

# The impact of COVID-19 pandemic on lifestyle among the Saudi population

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## Abstract

**Background:** During COVID-19, major change occurred in the governmental regulations to combat the pandemic. Lifestyle factors are changeable habits and routine behaviors with an impact on physical and mental health. With the pandemic, sudden and radical changes occurred in the lifestyle of people worldwide. The main purpose of the study is to assess the impact of COVID-19 on lifestyle factors including (dietary habits, physical activity, sleeping patterns, smoking, and alcohol use) among the Saudi population.

**Design and methods:** This is a cross-sectional study on a convenient sample of adults residing in Saudi Arabia. An online survey was distributed via social media channels. Descriptive statistics were used to analyze the distribution of demographic variables using Chi-square  $\chi^2$  tests for categorical variables and t-test for continuous variables. Bowker test, and McNemar's Test were performed to evaluate the effects of lockdown on lifestyle factors.

**Results:** A total of 1051 participants were included in the study. There was a slight decrease in the overall diet score during the pandemic (14.98%) compared to before the pandemic (15.05%) ( $p$ -value=0.02), indicating poorer dietary intake during the lockdown. Approximately one-fourth of the participants (26.1%) reported following specific eating habits or a restricted diet during the pandemic ( $p$ -value=0.0001). There was increased consumption of most components of dietary intake categories, during the lockdown. An increase in physical activities for three or more times was reported. A higher proportion of respondents reported sleeping nine or more hours a day during the lockdown (10.8%). Similarly, a higher percentage of individuals reported smoking daily during the lockdown (12.2%). As of overall health status, higher percentage of respondents reported poor health status during lockdown (6.1%).

**Conclusion:** This study revealed major changes in lifestyle factors, negative shifts were revealed in dietary habits and smoking patterns. Positive changes were shown in physical activity, drinking water, and sleeping patterns. Our findings suggest that COVID-19 played a major role in changing lifestyle factors among adults in Saudi Arabia. Healthcare providers and public health officials are encouraged to increase awareness of healthy lifestyle factors that strengthen the immune system to combat COVID-19. The Saudi population needs increased awareness programs about healthy lifestyles to be prepared during pandemics.

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## Keywords

Lifestyle, COVID-19, Saudi Arabia, dietary habits, physical activity, smoking, alcohol use, quarantine

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## Introduction

In December 2019, the first cases of the novel coronavirus emerged from Wuhan, China and since then, it outspread globally to more than 219 countries and has resulted in a formidable health crisis.<sup>1</sup> It was declared as a pandemic on the 11th of March 2020 by the World Health Organization (WHO).<sup>2</sup> Coronavirus disease 2019 (COVID-19) is an infectious disease that can cause a broad range of symptoms varying from minimal to severe, including fever, cough, and shortness of breath.<sup>3</sup>

During COVID-19, a sudden and a major global change occurred in the governmental regulations to combat the pandemic. Many countries, including Saudi Arabia, applied extreme preventative measures in response to the public health crises, which resulted in a dramatic containment of the virus. Social distancing and lockdown measures were implemented on a global level to manage the spread of the virus. The Saudi government enforced quarantine, curfew, and lockdown measures. In Saudi Arabia partial lockdowns were imposed between April 21, 2020, and May 11, 2020, which permitted residents to move freely between 6 am and 6 pm. Subsequently, during the peak of the pandemic, 24-h curfew measures were enacted in Saudi Arabia from May 23, 2020, to May 27, 2020. The lockdown measures mandated residents to remain at home except for individuals going out to purchase necessities during the day and certain workers with permits.<sup>4</sup> This led to a virtual shift in schools, universities, and jobs. It also impacted outdoor physical activity, restricted social lives, led to food stockpiling, increased food consumption, affected diet quality, and impacted sleep patterns.<sup>5</sup> Massive effects on lifestyle factors were noticed after COVID-19.<sup>6</sup>

