


The Association between Lifestyle Risk Factors and COVID-19 Hospitalization in a Healthcare Institution

Abstract: COVID-19 is an acute infectious respiratory disease caused by SARS-CoV-2, a subtype of the coronavirus. In addition to normal levels of biometric measures, a healthy lifestyle has been considered an indispensable element in preventing complications of coronavirus infection. Demographic characteristics are also critical in determining risk levels. **Aim:** Investigate potential significant associations between health behaviors, biometric screenings, demographics, and COVID-19 hospitalization in Loma Linda University Health employees. **Methods:** Participants are employees covered under the employer-sponsored health plan at Loma Linda University Health, Loma Linda, CA, who tested positive for COVID-19. Logistic regression models were applied to analyze demographics, biometric screenings, and lifestyle factors associated with COVID-19 hospitalization. In our study, 7% of participants required hospitalization. Variables independently associated with COVID-19 hospitalization included higher age (OR = 1.05 [1.01–1.08],

P = .005), non-White race compared to the White race (OR = 3.2 [1.22–8.38], P = .018), higher HbA1C levels showing a marginal association (OR = 1.31 [.99–1.72], P = .057), and lower vegetable consumption (OR = 4.39 [2.06–9.40], P < .001). Lower protein consumption decreased the Odds of hospitalization (OR = .40 [.19–.87], P = .021). Our results suggest that a diet that includes more vegetables and lower protein may

Introduction

On December 31st, 2019, China reported severe pneumonia cases of unknown origin in Wuhan's Hubei province to the World Health Organization (WHO). As a result, the WHO issued global warnings communicating the risks of a broader outbreak outside the initial epicenter.¹ In February 2020, the WHO officially used the term COVID-19 for severe acute

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confer some protection against COVID-19 hospitalization.

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respiratory syndrome caused by the new virus, gaining its definitive nomenclature: Sars-CoV-2.² Since then, the world has been intensely following the virus's rapid spread. The COVID-19 pandemic is one of the major threats that humankind has

DOI: 10.1177/15598276221135541. Public Health, Loma Linda University, Loma Linda, CA, USA (WPR, OM, JO, AW, JG, HDS). Address correspondence to: Hildemar Dos Santos, Public Health, Loma Linda University, 24951 Circle Dr, Loma Linda, CA 92354, USA; e-mail: hdossantos@llu.edu.

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faced in modern history. According to the WHO, globally, on March 1, 2022, there were 437, 333, 859 confirmed COVID-19 cases, resulting in 5 960 972 deaths.³

After an incubation period of 2–14 days (mean ~ 5 days), COVID-19 usually presents with fever and upper respiratory symptoms, such as dry cough, shortness of breath, and sore throat, according to the Centers for Disease Control and Prevention (CDC).⁴ But, the spectrum of presentation and evolution of the disease varies, from infection with mild symptoms to severe illness and death.⁵

About 80% of infected people recover from the disease without special treatment. However, patients who progress to more severe symptoms can have difficulty breathing, respiratory failure, shock, or multiorgan dysfunction.⁴ Immune response during the SARS-CoV-2 infection may depend on genetic factors (HLA genes), age, sex, nutritional and physical activity status, and associated risk factors such as smoking, obesity, type 2 diabetes, and metabolic syndrome.⁶ Obesity, type 2 diabetes, and metabolic syndrome lead to a greater expression of ACE2 receptors (used in the entry of SARS-CoV-2), possibly leading to more severe disease.^{7,8} In general, research findings imply that an unhealthy lifestyle is synonymous with an elevated risk of non-communicable disease and is also a risk factor for COVID-19 hospital admission, which might be partly explained by low-grade inflammation.^{9,10}

Since the beginning of the COVID-19 pandemic, patterns of symptoms, trends, spread, and fatality rates have been associated with some demographic characteristics and comorbidities. Fatal cases represent 3.4% of the population¹¹ and increase significantly in patients with comorbidities and those 60 years of age and older.¹² In addition, fatalities increase to approximately 15% among patients 80 years of age or older.¹³

Besides demographics and chronic diseases such as diabetes, hypertension, asthma, and being over 60 years old, health professionals are considered at higher risk for COVID-19. In the fight against the new coronavirus, health professionals worldwide have paid a high price: thousands have been infected and died. In September 2020, the WHO Director-General highlighted that even though health workers represent less than 3% of the population, 14% of the COVID-19 cases reported were among health workers. In some countries, this proportion reached up to 35%.¹⁴ This higher risk is because they are more likely to be exposed to infected patients, which causes them to receive a high viral load (millions of virus particles).^{15,16}

