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Associations between lifestyle factors and COVID-19 infection rates: a cross-sectional analysis in the USA

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ABSTRACT

Introduction The COVID-19 pandemic has underscored the vital connection between lifestyle factors and health outcomes, highlighting the need to understand how lifestyle choices influence both chronic and infectious diseases. Despite known links between lifestyle factors and chronic diseases, the relationship between these factors and infectious diseases like COVID-19 warrants further investigation.

Methods This cross-sectional study used an anonymous survey collected from a diverse sample of US residents aged 18 or older. Excluding individuals under 18 or residing outside the USA, the survey captured data on diet, body mass index, smoking status, alcohol consumption, physical activity, sleep duration, COVID-19 infection status, socio-demographics and other potential confounders. Statistical analysis was performed using χ^2 tests and logistic regression to explore the associations between lifestyle factors and COVID-19 infection, with a particular focus on gender differences.

Results Among 1032 participants, the prevalence of COVID-19 was higher in women (42.8%) compared with men (32.0%). Significant associations were found between inadequate sleep (less than 4 hours per day) and increased risk of COVID-19 in both genders (OR=2.89, 95% CI: 1.13 to 7.35, p=0.02 for men; OR=5.69, 95% CI: 3.14 to 10.29, p<0.00 for women). Additionally, a significant association was observed between a lifestyle index, incorporating multiple lifestyle factors and COVID-19 infection in women (OR=1.79, 95% CI: 1.05 to 3.025, p=0.03).

Conclusions The findings indicate a potential link between lifestyle factors and susceptibility to COVID-19, with inadequate sleep identified as a significant risk factor. These results suggest that promoting a healthy lifestyle could be an effective strategy for controlling the pandemic and mitigating the impact of infectious diseases. Further research is recommended to explore the role of restful sleep in preventing COVID-19 for men and women (including multiple lifestyle factors among women).

WHAT IS ALREADY KNOWN ON THIS TOPIC

⇒ Lifestyle choices significantly impact chronic disease outcomes.
⇒ The relationship between lifestyle factors and susceptibility to infectious diseases, like COVID-19, is less understood.

WHAT THIS STUDY ADDS

⇒ Our study provides evidence of a significant association between inadequate sleep and increased risk of COVID-19 infection in both genders.
⇒ It also identifies a correlation between a composite lifestyle index and COVID-19 risk among women.

HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

⇒ These findings underscore the importance of incorporating lifestyle modifications, particularly sleep optimisation, into public health strategies to mitigate the impact of COVID-19.
⇒ The study findings also encourage further research into how specific lifestyle factors may influence the course of infectious diseases, potentially guiding policy and practice towards more holistic health promotion approaches.

INTRODUCTION

A healthy lifestyle, including physical activity, adequate sleep and proper nutrition is known to lower the risk of chronic, non-communicable diseases by regulating oxidative stress and inflammation, managing weight, improving lipid profiles and enhancing blood circulation.[1 2] Such a lifestyle has also been linked to strengthening the immune system and reducing the risk of infections such as influenza and SARS-CoV-2.[2–4] A study conducted by Merino *et al*[5] on 592 571 participants from the smartphone-based COVID-19 Symptom Study found that consuming a plant-based diet rich in fruits and vegetables may potentially lower the risk of contracting COVID-19 by 9% and reduce severe cases by 41%.[5] Although physical activity has been found to reduce the incidence and severity of several viral infections, there is a lack of specific research on how a comprehensive healthy lifestyle incorporating physical activity, proper sleep, positive spiritual beliefs and a healthy diet may impact the severity and risk of COVID-19.[6] Pop *et al*[7] examined the relationship between body image satisfaction, perceived health and social media use among first-year medical university students. The authors aimed to shed light on the impact of social media and peers on body image. The results emphasise the significance of addressing issues with body image, especially among young women, in connection to social media.[7]