Lifestyle factors are changeable habits and routine behaviors that may impact physical and mental health. Lifestyle factors such as dietary habits, physical activity, sleeping patterns, smoking, and alcohol use are essential factors in maintaining a healthy body.<sup>7</sup> Promoting the adoption and maintenance of a healthy lifestyle play an important role in a well- functioning immune system necessary to combat COVID-19.<sup>8</sup> International studies have revealed changes in lifestyle factors during the pandemic.<sup>5,9</sup> A local study assessed the impact of quarantine on Saudi women's lifestyle, weight, and sleep habits. They concluded that there was a significant impact on young Saudi women's lifestyle behaviors, particularly weight change.<sup>10</sup>

Thus, the main purpose of the study is to assess the impact of COVID-19 and corresponding regulations and restrictions on lifestyle factors among the residents of

Saudi Arabia. The main factors that will be evaluated are dietary habits, physical activity, sleeping patterns, smoking, and alcohol use in Saudi Arabia before and during COVID-19.

## Materials and methods

**Participants:** This is a cross-sectional study among the Saudi population. Due to social distancing measures during the COVID-19 pandemic, we used an online survey method. The online survey was conducted via Google Forms web survey platform in both English and Arabic languages. The survey was distributed from May 22nd until June 2nd, 2021 through social media platforms such as Twitter, Facebook, and WhatsApp. Participation in the study was voluntary. Completing the survey was construed as consent to participate. Participants were able to withdraw at any time. All questions were anonymized to preserve privacy and no personal information was collected. All information was kept with the authors only and was used for research purposes only. Data was stored electronically in an encrypted file to ensure the security and privacy of information. The study population consisted of adults  $\geq 18$  years who reside in Saudi Arabia during Spring 2020.

## Study population

**Inclusion Criteria:** (1) adults aged 18 years and over and (2) males and females (3) residents of Saudi Arabia including citizens and expatriates.

**Exclusion criteria:** Children, individuals not residing in Saudi Arabia.

## Assessment tools

The survey was mainly taken from a previously published study and the survey was validated and modified to fit the objective of our study.<sup>9</sup> It also consisted of three widely used tools validated in both English and Arabic to assess the multiple pillars of lifestyle: diet intake, physical activity, sleep, smoking, and alcohol use. The validated tools used were the: (a) Mediterranean Diet Adherence Screener (MEDAS),<sup>11</sup> (b) International Physical Activity Questionnaire (IPAQ),<sup>12</sup> (c) Alcohol Use Disorders Identification Test (AUDIT-C).<sup>13</sup>

The questionnaire included two main sections. First section covered questions related to lifestyle factors such as: sleeping patterns, dietary habits, physical activity, smoking, and alcohol use. The second section covered demographic information including age, gender, marital status, nationality, income, education, and residential location (province). It also included questions related to self-reported chronic medical condition, and questions assessing COVID-19 infection and vaccination. Recalled information was collected to indicate behavior and habits

in two different time periods: (1) During COVID-19 pandemic referred to beginning of the pandemic up to date of filling the survey (period between January 2020 and May or June 2021). (2) Before COVID-19 referred to up to 1 year before the beginning of the pandemic (period between December 2018 and December 2019). Content validity has been achieved by three experts in the field. Face validity has been achieved by an official translator.

For the dietary section scoring scale, we used 0–3, (0=poor; 1=good; 2=very good; and 3=excellent), sections were divided according to food groups and serving portions as recommended by Dash diet from Mayo clinic, Stanford Healthcare organization and USDA.<sup>14–16</sup>

Data for each food group was ranked according to the following:

For fruits, the recommended portions were 2–4 per day, therefore, those who consumed 0 were scored as 0 (poor), occasionally 1 were scored as 1 (good), 1–2 per day were scored 3 (excellent), 3 and more were scored 2 (very good).

For vegetables, the recommended portions were 3–5 per day, therefore, those who consumed 0 were scored 0 (poor), occasionally 1 (Good), 1–2 per day were scored 2 (very good) and more than 3 were scored 3 (excellent).

