mean \pm SD
mMOS-SS: If you needed it, how often is someone available:		
1. To help you if you were confined to bed?		
None of the time	586 (12.5%)	13,740 (19.5%)
A little of the time	579 (12.3%)	7,368 (10.4%)
Some of the time	866 (18.4%)	11,712 (16.6%)
Most of the time	1,221 (25.7%)	15,734 (22.3%)
All of the time	1,464 (31.1%)	22,001 (31.2%)
2. To take you to the doctor if you needed it?		
None of the time	308 (6.5%)	8,760 (12.4%)
A little of the time	631 (13.4%)	8,790 (12.5%)
Some of the time	877 (18.6%)	14,346 (20.2%)
Most of the time	1,522 (32.3%)	18,246 (25.9%)
All of the time	1,368 (29.1%)	23,232 (33.1%)
3. To prepare your meals if you are unable to do it yourself?		
None of the time	403 (8.6%)	10,843 (15.4%)
A little of the time	550 (11.7%)	7,262 (10.3%)
Some of the time	1,042 (22.1%)	13,615 (19.3%)
Most of the time	1,317 (28.0%)	16,489 (23.4%)
All of the time	1,394 (29.6%)	22,346 (31.7%)
4. To help with daily chores if you were sick?		
None of the time	423 (9.0%)	10,829 (15.3%)
A little of the time	583 (12.4%)	8,057 (11.4%)
Some of the time	899 (19.1%)	12,297 (17.4%)
Most of the time	1,490 (31.7%)	18,148 (25.7%)
All of the time	1,319 (27.9%)	22,224 (31.2%)
5. To have a good time with?		
None of the time	303 (6.4%)	8,292 (11.8%)
A little of the time	522 (11.1%)	6,695 (9.5%)
Some of the time	985 (20.9%)	13,236 (18.8%)
Most of the time	1,346 (28.6%)	18,009 (25.5%)
All of the time	1,550 (32.9%)	24,264 (34.4%)
6. To turn to for suggestions about how to deal with a personal problem?		
None of the time	322 (6.8%)	8,443 (12.0%)
A little of the time	569 (11.9%)	7,668 (10.9%)
Some of the time	955 (20.3%)	13,094 (18.6%)
Most of the time	1,495 (31.8%)	19,103 (27.1%)
All of the time	1,375 (29.2%)	22,227 (31.5%)
7. Who understands your problems?		
None of the time	364 (7.7%)	8,967 (12.6%)
A little of the time	591 (12.6%)	7,578 (10.7%)
Some of the time	1,038 (22.1%)	14,150 (20.1%)
Most of the time	1,331 (27.9%)	17,796 (25.2%)
All of the time	1,402 (29.8%)	22,064 (31.3%)
8. To love and make you feel wanted?		
None of the time	338 (7.2%)	8,676 (12.3%)
A little of the time	553 (11.8%)	7,478 (10.6%)
Some of the time	878 (18.7%)	12,254 (17.4%)
Most of the time	1,322 (28.1%)	16,451 (23.3%)
All of the time	1,615 (34.1%)	26,696 (37.8%)
Emotional Subscale Score	14.65 \pm 4.37	14.32 \pm 5.07
Instrumental Subscale Score	14.30 \pm 4.62	13.79 \pm 5.35
Total Score	28.95 \pm 8.46	28.11 \pm 9.99