Loma Linda University Health is in Loma Linda, California, and currently has approximately 17 000 employees, mainly in the health sector. Our study population is taken from this group within a large tertiary care, academic health system.¹⁷ Studies show that health professionals who work on the front line of care for COVID-19 cases exhibit physical and mental exhaustion, difficulties in decision-making, and anxiety. They have to handle the pain of losing patients, colleagues, and the possibility of contaminating their families.^{15,18} The literature lacks information on how lifestyle relates to the severity of COVID-19 infection within the worksite setting. Therefore, this study aims to examine potential significant associations between health behaviors, biometric screenings, demographics, and COVID-19 hospitalization in Loma Linda University Health employees.

Methods

Study Design and Participants

Data on COVID-19 were collected from December 2020 to February

2021 through the Employee Health database. There were 1437 employees who tested positive for COVID-19; however, only 546 presented information on COVID-19 hospitalization and variables of interest. We included only those employees who were covered under the employer-sponsored health plan at Loma Linda University Health, Loma Linda, CA.

Demographic data and health behavior information were collected through self-reported questionnaires completed between 2016 and November 2021 and were extracted from the employee health plan data. This population consisted mostly of health care employees but also included institution educators, and administrative and staff members. Biometric screening and the electronic Health Risk Assessment were collected separately, and data were combined in the Living Whole database.

All data retrieved for this research were de-identified and password protected with access permitted only to the researchers. A confidentiality agreement was signed to prevent the disclosure and unauthorized use of confidential information exchanged between the parties—the researcher and the LLUH Department of Risk Management serving as the health plan administrator. This study was approved by the Institutional Review Board of Loma Linda University Health (# 5210352).

Variables

The outcome variable is COVID-19 hospitalization (yes/no). Patients that tested positive for COVID-19 and were *asymptomatic* or had only *mild illness* (any COVID-19 symptoms that did not require hospitalization) were categorized as *no*.

Demographic data included age (in years), gender (male/female), and race (White and non-Whites). Biometric data included the following: body fat %, waist

circumference, BMI (Body Mass Index), systolic and diastolic blood pressure, total cholesterol, HDL (High-density lipoprotein), and Hemoglobin A1C (HgbA1c).

Health behaviors variables included diet and exercise: frequency of breakfast (daily, occasionally, or seldom); servings of fruits, vegetables, whole grains, and protein (0–2 portions per day vs 3 or more portions per day); strength training per week (0–1 times vs 2 or more times per week).

Data Analysis

Patients with missing information on variables of interest (such as diet and exercise, biometrics, and demographics) were excluded from the analysis. Descriptive statistics were summarized and presented with frequencies for categorical data and averages for continuous variables. Bivariate analysis was used, such as two-sample independent t-test or Chi-square test of independence for each variable and COVID-19 hospitalization.

Logistic regression models were applied to determine the relationship between demographics, biometric screening variables, and lifestyle factors with COVID-19 hospitalization. For model selection, we identified important covariates based on a literature search, checked for collinearity, and collapsed categories with low counts. Then, we verified variables with the most effect size in the multiple models using Wald statistics and eliminated variables that were not important to the model. Two final models were built: the first model with demographic and biometric screening variables, including the following: age, gender, BMI, and Hemoglobin A1C; for the second model, health behavior variables were added to the model one such as vegetable servings, protein servings, and strength training. All analyses were performed using IBM SPSS software

Results

Our sample contained 546 individuals who were infected with COVID-19 during the study period, where 38 (7%) required hospitalization. Table 1 shows descriptive statistics of demographic data, biometric screenings, and health behavior variables among COVID-19 patients categorized by hospitalization status (yes/no). The hospitalized patients were significantly older than the non-hospitalized patients (49.1 and 43.1, respectively). About 80% of individuals were female ($n = 434$) and two-thirds of them were non-Whites ($N = 370$), which also had a significantly higher proportion of non-Whites with hospitalization. Biometric variables that were statistically significant on the bivariate analysis include waist circumference with the higher average among those hospitalized (36.8 vs 39.5, $P = .019$). BMI with higher values among those that required hospitalization than those non-hospitalized (29.9 vs 32.9 vs, $P = .042$), and body fat (33.1 among non-hospitalized and 36.4 among hospitalized, $P = .031$). A1C values were also higher among hospitalized than non-hospitalized patients (5.5 vs 6.2 vs, $P = .006$). Among health behavior variables, strength training frequency showed statistical significance with a higher percentage of hospitalization among those that do strength training only 0–1 time per week compared to those who engage 2 or more times (9% vs 4%, respectively, $P = .008$). Less frequent consumption of vegetables also was associated with higher hospitalization than in those with higher intake (13% vs 5%, respectively, $P = .001$).