For proteins, the recommended serving portions were 3–5 a day, so no protein intake was scored 0 (poor), occasionally 1 (good), 1–2 per day was scored 2 (very good), 3 and more were scored 3 (excellent).

For carbohydrates, the recommended serving portions were 6 (complex, such as whole grains, pasta, rice and bread) but it was not excluding simple carbohydrates in the study so it was ranked according to the following, those consuming 0 a day were ranked 0 (poor), occasionally 1 (good), 1–2 portions per day were ranked 3 (excellent), for those who take more than 3 portions a day took 2 (very good).

For dairy products, the recommended servings were 2–3 portions a day. Those consuming 0 ranked 0 (poor), for those who consumed occasionally were ranked 1 (good), 1–2 per day ranked 3 (excellent), and more than 3 portions a day were ranked 2 (very good).

For sweets and carbonated drinks, respondents not consuming any took the highest rank 3 (excellent), occasionally were ranked 2 (very good), 1–2 ranked 1 (good), and who consumed more than 3 servings were ranked 0 (poor).

For fats (both healthy and bad fat were included) so as per the recommendation, those who are taking no fat were given 0 (poor), occasionally ranked 2 (very good), 1–2 portions ranked 3 (excellent), and more than 3 portions ranked 1 (good).

The total daily water recommendation is 1.5–3 L a day depending on weight, so those taking 1–2 L ranked the highest rank 2 (excellent), less than 1 L ranked 0 (poor), and more than 3 L ranked 1 (good).

Regarding total daily meals, it is recommended to have at least 3 main meals if no snacks included. Those who

consumed 1 meal a day ranked 0 (poor), 2 meals 1 (good), 3 meals 3 (excellent), and more than 3 meals 2 (very good).

## Statistical analyses

Diet score was calculated in line with published tool-specific scoring instructions. We conducted descriptive statistics to analyze the distribution of demographic variables using Chi-square  $\chi^2$  tests for categorical variables and t-test for continuous variables. To evaluate the effects of lockdown on socioeconomic, lifestyle questions, paired before Covid-19 and during Covid-19 comparison was conducted. Bowker test of symmetry for more than  $2 \times 2$  table, and McNemar's Test for  $2 \times 2$  table were performed for questions where response was categorical. Participants with missing values in an outcome variable were excluded from any analysis on that variable. All statistical tests will use a 95% confidence interval with two-sided  $p$ -value  $< 0.05$  as level of significance. The authors assessed model of fit by using the Akaike Information Criterion (AIC),<sup>17</sup> all models were fit. The authors checked the assumption for independence among dependent variable categories by using the Hausman-McFadden test (Ref). All analyses were conducted using SAS statistical software version 9.4 (SAS Institute Inc. Cary, NC).

## Results

### Characteristics of the study participants

A total of 1051 participants were included in the study, of which 41% were 18–29 years old, 35% were 30–44 years old, 22% were 45–65 years old and 2% were 65 years or older. As for gender, 71% were females and 29% were males. Approximately, half of the participants were single (51%), had bachelor's degree (54%), and were living in Riyadh city (78%). Additionally, 24% of the respondents reported monthly income less than 9999 Saudi Riyals, while 24% reported having no monthly income. Non-Saudi respondents represented 51% of the sample. More than half of the sample completed the English version of the questionnaire (56%). While 80% of respondents reported no medical conditions, however, a little less than half of the sample were obese or overweight (46%). Regarding COVID-19 related questions, 19% of respondents reported previous COVID-19 infection, and 85% received at least one dose of the vaccine (Table 1).