Table 3. Health Characteristics and Comorbidities of Interest

Health Characteristics and Comorbidities	Experiencing Symptoms for COVID-19	Not Experiencing Symptoms for COVID-19
	N=4,706	N=70,555
	n (%) / Mean \pm SD	n (%) / Mean \pm SD
Body Mass Index (BMI) Category	26.85 \pm 7.50	27.50 \pm 8.41
Alcohol Use		
Do not drink	919 (19.5%)	23,708 (33.6%)
Once a week or less often	1,886 (40.1%)	27,168 (38.5%)
Multiple times a week or daily	1,901 (40.4%)	19,679 (27.9%)
Smoking Behavior		
Never smoked	2,303 (44.7%)	44,016 (62.4%)
Former smoker	849 (18.0%)	12,951 (18.4%)
Current smoker	1,754 (37.3%)	13,588 (19.3%)
Charlson Comorbidity Index (1987)	1.30 \pm 2.33	0.61 \pm 1.23
Conditions Experienced in Past 12 Months		
Asthma	1,188 (25.2%)	6,758 (9.6%)
Allergies	2,639 (56.1%)	26,186 (37.1%)
Psychological conditions: Depression, anxiety, general anxiety, social anxiety, panic disorder, or PTSD	2,979 (63.3%)	24,725 (35.0%)
Sleep conditions: Insomnia, idiopathic hypersomnia, narcolepsy, sleep apnea, or other sleep difficulties	3,276 (69.6%)	27,329 (38.7%)
Pain conditions: Migraine, headache, pain, diabetic neuropathic pain, or fibromyalgia	4,063 (86.3%)	42,232 (59.9%)
Conditions Ever Been Diagnosed with by a Doctor		
Respiratory conditions: COPD, emphysema, or chronic bronchitis	404 (8.6%)	3,017 (4.3%)
Cardiovascular conditions: Congestive heart failure or cardiac/cerebro/peripheral vascular diseases	396 (8.4%)	3,514 (5.0%)
Any Type of Cancer	833 (17.7%)	7,990 (10.2%)
Liver or Renal Diseases	488 (10.4%)	3,271 (4.6%)

Table 4. Health-Related Quality of Life and Overall HCRU

HRQoL and HCRU Variables	Experiencing Symptoms for COVID-19	Not Experiencing Symptoms for COVID-19
	N=4,706	N=70,555
	n (%) / Mean \pm SD	n (%) / Mean \pm SD
RAND-36 HSI: Mental Health Composite T Score		
Mean \pm SD	36.11 \pm 10.17	43.60 \pm 11.78
Median (min-max)	34.00 (11.00 - 66.00)	43.00 (11.00 - 66.00)
RAND-36 HSI: Physical Health Composite T Score		
Mean \pm SD	37.78 \pm 10.32	44.99 \pm 11.04
Median (min-max)	36.00 (15.00 - 61.00)	48.00 (15.00 - 61.00)
Healthcare Provider Visits in Past 6 Months	5.79 \pm 8.71	3.34 \pm 5.63
ER Visits in the Past 6 Months	1.19 \pm 3.00	0.42 \pm 1.79
Hospitalizations in the Past 6 Months	1.11 \pm 3.32	0.35 \pm 1.85

Table 5. Other COVID-19 Related Variables of Interest

Other COVID-19-Specific Variables	Experiencing Symptoms for COVID-19
	N=4,706
	n (%) / Mean \pm SD
Had ER Visits in the Past 6 Months Due to COVID-19	3,292 (70.2%)
Had Hospital Visits in the Past 6 Months Due to COVID-19	1,138 (24.2%)
Received COVID-19 Vaccine in the Past 12 Months	3,309 (70.3%)
Told by Doctor to Have COVID Syndrome or "Long COVID" Based on Symptoms	2,040 (43.3%)
Self-Reported Level of Severity of COVID-19	
Mild	2,330 (49.5%)
Moderate	1,318 (28.0%)
Severe	572 (12.2%)

Table 6. COVID-19 Symptoms and Duration of Symptoms

COVID-19 Symptoms	Experiencing Symptoms for COVID-19	Duration of Symptoms (weeks)
	N=4,706	Mean \pm SD (N abs)
	n (%) / Mean \pm SD	
Cough	3,316 (280.1%)	27.03 \pm 35.46 (800)
Fatigue/tired	3,325 (277.8%)	36.47 \pm 37.90 (880)
Difficulty breathing or shortness of breath	847 (18.0%)	50.00 \pm 39.27 (464)
New loss of smell and taste	771 (16.4%)	47.30 \pm 36.67 (466)
New confusion (brain fog)	723 (15.4%)	48.83 \pm 37.43 (437)
Muscle or body aches	719 (15.3%)	40.09 \pm 39.62 (396)
Headache	686 (14.6%)	28.72 \pm 35.42 (363)
Sleep problems	567 (12.0%)	46.44 \pm 37.90 (290)
Congestion or runny nose	554 (11.8%)	21.76 \pm 32.77 (340)
Anxiety/depression	537 (11.4%)	56.21 \pm 39.97 (262)
Fever or chills	508 (10.8%)	41.88 \pm 35.40 (224)
Sore throat	393 (8.4%)	21.78 \pm 30.61 (193)
Digestive issues	392 (8.3%)	47.51 \pm 40.86 (189)
General pain/discomfort	383 (8.1%)	41.65 \pm 41.52 (238)
Memory loss	370 (7.9%)	53.09 \pm 38.25 (230)
Persistent pain or pressure in the chest	365 (7.8%)	50.49 \pm 34.88 (166)
Pale, gray, or blue-colored skin, lips, or nail beds, depending on skin tone	346 (7.4%)	55.83 \pm 28.00 (154)
Dizziness/light-headedness on standing	342 (7.4%)	40.24 \pm 37.83 (198)
Mood changes	316 (6.6%)	45.67 \pm 37.55 (158)
Diarrhea	283 (6.0%)	36.45 \pm 39.69 (115)
Inability to wake or stay awake	271 (5.8%)	48.46 \pm 38.87 (123)
Pink eye	263 (5.6%)	53.55 \pm 35.06 (102)
Fast-beating, pounding heart	254 (5.4%)	45.94 \pm 37.85 (121)
Pins and needles feeling	200 (4.2%)	45.96 \pm 40.59 (93)
Change in menstrual cycles	178 (3.8%)	47.61 \pm 37.38 (81)
Other	180 (3.8%)	40.63 \pm 36.29 (93)
Rash	75 (1.6%)	48.76 \pm 37.20 (31)