It has been reported that there are several habits, including stress, unhealthy food, alcohol, smoking, loneliness and insufficient sleep, that can potentially harm the immune system and predispose people to infectious illnesses.[8] Bigalke and colleagues[9] conducted a study that focused on sex differences, and sought to evaluate the effects of COVID-19 and stay-at-home directives on anxiety and sleep quality. They found that women reported greater rates of increased anxiety, and both sexes reported worse sleep quality.[9] Moreover, Krishnan and Collop[10] provided insights into gender differences in sleep, revealing that women frequently experience more sleep-related issues while having better overall sleep quality. It also discusses the influence of physiological cycles and variations in gender-specific sleep disorders.[10] In addition, women were reported to have a higher likelihood of experiencing poor sleep quality compared with men, and advancing age was associated with deteriorating sleep, with women showing a stronger association.[11]

Sleep plays a critical role in modulating the immune system. It influences immune responses, lowering infection risks and enhancing vaccination efficacy. Numerous studies highlight that insufficient sleep can impair immune function, increase infection severity and exacerbate inflammatory disorders.[12,13] Specifically, sleep affects key immune processes, such as cytokine production and leucocyte activity, which are crucial for fighting infections and responding to vaccines. This relationship is particularly pertinent in understanding the immune challenges posed by COVID-19.[14]

Obesity can also affect the immune system, and lead to severe complications among patients with COVID-19.[15–17] In addition, alcohol consumption has a dose-dependent relationship with viral infection severity attributed to increased expression of ACE2 and angiotensin II type 1 receptor, as well as causing an upregulation of ACE2 in the lung.[18] It also damages tight endothelial junctions, compromising the microbiota, promoting the translocation of lipopolysaccharides and pathogen-associated molecular patterns and stimulating the production of pro-inflammatory cytokines.[18,19] Smoking has also been reported to have a negative effect on the immune system and COVID-19 infection.[20–23]

Regular, moderate physical activity is a key element of a healthy lifestyle, consistently associated with improved immune function. Such activity has been shown to strengthen the immune system, potentially enhancing the body's defences against communicable diseases, including viral infections like COVID-19.[24] In contrast, while physical activity is beneficial, it's crucial to distinguish between moderate physical activity and high-intensity or prolonged physical exertion. The latter, especially when engaged in for an excessive period of time or without adequate recovery, has been linked to temporary immune suppression and an elevated risk of respiratory infections. This effect is particularly notable in athletes and individuals participating in extreme endurance activities, such as marathon running.[25] Thus, it is important to further explore the impact of physical activity in the context of a pandemic such as COVID-19.

To the authors knowledge, research to assess the potential association between healthy lifestyle factors, such as physical activity and sleep and COVID-19 infections (including how gender may influence this association), is scarce. Therefore, the purpose of this study was to investigate the relationship between these lifestyle factors and COVID-19 diagnosis across genders in the USA, exploring any potential links among adults.

MATERIALS AND METHODS

This was a cross-sectional study, in which data was collected between January 2022 and January 2023. The study's inclusion criteria were individuals who were 18 years of age or older and live in the USA. Anyone not from the USA or younger than 18 years old was excluded from the study. Moreover, the participants were instructed not to include any personal identifying factors, such as name, email or phone number during the survey to preserve anonymity. Data was collected anonymously using Qualtrics software as well as hardcopy surveys that were administered throughout the USA.

The survey was distributed using the following methods: flyers, word-of-mouth communication in various settings including schools, churches, community clinics and health expos. Furthermore, social media platforms such as Instagram, Facebook, LinkedIn and Reddit were used to advertise the survey nationwide. Participants were provided with informed consent, and had the option to discontinue participation at any time.

Survey items and outcome measures

The survey used in this study was developed by the authors and included demographic questions (7 items), health history questions (8 items), lifestyle questions (17 items), physical activity questions (5 items) and spirituality questions (5 items) (see online supplemental file 1). A pilot study was conducted with a small group of 20 participants to evaluate the survey's internal validity and reliability, yielding a Cronbach's alpha value of 0.85, indicating high internal consistency. Feedback was collected to identify any issues with the survey questions and structure, leading to adjustments that enhanced the survey's clarity and relevance for the larger study.