### Comparison of lifestyle habits before and during lockdown (dietary intake score)

There was a slight decrease in the overall diet score during the pandemic (14.98%) compared to before the pandemic (15.05%) ( $p$ -value = 0.02), indicating poorer dietary intake during the pandemic. Slightly more than one-fourth of the

**Table 1.** Demographics and health related characteristics.

Demographic characteristics	Total (N= 1051)	
	n	%
Age group		
18–29	433	41.20
30–44	368	35.01
45–65	226	21.50
>65+	24	2.28
Gender		
Female	745	70.88
Male	306	29.12
Marital status		
Single	539	51.28
Married	470	44.72
Divorced	30	2.85
Widowed	12	1.13
Education attainment		
Bachelor's degree	568	54.04
Graduate degree	200	19.03
High school, diploma, or less	283	26.93
Monthly income in Saudi Riyal		
Less than 9999	257	24.45
10,000–19,999	151	14.37
>20,000	147	13.99
I do not have a monthly income	248	23.60
I prefer not to answer	248	23.60
Nationality		
Saudi	520	49.48
Non-Saudi	531	50.52
Province of residency		
Riyadh	822	78.21
Eastern Province	72	6.85
Western Province	94	8.94
Southern Province	63	5.99
Language		
English	585	55.66
Arabic	466	44.34
BMI*		
Underweight	301	28.80
Healthy weight	268	25.65
Overweight	150	14.35
Obese	326	31.20
Chronic medical condition		
Yes	214	20.36
No	837	79.64
History of COVID-19 infection		
Yes	201	19.12
No	850	80.88
Receipt of COVID-19 vaccine (at least one dose)		
Yes	898	85.44
No	153	14.56

\*Missing value in BMI (3).

participants, 26.1% reported following specific eating habits or a restricted diet during the pandemic compared to

20.8% before the pandemic ( $p$ -value=0.0001). A higher proportion of participants reported eating four or more meals during the pandemic, (12.4% vs 2.3% before the pandemic,  $p$ -value=0.0055). There was increased consumption of most components of dietary intake categories, during the pandemic as compared before the pandemic. Consumption increased for fruits from 6.3% to 10.4%, for vegetables from 8.3% to 10.4%, for fat from 10.3% to 11.3%, for dairy products from 11.4% to 14.1%, and for protein from 20% to 24.5% before and during the pandemic, respectively. There was a significant change in the intake of carbohydrates before and during the pandemic and no changes in sweetened carbonated beverages intake. Yet, water consumption changed significantly during the pandemic compared to before the pandemic ( $p$ -value=0.0001). Results showed that 21.5% of respondents drank more than 2L of water a day before the pandemic compared to 28% during the pandemic (Table 2).

### *Change in lifestyle factors (physical activity, sleeping, smoking, alcohol use, and overall perceived health)*

The percentage of respondents exercising three or more times a week increased during COVID-19. Moreover, the percentage of respondents without regular physical activity decreased during lockdown. A higher proportion of individuals reported exercising three or more times per week during the lockdown (28.45%) compared to before the lockdown (21.89%). Moreover, lower proportion of individuals reported no regular physical activity during lockdown (43.96%) compared to before the lockdown (49.76%). Regarding sleeping habits, there was a significant change before and during the pandemic among respondents ( $p$ -value<0.0001). A higher proportion of respondents reported sleeping nine or more hours a day during the pandemic 10.8% compared to 3.8% before the pandemic. Similarly, higher percentage of individuals reported sleeping in the morning during the pandemic compared to before the pandemic (34.4% and 19.6%, respectively). In the contrary, fewer individuals reported sleeping at night during the pandemic compared to before the pandemic (65.7%, and 80.4%, respectively).

Regarding smoking, the proportions of respondents who reported smoking versus non-smoking were significantly different before and during the lockdown ( $p$ -value<0.0001). Higher percentage of individuals reported smoking daily during the pandemic compared to before (12.2%, 11.5%, respectively). In contrast, there was no significant differences among proportions of alcohol use before and during the pandemic ( $p$ -value<0.33). As of overall health status, there was a significant difference before and during the pandemic ( $p$ -value<0.0001). There were 41 (3.9%) respondents reported poor health status before the pandemic, while 64 (6.1%) reported poor health status after the pandemic (Figure 1, Table 3).