Table 2 shows logistic regression results for demographic and biometric variables as well as health behaviors. Age, race, vegetable consumption, and protein consumption showed a significant

association with COVID-19 hospitalization. An increase in 1 year of age raised the odds of hospitalization by 5% (OR = 1.05, 95% CI 1.01–1.08, $P = .005$). Also, an increase of 1% in HbA1C raised the odds of hospitalization by 31% (OR = 1.31, 95% CI .99–1.72, $P = .057$) although it was marginally significant. Non-Whites compared to Whites had three times higher odds of hospitalization (95% CI 1.22–8.38 $P = .018$). We also found that vegetable and protein consumption was significantly associated with COVID-19 hospitalization. Eating only 0–2 vegetable servings per day was associated with 4.4 times higher odds of hospitalization (95% CI 2.06–9.40, $P < .001$) when compared to those who eat 3 or more servings per day. In addition, protein consumption of 0–2 servings per day was associated with 60% decreased odds of hospitalization (OR = .40, 95% CI .19–.87, $P = .021$) when compared to consumption of 3 or more servings per day.

Discussion

Our study findings showed that among our study sample of 546 employees who tested positive for COVID-19, 38 (7%) developed a severe illness that required hospitalization. Our regression analysis found that older age, non-White race, higher HgbA1C value, lower vegetable, and higher protein consumption were associated with COVID-19 hospitalization. To our knowledge, this study is the first to show those two diet variables associated with COVID-19 hospitalization in a relatively high-risk population.

Our findings on demographic variables associated with hospitalization corroborate other published literature findings. Older age, for instance, is independently associated with COVID-19 severity as it was well

Table 1.

Descriptive Data and Univariate Analysis of Demographics, Biometric Screening, and Health Behaviors among COVID-19 Patients at Loma Linda University Health by Hospitalization Status.

Variables	All (N = 546) mean (SD) or frequencies (%)	Hospitalization		P-value
		No (N = 508)	Yes (N = 38)	
Demographics				
Age	40.4 (11.9)	43.1 (11.4)	49.1 (11.8)	.002
Gender				
Male	112 (21%)	105 (94%)	7 (6%)	.741
Female	434 (79%)	403 (93%)	31 (7%)	
Race				
White	176 (32%)	170 (97%)	6 (3%)	.025
Non-White	370 (68%)	338 (91%)	32 (9%)	
Biometrics				
Body fat	33.3 (8.8)	33.1 (8.8)	36.4 (8.5)	.031
Waist circumference	37.0 (6.8)	36.8 (6.7)	39.5 (7.7)	.019
BMI	30.1 (7.2)	29.9 (7.0)	32.9 (8.8)	.042
BP systolic	122.5 (14.9)	122.4 (14.7)	124.2 (16.9)	.475
BP diastolic	77.9 (10.8)	77.7 (10.6)	79.5 (12.7)	.329
Total cholesterol	176.5 (37.1)	176.2 (36.7)	181.5 (41.6)	.390
HDL	51.1 (15.1)	51.4 (15.3)	47.0 (13.4)	.082
HbA1C	5.5 (.9)	5.5 (.8)	6.2 (1.6)	.006
Health behavior				
Strength training				
0–1 days/week	305 (56%)	276 (91%)	29 (9%)	.008
2+ days/week	241 (44%)	232 (96%)	9 (4%)	
Breakfast				
Daily	60 (11%)	55 (91%)	5 (9%)	.718
Occasionally	164 (30%)	152 (93%)	12 (7%)	
Seldom	322 (59%)	301 (94%)	21 (6%)	
Fruit servings				
0-2/day	217 (40%)	197 (91%)	20 (9%)	.092
3+/day	329 (60%)	311 (95%)	18 (5%)	

(continued)

Table 1. (continued)

Vegetable servings				
0–2/day	166 (30%)	145 (87%)	21 (13%)	<.001
3+/day	380 (70%)	363 (95%)	17 (5%)	
Whole grains servings				
0–2/day	475 (87%)	441 (92%)	34 (8%)	.604
3+/day	71 (13%)	67 (94%)	4 (6%)	
Protein servings				
0–2/day	270 (49%)	254 (94%)	16 (6%)	.402
3+/day	276 (51%)	254 (92%)	22 (8%)	

Table 2.

Logistic Regression Models Examining Association with COVID-19 Hospitalization among Employees at Loma Linda University Health (N = 546).