Statistical analysis

To determine the sample size, we conducted a power analysis using G-power software (V.3.1; Faul, Erdfelder, Buchner and Lang, 2009). With an assumed alpha error of 5% and 80% power, a sample size of 1000 was determined to be required.

Dependent variables

The dependent variable is COVID-19 self-report which was determined by answering the following question:

Have you had a COVID-19 positive test: (yes=1 or no=0).

Independent variables

The independent exposure variables consisted of dietary patterns, sleep duration per 24 hours, physical activity, body mass index (BMI) and lifestyle index.

Below is a detailed description of the independent variables:

Dietary patterns

We created a dietary pattern variable using questions from the survey, such as 'What type of diet do you follow?' to determine whether participants were vegetarian or non-vegetarian. We then assigned scores to each response and categorised individuals as either non-vegetarian or vegetarian, including vegans, lacto-ovo vegetarians, lacto-vegetarians and pescatarians. Furthermore, in the analysis, because of lower frequencies in the different vegetarian groups, we grouped all types of vegetarian diets into a single category called 'vegetarian'.

Sleep

This variable is about sleep duration per 24 hours. The study had three categories for this question: sleep less than 4 hours per 24 hours, between 5 and 6 hours of sleep per 24 hours and 7 hours of sleep or more per 24 hours.

Physical activity

The question was about the frequency of their regular, moderate or vigorous physical activity per week, based on three categories: less than three times a week, between three and four times a week and five or more times a week.

Healthy Lifestyle Index

The creation of the Healthy Lifestyle Index (HLI) variable was based on a community cohort study published in 2022, which investigated the impact of an HLI and lifestyle patterns on mortality risk.[26] The HLI was established based on six influential factors: dietary quality, BMI, cigarette smoking, alcohol consumption, physical activity (PA) and sleep duration per 24 hours. These factors were represented as dichotomous variables, and their respective definitions were previously mentioned.

Each lifestyle factor was assigned a score based on specific criteria: to collect information on dietary consumption from each participant, we used a self-reporting method. Participants were requested to provide details regarding their daily intake of various food items such as fruits, vegetables, legumes, fried food or fast food, caffeinated beverages and sugar-sweetened beverages. Participants' dietary quality was assessed on a scale ranging from 0 to 6. Scores of 4–6 were coded as 1 to indicate unhealthy dietary choices. Conversely, lower scores between 0 and 3 indicated better dietary quality, reflecting participants' adoption of healthier eating habits based on their survey responses.

A healthy BMI was assigned a score of 0 (BMI between 18.5 and 24.9 kg/m^2), and an unhealthy BMI was assigned a score of 1 (BMI lower than 18.5 kg/m^2, or 25 kg/m^2 and above).

Coding scores were also provided for cigarette smoking (0=not current smoker, 1=current smoker), alcohol consumption (0=none or low-level alcohol consumption, 1=medium or high-level alcohol consumption), PA (0=met the minimum level of recommended PA by the WHO, 1=did not meet the minimum level of recommended PA by the WHO) (WHO, 2023), and for sleep duration per 24 hours: 0=good sleep (7 hours or more), 1=poor sleep (less than 7 hours).

The total HLI score was calculated by summing the scores of these six lifestyle factors, which ranged from 0 to 6 points. A higher score indicated an unhealthy lifestyle, while a lower score indicated a healthier lifestyle. This composite score was referred to as the lifestyle index, which was used in the final logistic regression model.