Figure 1. Correlation Matrix of RAND-36 HSI Scores and COVID-19 Symptoms

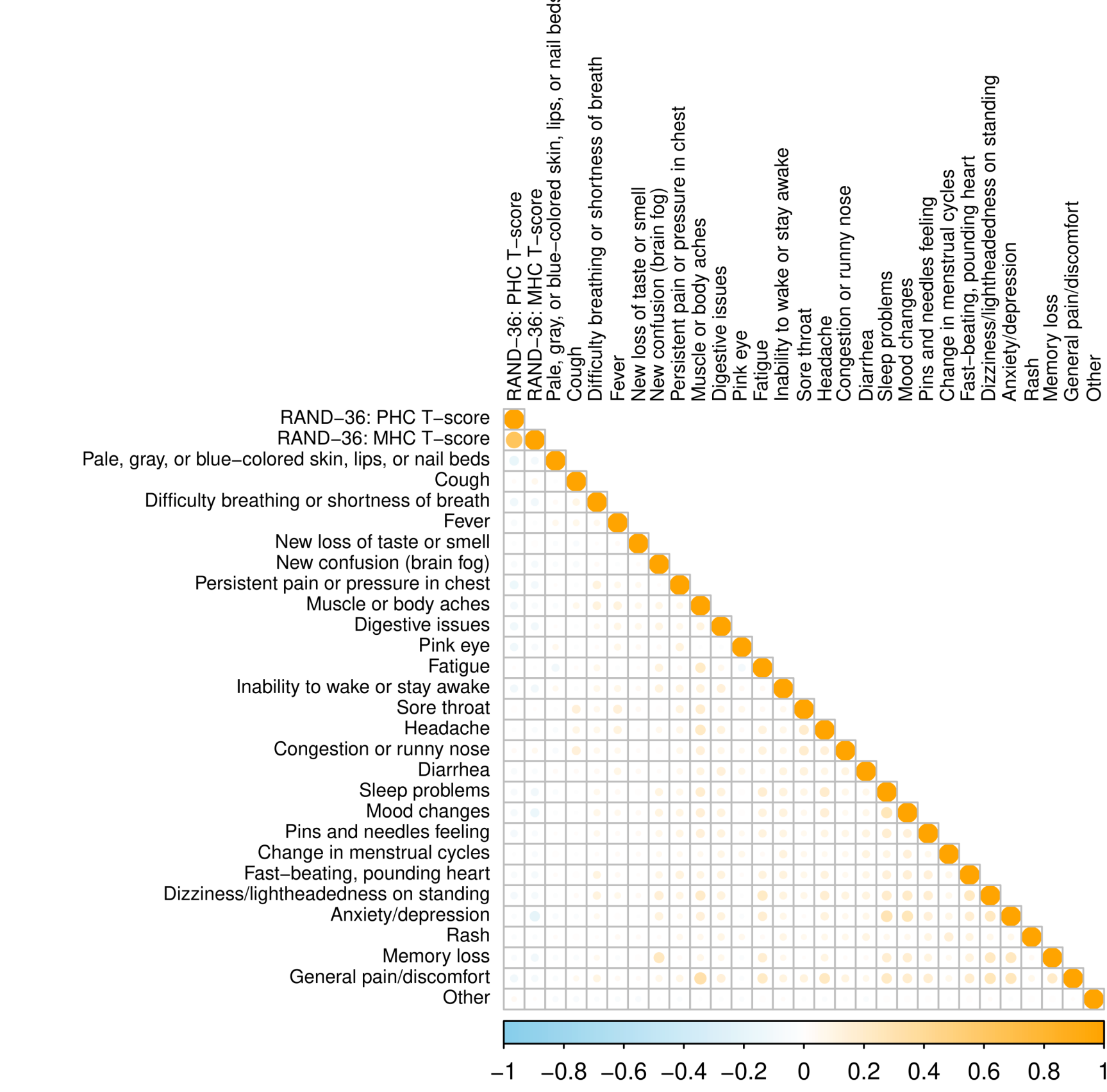


Figure 2. Correlation Matrix of RAND-36 HSI Scores and COVID-19 Symptom Duration in Weeks