**Table 2.** Dietary intake.

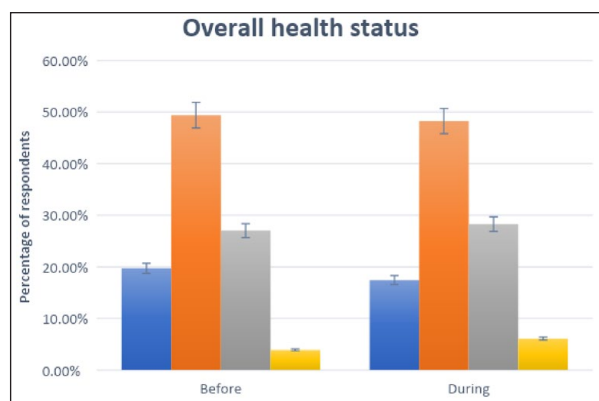
	Before COVID-19	During COVID-19	p Value
	n (%)	n(%)	
Dietary intake			0.02 <sup>b</sup>
Diet overall score <sup>a</sup>	15.05	14.98	
Do you follow specific eating habits or a restricted diet?			<.0001 <sup>c</sup>
Yes	419 (20.84)	274 (26.07)	
No, regular diet	832 (79.16)	777 (73.93)	
How many servings of fruits do you eat per day?			<.0001 <sup>d</sup>
0	67 (6.37)	70 (6.66)	
Occasionally (Less than daily use)	494 (47)	423 (40.25)	
1–2	423 (40.22)	440 (41.86)	
3 and more	67 (6.33)	109 (10.37)	
How many cups of cooked/raw vegetables do you eat per day?			<0.0001
0	84 (7.99)	85 (8.09)	
Occasionally (Less than daily use)	390 (37.11)	335 (31.87)	
1–2	490 (46.62)	502 (47.76)	
3 and more	87 (8.28)	129 (12.28)	
How many servings of protein do you eat per day?			<0.0001
0	20 (1.90)	25 (2.38)	
Occasionally (Less than daily use)	160 (15.22)	150 (14.27)	
1–2	661 (62.89)	618 (58.80)	
3 and more	210 (19.98)	258 (24.54)	
How many servings of carbohydrates do you eat per day?			0.0054
0	30 (2.58)	46 (4.38)	
Occasionally (Less than daily use)	117 (11.13)	123 (11.17)	
1–2	571 (54.33)	553 (52.62)	
3 and more	333 (31.68)	329 (31.31)	
How many servings of dairy products do you have per day?			<0.0001
0	62 (5.90)	75 (7.14)	
Occasionally (Less than daily use)	261 (24.83)	228 (21.69)	
1–2	608 (57.85)	600 (57.09)	
3 and more	120 (11.42)	148 (14.08)	
How many cups of sweetened carbonated beverages do you drink per week?			0.018
0	299 (28.45)	330 (31.40)	
Occasionally (Less than daily use)	375 (35.68)	359 (34.16)	
1–2	270 (25.69)	255 (24.26)	
3 and more	107 (10.18)	107 (10.18)	
How many servings of fat do you eat per day?			<0.0001
0	81 (7.71)	104 (9.90)	
Occasionally (Less than daily use)	247 (23.50)	256 (24.36)	
1–2	615 (58.52)	572 (54.42)	
3 and more	108 (10.28)	119 (11.33)	
How many liters of water do you drink per day?			<0.0001
Between 1 and 2L	528 (50.24)	572 (54.42)	
Less than 1L	297 (28.26)	186 (17.70)	
More than 2L	226 (21.50)	293 (27.88)	
How many meals do you eat per day?			0.0055
1 Meal	60 (5.71)	69 (6.57)	
2 Meals	378 (35.97)	417 (39.68)	
3 Meals	524 (49.86)	435 (41.39)	
4 and more	24 (2.30)	130 (12.38)	

<sup>a</sup>Overall diet mean score.

<sup>b</sup>Paired t-test was used for the comparison of paired measures before and during COVID-19, between February 2020 (i.e. - the Month before Lockdown) and lockdown.

<sup>c</sup>McNemar's Test for 2 × 2 table was used for the comparison of paired measures before and during COVID-19, between February 2020 (i.e. - the Month before Lockdown) and lockdown.