Body mass index (confounder variable)

We created a variable by asking participants about their weight and height and calculated their BMI based on kilograms/metres^2. The study classified BMI into four categories: less than 18.5 kg/m^2, 18.5–24.9 kg/m^2, 25–29.9 kg/m^2 and 30 and above kg/m^2. We combined the unhealthy levels of BMI into one category, including underweight and overweight individuals. This approach was valid because we were emulating what has already been peer-reviewed as a valid instrument.[26]

The baseline social demographics, lifestyle factors and other covariates were presented with their distributions and a χ^2 test was employed to determine any differences among the categorical variables. A cross-tabulation analysis was performed to assess the association between gender and positive COVID-19 diagnosis, as well as several other variables. All analyses were conducted using SPSS (IBM SPSS, V.28.0. Armonk, New York, USA)

The independent exposure variables included a lifestyle index, dietary patterns, sleep duration per 24 hours and PA, along with potential confounders such as comorbidities, BMI, smoking, alcohol drinking, age, gender, race and income. Bivariate analyses were conducted first to examine the relationship between each individual variable and the reported odds of having COVID-19. The variables that showed a significant association with the outcome variable at a 10% level of change in the primary variable were then included in the logistic regression model.[27] This approach helped to control for potential confounding factors and provided a more accurate understanding of the association between lifestyle and COVID-19 variables.

We then built separate multivariable models using logistic regression for each exposure variable, including sleep duration per 24 hours, PA, dietary pattern and lifestyle index, with COVID-19 as the outcome. We conducted both crude and fully adjusted analyses and reported ORs and 95% CIs for each analysis.

RESULTS

A total of N=1032 responded to the survey with a mean age of 30.5 years (SD=1.15). Table 1, shows that 32.0% of men and 42.8% of women tested positive for COVID-19. It also presents the demographic analysis of participants in the lifestyle and infectious diseases study, highlighting notable differences between individuals with and without COVID-19 across both male and female groups. The highest percentage of cases was observed in the age group between 25 and 34 years. Regarding sleep duration per 24 hours, the percentage of men sleeping less than 4 hours per night was significantly higher among those with COVID-19 (39.0%) compared with those without COVID-19 (28.9%). Among women, the percentage of those sleeping less than 4 hours per night was significantly higher in those with COVID-19 (54.9%) compared with those without COVID-19 (25.1%).

Geographically, the East Coast had the highest proportion of COVID-19 cases, with 50.9% of men with COVID-19 (p=0.036) and 58.0% of women with COVID-19 (p<0.001) being residents of this region. There was no significant difference in PA frequency between men with and without COVID-19 (p=0.54). However, among women, the proportion who exercised less than three times per week was higher among those with COVID-19 (60.8%) than those without COVID-19 (52.8%) (p=0.033).

As shown in table 1, regarding BMI in the male subgroup, the percentage of individuals with a BMI of 25–29.9 kg/m^2 or higher was significantly greater among those with COVID-19 (38.5%) compared with those without COVID-19 (24.1%). Similarly, in the female subgroup, the percentage of individuals with a BMI of 30 or higher was significantly greater among those with COVID-19 (47.0%) compared with those without COVID-19 (22.5%).

There was a statistically significant association between COVID-19 and dietary patterns in both men and women (p<0.001). In the male subgroup, a higher proportion of participants with COVID-19 reported following a non-vegetarian diet (74.8%) compared with those without COVID-19 (55.0%). Similarly, in the female subgroup, a higher percentage of participants with COVID-19 reported following a non-vegetarian diet (78.4%) compared with those without COVID-19 (58.1%). Moreover, we selected from table 1, the significant variables for the final analysis using logistic regression.

Table 2, displays the components that contributed to the lifestyle index, which were assessed using several factors, including diet quality, BMI, smoking status, alcohol consumption, PA level and sleep duration per 24 hours, revealing significant differences with COVID-19 diagnosis for both genders. Table 2, revealed a significant association between diet quality (p<0.001), smoking (p<0.001) and COVID-19 for both men and women. BMI (p<0.001), PA (p=0.02) and sleep (p<0.001) were significantly associated with COVID-19 only for women.

The results also showed that the percentage of alcohol drinkers, defined as often drinking, did not significantly differ between participants with and without COVID-19 for both male and female groups.

The results presented in table 3 display the final logistic regression model comparing the exposure variables of sleep duration per 24 hours, PA, lifestyle index, dietary pattern and COVID-19.