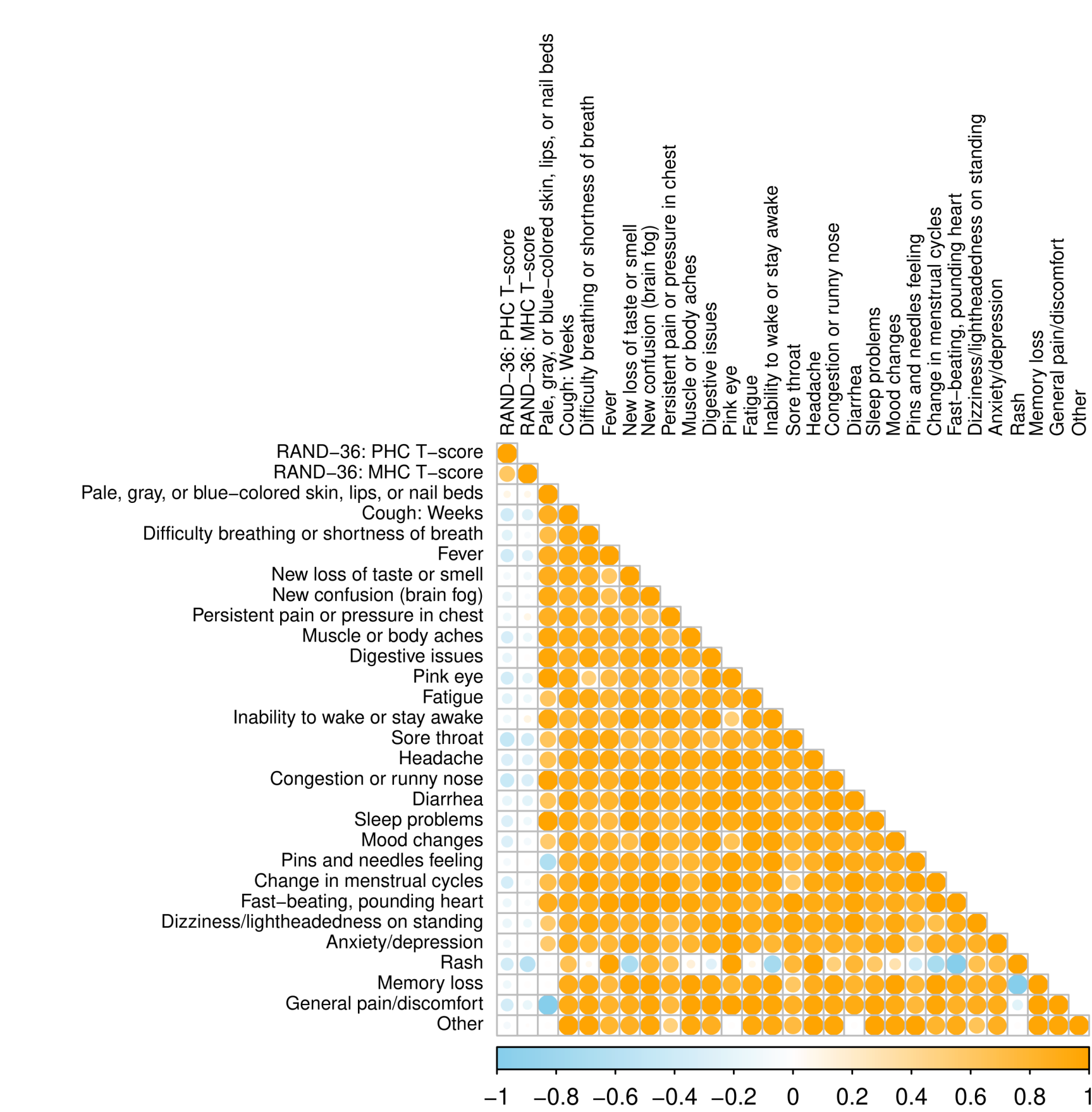