<sup>d</sup>Bowker test of symmetry for more than 2 × 2 table was used for the comparison of paired measures before and during COVID-19, between February 2020 (i.e. - the Month before Lockdown) and lockdown.



**Figure 1.** The overall health status before and during COVID-19.

## Discussion

In a sample of Saudi Arabia residents who were largely females and under 45 years of age, we found that overall health was worse during the COVID-19 pandemic as compared to before the COVID-19 pandemic. Changes in individual dietary and lifestyle factors varied. There was an increase in the number of meals eaten during the pandemic as compared to before, which aligned with the increased food consumption that was reported (e.g. increased consumption of fruits, vegetables, fat, dairy, proteins, and water). Sleeping patterns changed, with a higher proportion of participants reporting sleeping 9+ hours per day during the pandemic. The proportion of respondents who reported smoking daily also increased from before versus during the pandemic. Interestingly, there was an increase in exercising three or more times per week.

The findings demonstrated a slight decrease in the overall diet score during the pandemic, indicating a slightly poorer quality of dietary intake. A local study among Saudis ( $n=2706$ ) during the pandemic shows similar findings indicating poor dietary habits in terms of quality and quantity of food during the pandemic.<sup>18</sup> Another local study among Saudi residents ( $n=1965$ ) also confirms our findings as it revealed unhealthy dietary habits during the pandemic.<sup>19</sup> Similarly, Western populations such as Italy, France and Denmark have shown an increase in quantity and decrease in quality of consumed food during Covid-19. For instance, Freiberg et al. conducted a review study in 2021 using the probability sampling methods, showing that the amount of food intake among adults increased and some adults reported weight gain during quarantine and lockdown.<sup>20</sup> Another cross-sectional study among French adults showed similar results by using the Alternative Healthy Eating Index (AHEI) score of participants, which demonstrated slight changes, such as increased snacking and decreased consumption of fresh food.<sup>21</sup> Another French study ( $n=938$ ) confirms our findings as the nutritional quality of diet was lower during the lockdown

compared to before.<sup>22</sup> A Denmark study reported that 41.7% of its participants snacked more frequently, 29.9% cooked more at home, and 42.8% of overall food intake increased during the COVID-19 pandemic lockdown.<sup>23</sup> According to the findings of an Italian study, half of participants showed an increase in consumption of comfort foods -high in sugar and fat- which could be explained by the heightened levels of anxiety, stress, and boredom. Increased consumption of homemade meals has also been noted which can be linked to fear of transmission of COVID-19 through food delivery.<sup>8</sup> Yet one study found contradicting results, a self-reported survey was done in Northern Italy on 490 adults and results show that 34% participants reported an improvement in diet quality, 42% increased food intake, while 13% decreased intake.<sup>24</sup>

The study revealed an increase in the number of individuals following a restricted diet or a specific eating habit during the pandemic. A previous cross-sectional online experiment conducted in France has shown a decrease in the nutritional quality of diet among participants, which was attributed to modifications in food choice motives such as increased weight control and improved health.<sup>22</sup> A significant increase in the number of daily meals intake was demonstrated during the pandemic. Similarly, a cross-sectional among adults residing in the UAE reported an increase in food intake by 32%. This was attributed to the fact that being confined indoors could lead to irregular eating patterns, frequent snacking and consequently a higher caloric balance.<sup>25</sup>

Individuals in our study demonstrated changes in fat consumption and increase in fruits, vegetables, and dairy products. In contrast, a study in Poland showed that there was a decrease in the consumption of vegetables and fruits and an increase in dairy and fats,<sup>26</sup> which can be due to grocery stores limited hours. Yet, in France participants ate more vegetables but slightly less fruits.<sup>21</sup> Likewise, a study among Spanish participants shows that there is a decrease in the daily consumption of fruits and vegetables during the Lockdown.<sup>27</sup> The increase in fruits and vegetables intake among the Saudis could have been a result of the desire to enhance the immune system.