Sleep duration per 24 hours

The logistic regression analysis revealed a significant association between sleep duration per 24 hours and COVID-19 risk, with ORs observed among men (OR=2.892, 95% CI: 1.137 to 7.358, p=0.02) and women (OR=5.690, 95% CI: 3.146 to 10.292, p<0.001) for those with sleep duration less than 4 hours/day compared with those who slept 7 hours or more. For the combined sample (men and women), the OR was 4.305 (95% CI: 2.660 to 6.969, p<0.001).

Lifestyle index

There was no significant association between the unhealthy lifestyle index and COVID-19 among the male group (OR=1.784, 95% CI: 0.783 to 4.062, p=0.16). However, among the female group, there was a significant positive association between an unhealthy lifestyle index and COVID-19 (OR=1.790, 95% CI: 1.059 to 3.025, p=0.03). In combined analyses for men and women, an unhealthy lifestyle index was significantly associated with higher odds of COVID-19 (OR=1.832, 95% CI: 1.186 to 2.828, p<0.001). The variance inflation factor for the lifestyle index variable was less than 10%, indicating that it was a good predictor of the association between lifestyle and COVID-19.

Dietary patterns and physical activity

The logistic regression analysis revealed no significant association between dietary patterns (comparing non-vegetarians to vegetarians) and COVID-19 among the male group (OR=0.98, 95% CI: 0.44 to 2.18, p=0.95) or among the female group (OR=0.94, 95% CI: 0.54 to 1.61, p=0.82). Also, there was no significant association between PA and COVID-19 among the male group, based on ORs for exercising less than three times a week (0.86 (95% CI: 0.40 to 1.85)) and between three and four times a week (0.70 (95% CI: 0.31 to 1.60)) nor among the female group, based on ORs for exercising less than three times a week (0.91 (95% CI: 0.58 to 1.44)) and between three and four times a week (1.06 (95% CI: 0.65 to 1.73)).

DISCUSSION

The aim of this study was to investigate the association between lifestyle factors, including sleep duration per

Table 1 Demographics analysis for people who participated in lifestyle and infectious disease

	Men			Women		
	Without COVID-19 N=225 %	**With COVID-19** N=106 %	X^2 **P value**	**Without COVID-19** N=401 %	**With COVID-19** N=300 %	X^2 **P value**
Variables*						
Age			**0.009**			**<0.001**
18–24	15.6	11.3		11.7	10.0	
25–34	34.7	50.9		44.1	48.7	
35–44	17.3	21.7		15.7	28.7	
45–64	16.0	7.5		19.5	8.0	
65 and above	16.4	8.5		9.0	4.7	
Marital status			0.193			**<0.001**
Single	37.8	46.2		34.4	58.3	
Married/cohabitating	57.8	51.9		57.9	36.3	
Separated with children	2.7	0		4.5	3.3	
Separated without children	0.9	1.9		2.0	1.0	
Widowed	0.9	0		1.2	1.0	
Income per year			**0.002**			**<0.001**
<US$20 000	24.0	18.9		26.4	16.7	
US$20 000 to US$49 999	32.0	26.4		28.7	11.7	
US$50 000 to US$99 999	21.8	11.3		21.9	13.3	
US$100 000 to US$199 999	12.9	22.6		15.5	29.0	
≥US$200 000	9.3	20.8		7.5	29.3	
Education			0.499			0.446
Some college but no degree	15.6	15.1		12.2	9.7	
Associate degree	4.4	1.9		6.7	8.3	
Bachelor's degree—graduate degree	80.0	83.0		81	82.0	
Race/ethnicity			0.018			**<0.001**
White or Caucasian	40.4	35.8		43.9	36.0	
Hispanic or Latino	9.8	7.5		9.0	17.0	
Black or African American	5.8	17.0		5.5	18.7	
Asian	19.1	13.2		20.7	15.7	
Other†	24.9	26.4		20.9	12.7	
Residency by time zone‡			**0.036**			**<0.001**
Eastern Standard Time	44.2	50.9		41.1	58.0	
Central Standard Time	12.4	20.8		11.3	5.7	
Mountain Standard Time	12.0	8.5		6.7	5.0	
Pacific Standard Time	31.3	19.8		40.9	31.3	
Sleep duration per 24 hours	**N=180**	**N=100**	**<0.001**	**N=304**	**N=283**	**<0.001**