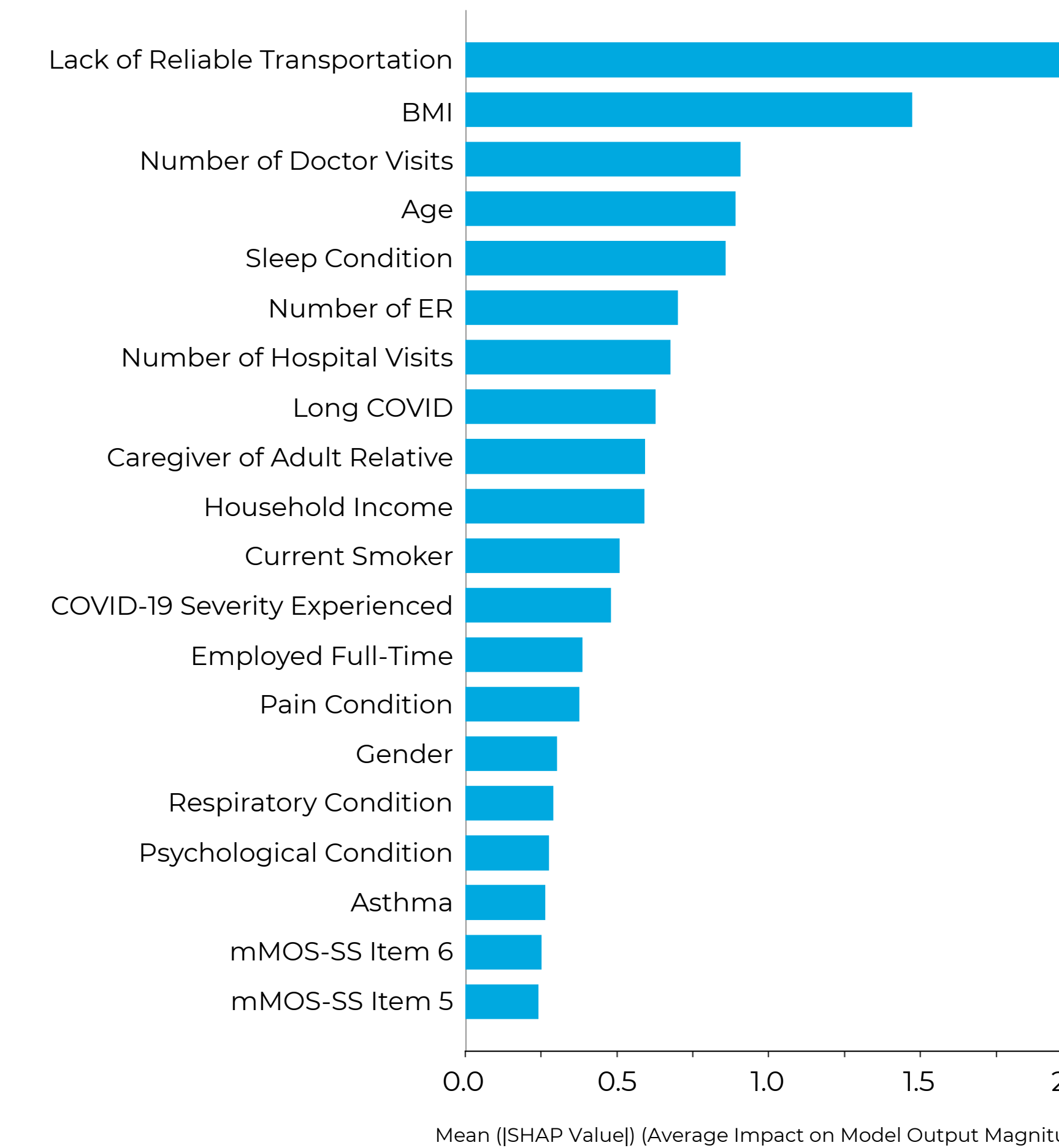