A slight decrease was noted in the consumption of carbohydrates and no change was noted in consumption of sweetened carbonated beverages. Various studies have reported conflicting findings in relation to changes in the consumption of carbohydrates and sweetened beverages. A cross-sectional study in France has indicated that the consumption of sweet-tasting beverages, sugary foods, processed meats, and other foods of low nutritional value were more frequently consumed during the pandemic.<sup>22</sup> Similarly, a sample of the Italian population reported dietary habits modification during COVID-19 lockdown. The results indicated that 46.1% of the participants reported eating more during lockdown. Specifically, an increase in "comfort food" like chocolate, ice-cream, and

**Table 3.** Lifestyle factors (PA, sleep, smoking, and alcohol use) before and during the pandemic.

Lifestyle factors	Before COVID-19	During COVID-19	p Value <sup>a</sup>
	n (%)	n (%)	
<i>PA</i>			
How often do you exercise or engage in physical activity (30+ min)?			0.003 <sup>b</sup>
1–2 times per week	298 (28.35)	290 (27.59)	
3 or more times per week	230 (21.89)	299 (28.45)	
I do not exercise regularly	523 (49.76)	462 (43.96)	
<i>Sleeping</i>			
How many hours do you sleep?			<0.0001
<7h	531 (50.52)	448 (42.63)	
Between 7 and 9 h	480 (45.67)	490 (46.62)	
>9h	40 (3.81)	113 (10.75)	
Does the majority of your sleep occur in the morning or night?			<0.0001 <sup>c</sup>
Morning	206 (19.60)	361 (34.35)	
Night	845 (80.40)	690 (65.65)	
<i>Smoking</i>			
How often do you smoke (Cigarettes, cigars, electronic vape, shisha)?			<0.0001
I don't smoke	840 (79.92)	839 (79.83)	
1–2 times a week	60 (5.71)	56 (5.33)	
3–5 times a week	30 (2.85)	28 (2.66)	
Daily	121 (11.51)	128 (12.18)	
<i>Alcohol use</i>			
How often do you drink alcohol?			0.33
I don't drink	1007 (95.81)	1003 (95.43)	
1–2 times a week	29 (2.760)	36 (3.43)	
3–5 times a week	6 (0.57)	5 (0.48)	
Daily	9 (0.86)	7 (0.67)	
<i>Overall health status</i>			
How do you rate your general health?			<0.0001
Excellent	207 (19.70)	183 (17.41)	
Very good	519 (49.38)	507 (48.24)	
Fair	284 (27.02)	297 (28.26)	
Poor	41 (3.90)	64 (6.09)	

<sup>a</sup>Change in proportion before and during pandemic.

<sup>b</sup>Bowker test of symmetry for more than 2×2 table was used for the comparison of paired measures before and during COVID-19, between February 2020 (i.e. - the Month before Lockdown) and lockdown.

<sup>c</sup>McNemar's Test for 2×2 table was used for the comparison of paired measures before and during COVID-19, between February 2020 (i.e. - the Month before Lockdown) and lockdown.

desserts (42.5%) and salty snacks (23.5%).<sup>8</sup> Yet, carbohydrate intake is less frequently consumed, while protein intake slightly increased among adults during lockdown<sup>21</sup>

Looking at water consumption, we found that participants drank more water during COVID-19. Likewise, a Polish study has also shown that 24% of respondents reported an increase in water intake.<sup>28</sup>

## Physical activity

Physical activity has numerous health benefits, including strengthening the immune system, lowering risk of chronic medical conditions, and improving overall mental health. However, in an effort to reduce the transmission of COVID-19, social distancing measures have been implemented

worldwide, which may have impacted people's ability to engage in physical activities.<sup>29</sup> Countries in the Middle East showed a decrease in physical activities during the pandemic. For instance, a study among 2507 Lebanese adults has shown a decrease in physical activity during lockdown and that staying at home may have led to an increase in sedentary behaviors such as sitting for prolonged periods and increased screen time.<sup>30</sup> Similarly, a cross-sectional study done in the United Arab Emirates shows a decrease in physical activity by 30% during lockdown.<sup>25</sup> A cross-sectional study among Saudis ( $n=2255$ ) concluded that about half of their participants reported increased food consumption, and reduced physical activities during lockdown.<sup>10</sup> In another cross-sectional study ( $n=1965$ ) among Saudi adults, participants reported a significant decrease in