Continued

Table 1 Continued

	Men			Women		
	Without COVID-19 N=225 %	**With COVID-19** N=106 %	**X^2 P value**	**Without COVID-19** N=401 %	**With COVID-19** N=300 %	**X^2 P value**
Less than 4 hours	28.9	39.0		25.1	54.9	
Between 5 and 6 hours	32.3	24.8		32.7	24.9	
7 hours and above	38.7	36.2		42.3	20.0	
Physical activity per week	**N=251**	**N=106**	0.54	**N=420**	**N=300**	**0.033**
Less than three times a week	40.3	63.2		52.8	60.8	
Between three and four times a week	36.1	18.9		27.6	24.2	
Five times a week or more	23.6	17.9		19.7	15.0	
Body mass index	**N=237**	**N=104**	0.05	**N=395**	**N=296**	**<0.001**
Less than 18.5 (kg/m^2‡)	7.6	4.8		10.4	5.4	
Between 18.5 and 24.9 (kg/m^2‡)	34.6	26.9		46.6	28.0	
Between 25 and 29.9 (kg/m^2‡)	24.1	38.5		20.5	19.6	
30 and above (kg/m^2‡)	33.8	29.8		22.5	47.0	
Dietary pattern	**N=251**	**N=106**	**<0.001**	**N=420**	**N=300**	**<0.001**
Non-vegetarian	55.0	74.8		58.1	78.4	
Vegetarian	45.0	25.2		41.9	21.6	

Bold p values are significant (<0.05).
*All p values based on χ^2.
†Other races include mixed races, middle Eastern, Pacific Islander, Native American or American Indian.
‡Residency by time zone includes Eastern Standard Time (CT, DE, GA, ME, MD, MA, NH, NJ, NY, NC, OH, PA, RI, SC, VT, VA, WV) Central Standard Time (AL, AR, IL, IA, KS, LA, MN, MS, MO, OK, ND, SD, TX, WI). Mountain Standard Time (AZ, CO, MT, NM, UT, WY, ID). Pacific Standard Time (CA, WA, OR, NV) and Hawaii-Aleutian time, and Alaska time.

24 hours, PA, dietary patterns, smoking and alcohol consumption, and the likelihood of contracting COVID-19 among individuals of both genders in the USA. Our findings showed that lack of sleep was significantly associated with greater than four times the odds of COVID-19 infection when comparing insufficient sleep with sufficient sleep among men and women. The association between sleep deprivation and COVID-19 risk is consistent with previous research that has linked sleep deprivation to impaired immune function and increased susceptibility to infectious diseases. Therefore, we believe that this finding suggests that getting enough sleep is essential as part of a healthy lifestyle to reduce the risk of contracting COVID-19.

Furthermore, our study and findings revealed that individuals who consistently slept less than 4 hours were at a higher risk of potentially contracting COVID-19. Specifically, our analysis demonstrated a significant association between sleep and COVID-19 among women who slept less than 4 hours (p<0.001). Therefore, there is a very close association between sleep and the immune system. Sleep affects various immune parameters, decreases infection risk and improves response to vaccination and infection outcomes. Women, who could have had multiple responsibilities such as working from home, caring for children or elderly relatives and managing household tasks, may have been particularly affected. Increased anxiety and concerns for their family's health and well-being during the pandemic could further disrupt their sleep patterns.[28] Moreover, women experiencing sleep deprivation may not have had reduced protection from COVID-19 vaccine, as past research has shown that sleep deprivation is associated with reduced uptake of vaccines.[29] All of these factors could contribute to the higher prevalence of sleep problems among women during the pandemic. Thus, our findings underscore the significant influence of lifestyle factors, especially for women, on health.