Variables	Model 1		Model 2	
	Or (95% CI)	P-value	Or (95% CI)	P-value
Age (in years)	1.04 (1.01–1.07)	.013	1.05 (1.01–1.08)	.005
Male	.68 (.27–1.69)	.406	.64 (.26–1.61)	.347
Female	Ref		Ref	
Non-White	3.27 (1.29–8.33)	.013	3.20 (1.22–8.38)	.018
White	Ref		Ref	
BMI	1.04 (.99–1.08)	.116	1.04 (.99–1.09)	.104
HbA1C	1.34 (1.03–1.75)	.027	1.31 (.99–1.72)	.057
Vegetable servings (0–2/day)	–	–	4.39 (2.06–9.40)	<.001
3+/day			Ref	
Protein servings (0–2/day)	–	–	.40 (.19–.87)	.021
3+/day			Ref	
Strength training (0–1/week)	–	–	1.76 (.77–4.07)	.181
2+/week			Ref	

Note: OR = Odds Ratio; CI = Confidence Interval.

established since the beginning of the pandemic.^{19,20} Comorbidities that are more common with aging, such as diabetes mellitus, heart disease, and lung diseases such as asthma, are considered risk factors for increasing this severity. Another point would be the lower effectiveness of the immune system with aging. Alteration of T cells and macrophages responding more slowly to antigens may partly explain why viral infections are more frequent in the elderly and more often progress to severe conditions.^{20,21}

HgbA1C was marginally associated with COVID-19 hospitalization. HgbA1C is a commonly used diagnostic test for pre-diabetes, diabetes type 1 and 2. It is mainly used by health care providers to determine the average blood sugar levels over the past 3 months and to subsequently adjust the treatment regimen for improved control. Patients in our study who required hospitalization presented with higher HgbA1C levels (6.2), in the range of pre-diabetes and diabetes, compared to those that did not require hospitalization (5.5). The normal range for HgbA1C is between 4% and 5.6%. Pre-diabetics have hemoglobin A1C levels at 5.7 to 6.4%, and those with higher than 6.5% hemoglobin A1C levels are diagnosed with diabetes.²² Studies show that higher levels of HgbA1C were associated with hospitalizations due to COVID-19.¹⁰ The probable mechanism connecting HgbA1C and the severity of COVID-19 symptoms leading to hospitalization is the inflammatory environment created by the release of pro-inflammatory cytokines and oxidative stress in patients with hyperglycemia. Scientists from the Oswaldo Cruz Foundation (Fiocruz)²³ discovered that diabetes induces inflammation in the circulating cells of the immune system with increased expression of the ACE2 and ALOX5 genes, making

them more prone to the invasion of the new coronavirus, Sars-CoV-2.

The study also reported the increase in leukotriene B4 (LTB4) in the blood cells of these patients. LTB4 is an inflammation-associated lipid mediator that may increase the risk of severe COVID-19 symptoms in diabetic individuals because of its association with a more pronounced systemic inflammatory response.²³

Our study showed that those who ate fewer servings of vegetables per day had higher odds of hospitalization compared with those who had higher vegetable consumption. In addition, lower consumption of protein servings per day had lower odds of hospitalization. Kim et al. (2021) found similar results when comparing a plant-based diet and high protein diet with COVID-19 hospitalization. The food groups ingested by those following a plant-based diet consisted of higher vegetables, legumes, and nuts, while a higher quantity of poultry, red and processed meats, sugar-sweetened beverages, and alcohol was found among those on the low carbohydrate and high protein diet.²⁴ Participants who reported following a low carbohydrate and high protein diet, compared to those on a plant-based diet, had higher odds of moderate-to-severe COVID-19 illness (OR = 3.86 CI 1.13–13.24). It is unclear whether the protein servings were of animal or plant origin in our study. However, our results suggest that following a diet with fewer protein servings per day is associated with lower odds of hospitalization. Protein from animal products has been associated with insulin resistance,²⁵ and consumption of red and processed meat is associated with an increased risk of cardiovascular disease and mortality.²⁶ Higher meat intakes were also associated with higher plasma concentrations of inflammatory and glucose metabolic biomarkers in women.²⁷ These

results are also consistent with the evidence from the Mediterranean Diet, which is well known to reduce CVD incidence and mortality, type 2 diabetes and metabolic syndrome, the incidence of some cancers, and improve cognitive function.²⁸

It is well established in the literature that nutritional deficiencies are associated with susceptibility to infections. Nutrients such as vitamin C, D, E, Folic Acid, Carotenoids, and Zinc, present in fruits and vegetables, are the main nutrients that help the immune system function. Antioxidants obtained from the diet, such as vitamins C, E, and A, flavonoids, and carotenoids are extremely important in the interception of free radicals.