Figure 3. Top Features from PHC XGBoost Model, Based on SHAP Values



Results, continued

- After entering all study variables into the XGBoost model, and tuning the hyperparameters, model results for predicting PHC and MHC scores are shown in **Figures 3-6**.
 - The final PHC model had RMSE of 7.54 on the validation data and 7.49 on the test data, and the final MHC model had RMSE of 7.78 on the validation data and 7.81 on the test data.
 - Three common top features from both models were having lack of reliable transportation, experienced a sleep/psychological condition in the past 12 months, and age (**Figures 3 and 4**). All had a negative impact on model output (**Figures 5 and 6**).
 - Other top features include number of doctor visits overall, being a caregiver, income, level of social support, BMI, and COVID-19 symptoms experienced.

Figure 4. Top Features from MHC XGBoost Model, Based on SHAP Values

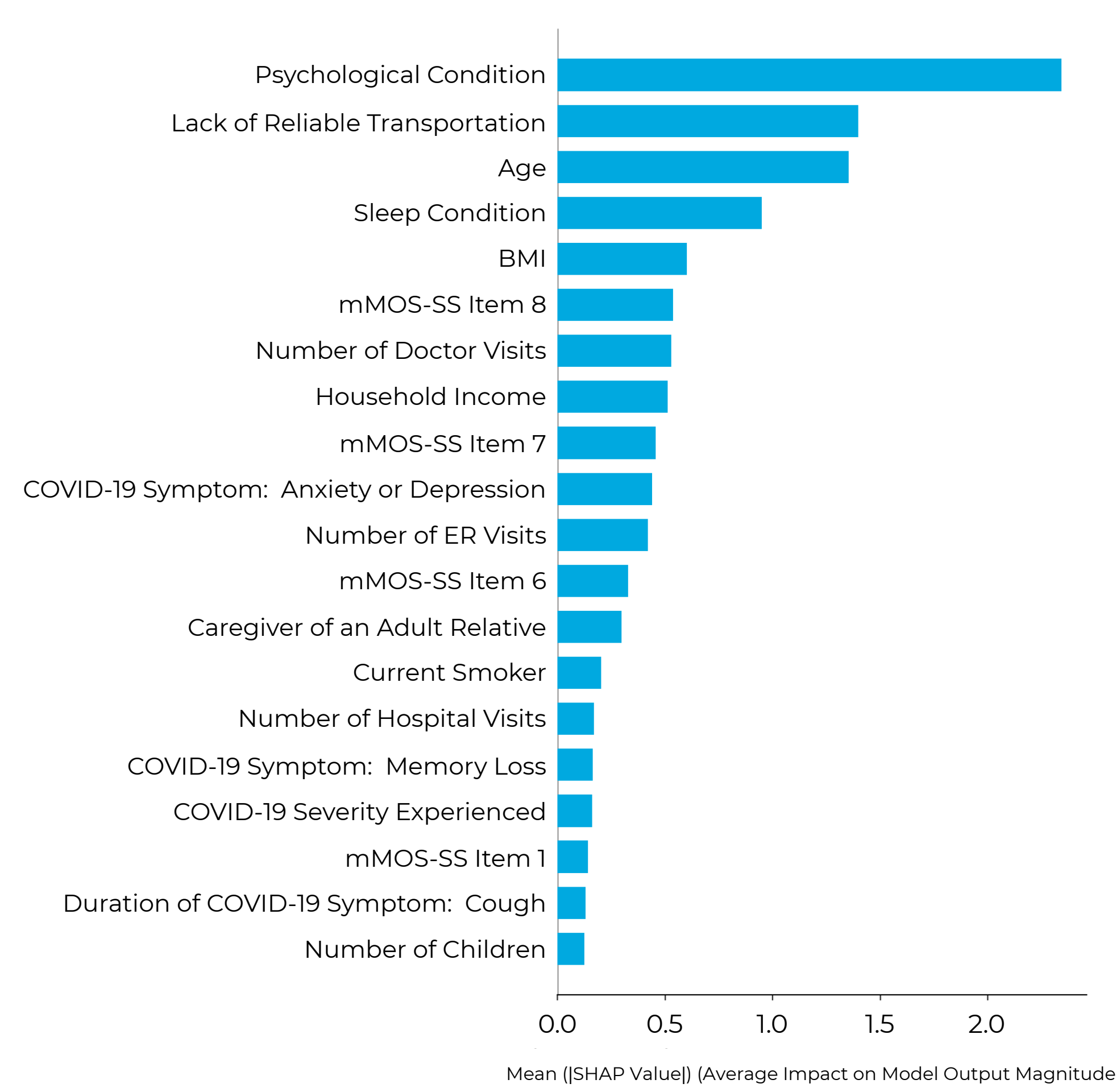


Figure 5. Impact of Top Features from PHC XGBoost Model, Based on SHAP Values

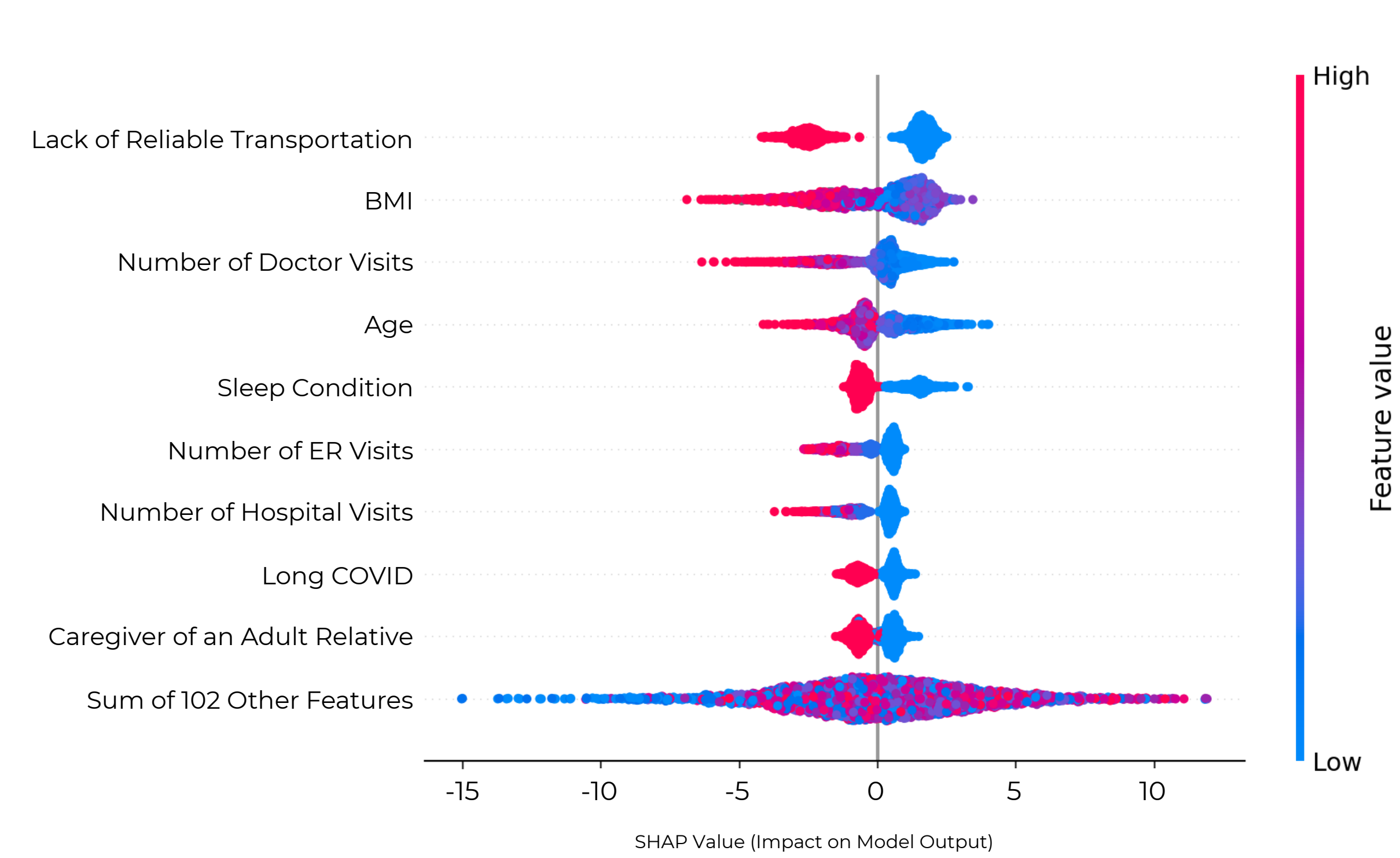