The analysis revealed a significant association (p=0.03) between COVID-19 and the lifestyle index for women, but not for men (p=0.16). These findings emphasise the importance of maintaining a healthy lifestyle, which includes getting adequate sleep, following a healthy diet,

Table 2 The components of the Healthy Lifestyle Index men women

	Men			Women		
	Without COVID-19 N=225 %	**Without COVID-19 N=106 %**	**χ^2 P value**	**Without COVID-19 N=401 %**	**Without COVID-19 N=300 %**	**χ^2 P value**
Variables Diet quality			**<0.001**			**<0.001**
Unhealthy diet: dietary quality 4–6*	55.6	76.7		55.1	78.1	
Healthy diet: dietary quality 0–3	44.4	23.3		44.9	21.9	
Body mass index (BMI)			0.133			**<0.001**
Unhealthy BMI: (BMI<18.5 or >24.9 kg/m^2)	64.8	73.3		53.0	71.7	
Healthy BMI: (BMI between 18.5 and 24.9 kg/m^2)	35.2	26.7		47.0	28.3	
Smoking			**<0.001**			**<0.001**
Smoker: current smoker	11.6	27.4		3.6	13.7	
Non- smoker: never smoker or former smoker	88.4	72.6		96.4	86.3	
Alcohol drinking			0.184			0.129
High-level: often drinking	17.1	23.6		21.7	17.0	
Low-level: no drinking or occasionally drinking	82.9	76.4		78.3	83.0	
Physical activity			0.77			**0.012**
Unhealthy: did not achieve the minimum recommended	76.44	82.1		80.3	91.0	
Healthy: achieved minimum recommended	23.6	17.9		19.7	9.0	
Sleep duration per 24 hours.			0.657			**<0.001**
Unhealthy: (less than 7 hours)	61.3	63.8		57.7	79.8	
Healthy: (7–8 hours)	38.7	36.2		42.3	20.2	

Bold p values are significant (<0.05).

*Note: The dietary quality of participants was measured on a scale of 0–6, with scores of 4–6 being coded as 1 for choosing unhealthy dietary quality answers. A lower score between 0 and 3 indicates better dietary quality, indicating that people are adopting healthier dietary habits as per their responses to the survey. A score of 0 was coded as healthy lifestyle variables, while a score of 1 was coded as unhealthy lifestyle variables such as consuming fried food, sugar-sweetened beverages, caffeinated beverages and inadequate servings of fruits, vegetables and legumes. Consequently, the higher the score, the unhealthier the dietary habits of the participants.

Table 3 Logistic regression modelling results of the health variables (sleep duration per 24 hours, physical activity, dietary pattern, lifestyle index) and COVID-19

Men only	n*	OR† (95% CI)	P value
Sleep duration per 24 hours Less than 4 hours	104	2.89 (1.13 to 7.35)	**0.02**
Between 5 and 6 hours	102	0.75 (0.40 to 1.43)	0.39
7 hours and above	125	REF	
Physical activity Less than three times a week	160	0.86 (0.40 to 1.85)	0.7
Between three and four times a week	102	0.70 (0.31 to 1.60)	0.4
Five times a week or more	69	REF	
Lifestyle index (unhealthy)	184	1.78 (0.78 to 4.06)	0.16
Lifestyle index (healthy)	108	REF	
Dietary pattern (non-vegetarian)	181	0.97 (0.43 to 2.18)	0.95
Dietary pattern (vegetarian)	111	REF	
Women only	**n**	**OR† (95% CI)**	**P value**
Sleep duration per 24 hours Less than 4 hours	244	5.69 (3.14 to 10.29)	**<0.001**
Between 5 and 6 hours	215	1.56 (1.00 to 2.43)	0.05
7 hours and above	230	REF	
Physical activity Less than three times a week	414	0.97 (0.53 to 1.74)	0.92
Between three and four times a week	165	1.43 (0.75 to 2.71)	0.26
Five times a week or more	102	REF	
Lifestyle index (unhealthy)	416	1.79 (1.05 to 3.02)	**0.03**
Lifestyle index (healthy)	217	REF	
Dietary pattern (non-vegetarian)	427	0.94 (0.54 to 1.61)	0.82
Dietary pattern (vegetarian)	206	REF	
Both genders	**n**	**OR‡ (95% CI)**	**P value**
Sleep duration per 24 hours Less than 4 hours	348	4.30 (2.66 to 6.96)	**<0.001**
Between 5 and 6 hours	317	1.24 (0.87 to 1.76)	0.29
7 hours and above	355	REF	
Physical activity Less than three times a week	574	0.91 (0.58 to 1.44)	0.32
Between three and four times a week	267	1.06 (0.65 to 1.73)	0.41
Five times a week or more	171	REF	
Lifestyle index (unhealthy)	600	1.83 (1.18 to 2.82)	**<0.001**
Lifestyle index (healthy)	325	REF	
Dietary pattern (non-vegetarian)	608	0.94 (0.60 to 1.45)	0.78
Dietary pattern (vegetarian) 317 REF			