Bioactive compounds present in foods can have different types of antioxidant actions, competing for active sites and receptors in different cellular structures, and modulating gene expression that encodes proteins involved in intracellular defense mechanisms against degenerative oxidative processes of cellular structures (DNA, membranes). The immunomodulation conferred by plant derivatives has been the subject of evaluation for many years and remains an essential research focus.²⁹

Non-Whites in our study presented with a greater proportion of hospitalizations. This corroborates with the literature that has found an increased risk among Blacks and Asians for COVID-19 infection, severity, ICU admission, and premature death.^{30–32} In one study, Asian patients had the highest COVID-19 cardiorespiratory severity at presentation (OR = 1.48, 95% CI, 1.16–1.90).³³

Obesity has been indicated as a risk factor for severe COVID-19 infection, and the mechanism involved may be associated with immune hyper-reactivity, an inefficient metabolic response, and the decreased forced expiratory

volume and vital capacity that occur in individuals with obesity.³⁴ In our sample, the difference in waist circumference and BMI was not independently associated with COVID-19 hospitalization.

We also had a greater number of women with COVID-19 in our sample. That is explained by the higher proportion of female gender among the employer-sponsored health plan at Loma Linda University Health. Still, it is also important to note that women are more likely to suffer from depression and stress, leading to an unhealthy lifestyle.³⁵ Moreover, women present risk factors that men do not experience, such as early menarche, polycystic ovarian syndrome (PCOS), multiparity, adverse pregnancy outcomes, premature menopause, and other hormonal factors.³⁶ Therefore, special attention to actions to improve the quality of life among women is required.

Finally, among our exercise variables, strength training was statistically associated with COVID-19 severity, only on our bivariate analysis. Man has become less physically active during the last century, adopting increasingly sedentary habits. It has caused an increase in chronic diseases such as cardiovascular disease, type 2 diabetes, and metabolic syndrome. Physical activity influences health by altering metabolic states and the immune system. Several studies have observed variations in leukocytes, distribution of lymphocyte populations, and immune function (neutrophils, accessory cells, spontaneous cytotoxic or Natural Killer cells, T and B lymphocytes) as a result of exercise.^{6,37}

The quality of changes on metabolic states and immune system seems to depend on the regularity, intensity, duration, and type of exercise. Many studies have reported an increase in the serum concentration of anti-inflammatory

cytokines (IL-4, IL-10, and TGF- β) after different types of exercise.^{6,38,39} Moderate-intensity physical activity is responsible for providing an increase in the anti-pathogenic activity of macrophages. At the same time, it elevates the circulation of immune cells, immunoglobulins, and anti-inflammatory cytokines, thereby reducing the burden of the pathogen on such organs as the lung and the risk of lung damage due to the influx of inflammatory cells.⁴⁰ Thus, regular and adequate intensity exercise is suggested as an additional tool in strengthening and preparing the immune system for COVID-19.⁴¹

This study has several strengths. It is a unique study, investigating a variety of lifestyle factors and their association with COVID-19 hospitalization in a predominantly health care industry setting. Other strengths include having a large sample size and including potential confounders. We also included several biometric variables. However, some limitations must be considered. All the lifestyle-related variables were based on self-reported answers, and there is the possibility of recall bias. In addition, other lifestyle factors such as alcohol intake, tobacco use, and certain dietary factors were not included in the analysis. We only had data on those who were part of the employee-sponsored health plan, primarily females, and not all participants were working in a healthcare setting.

Conclusion

Our study presented 546 individuals who were infected with COVID-19, where 7% of them required hospitalization. This is a study that included a high-risk population of health workers possibly with higher exposure to the virus, receiving high viral loads, and exposed to physical and mental exhaustion. The Western lifestyle

and culture of poor diet promotes an increase in chronic diseases and a decrease in the capability of the immune system to fight infections, including COVID-19. Factors that were independently associated with COVID-19 hospitalization in our study included higher age, non-White race, higher HbA1C levels, lower vegetable consumption, and higher protein consumption. A diet that includes more vegetables and low protein may confer some protection against COVID-19 hospitalization. However, more detailed data on dietary factors and different food groups should be considered to definitively establish an association with COVID-19 hospitalization.

Declaration of Conflicting Interests

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ORCID iDs

Wenes Pereira Reis  <https://orcid.org/0000-0001-9983-2664>

Jisoo Oh  <https://orcid.org/0000-0001-8905-7633>



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