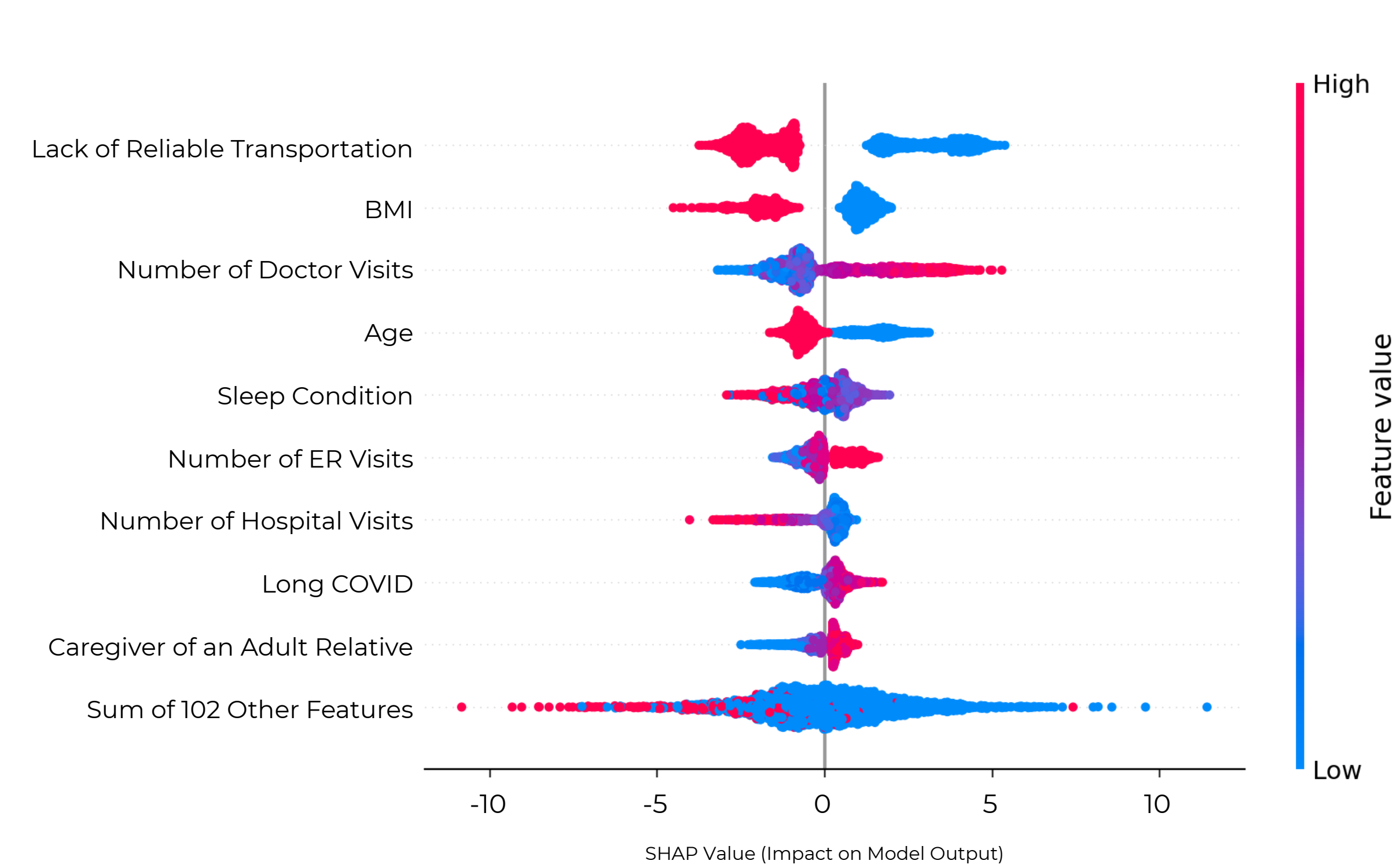


Figure 6. Impact of Top Features from MHC XGBoost Model, Based on SHAP Values



Conclusion

Among all risk factors examined, health-related quality of life among US adults currently having COVID-19 were most strongly impacted by **access to reliable transportation, having comorbidities like a sleep or a psychological condition, and old age**. Though not as strong, **HCRU, socioeconomic status, social support**, as well as **COVID-19 symptoms** experienced, also impacted health-related quality of life.

Limitations