Bold p values are significant (<0.05).
*Note: Sample size (n) included the number of participants who participated in finding the associations between the predictor variables and the outcome variable.
†Adjusted models for age, race, ethnicity, income and residency by time zone.
‡Adjusted models for age, gender, race, ethnicity, income and residency by time zone.
§The reference group for the ORs of the lifestyle variable was the healthy lifestyle group, which was created based on several questions related to healthy food The healthy lifestyle group was defined as participants who scored 0–3 on a scale of 0–6, with higher scores indicating unhealthier dietary habits. Participants who scored 4–6 were coded as 1 for having more unhealthy lifestyle variables.
¶The reference group for the ORs of the dietary pattern variable was the healthy diet group. The healthy dietary pattern group was created based on a combination of vegetarian diets.

maintaining weight, doing adequate PA and avoiding smoking, especially in the context of the current COVID-19 pandemic. Adopting such healthy lifestyle practices not only reduces the risk of COVID-19, but also improves overall health and well-being. On the other hand, an unhealthy lifestyle has been linked to chronic diseases and weakened immune function, increasing the risk of contracting COVID-19.[2] This finding suggests that the lifestyle index variable was an important factor in explaining the variation in COVID-19, and could be used to assess the association between lifestyle and COVID-19.

In order to acquire a thorough understanding of the particular risk factors and protective variables connected to COVID-19 infection and severity, we believe it is important to highlight the necessity for a targeted study focusing more on women. The effect of hormonal variations, pregnancy, breast feeding and gender-specific lifestyle variables on COVID-19 results in women may be better understood by examining a variety of research fields. According to studies, hormonal changes during the menstrual cycle and pregnancy might affect how the immune system reacts to infections.[30 31] Additionally, the severity and development of COVID-19 in pregnant women may be impacted by the physiological changes related to pregnancy and the postpartum period.[32] To clarify the specific processes and effects of these elements, further studies are needed. Therefore, by promoting better lifestyle practices, including sufficient sleep, we can potentially help reduce the risk of COVID-19 and enhance overall immune health among women. These findings highlight the importance of targeted public health interventions and education campaigns that address gender-specific factors to empower women in their efforts to mitigate the risk of COVID-19 through healthy lifestyle choices.

Strengths and limitations of the study

This study facilitated the identification of associations between lifestyle factors and COVID-19 risk among a diverse sample and serves to generate a hypothesis for further investigation through longitudinal studies. However, the study has several limitations, first, although we have more than 1000 responses, the majority represent California and New York. Second, another limitation of the study was the lack of information on sleep dysfunction among individuals diagnosed with COVID-19. Therefore, we encourage future researchers to consider validated sleep tool such as the Pittsburgh Sleep Quality Index, as it may provide more insightful outcomes regarding quality of the sleep that is beyond our study.

CONCLUSION

This study was among the first to comprehensively explore the relationship between lifestyle factors, gender and COVID-19 risk, highlighting the significant role of factors like sleep duration. Our findings contributed to the evidence base linking lifestyle choices to disease risk and underscored the importance of targeted public health strategies. These insights can inform efforts to enhance community resilience against COVID-19 and future pandemics, emphasising equitable approaches to recovery and health promotion.

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