the percentage of those walking daily for more than 4 times a week (30.5% vs 29.1%) and an increase in the number of individuals who did not walk daily during quarantine (21% vs 23.6%).<sup>19</sup> Likewise, a cross-sectional study conducted in Saudi Arabia has shown a 12% decrease in physical activity.<sup>31</sup> Looking at the Western population, a French study shows 53% of participants reported decreased in their reported physical activity during lockdown.<sup>21</sup> However, our findings show increased physical activity among the Saudi population during COVID-19 ( $p$ -value=0.003). These differences in the results may be attributed to the comparison group used, these studies focused on COVID-19 lockdown, while we measured changes starting from the beginning of the pandemic up to the present time, which extends beyond lockdown.

## Sleeping

Sleep is also crucial for mental and emotional well-being as well as confronting stress and anxiety.<sup>32</sup> A significant increase in sleeping hours has been reported in this study. A higher proportion of participants reported sleeping nine or more hours a day during the pandemic (10.8%) compared to (3.8%) before the pandemic. Similar results were seen in a study from Italy, which reported an increase in sleeping hours among participants during lockdown.<sup>9</sup> In a prospective study among young Saudi women, despite reporting an increase in sleeping hours compared to their baseline before the pandemic, a large proportion of participants reported poor quality of sleep (70%) and short sleep of  $\leq 7$ h (44%).<sup>10</sup> Similarly, a study conducted in Turkey among 405 participants showed that the prevalence of poor sleep was 55.1%.<sup>33</sup> Yet, contradictory results were reported in the United Arab Kingdom, a cross-sectional study recorded decreased sleeping hours.<sup>25</sup> This reduced number of sleeping hours is thought to be due to increased emotional exhaustion and stress levels during the lockdown.

Sleeping hours can be negatively affected by increased emotional exhaustion and stress levels during the pandemic.<sup>25</sup> In addition, this study reported a higher percentage of individuals sleeping in the morning during the pandemic compared to before the pandemic (34.4% and 19.6%, respectively). While fewer percentage of individuals slept at night during the pandemic compared to before the pandemic (80.4% and 65.7%, respectively). A study conducted among Scottish and United Kingdom indicated that sleeping patterns did not change for third of the participant's, while it got worse for a little more than half of the participants.<sup>34</sup> A Saudi study revealed disturbed sleep patterns with most participants sleeping during the day, rather than at night during the pandemic.<sup>18</sup> The differences in the sleep patterns between the studies could be due to the difference in the timing of the studies, especially that our study was conducted after the lockdown period.

## Smoking

There are conflicting views in the literature on the changes in smoking habits during COVID-19. Some studies reported an increase in smoking frequency during COVID-19 while others reported a reduction in smoking frequency.<sup>9,25</sup> Higher smoking rates have been reported in this study during the pandemic. Similar to the findings of an Italian study which reported an increase in cigarette consumption by 9.1% during lockdown. The worsening of smoking habits were mainly associated with mental distress.<sup>35</sup> In contrast to another study that was also conducted in Italy which reported a reduction in smoking by 0.5% in individuals who smoked more than 10 cigarettes daily. This improvement in smoking habits was thought to be linked to the fear of COVID-19 mortality.<sup>9</sup> In the United Arab Emirates, a recent study showed no reported change in smoking habits among approximately 40% of the participants, while 21% have reported smoking more.<sup>25</sup>

## Alcohol use

Globally, alcohol use has also been another growing concern in this pandemic. In a study in the United Kingdom, there has been a 50.4% increase in alcohol use among individuals aged 18–34 years old, 45.4% among 35–64 years, and 4.2% among people over 65 years during lockdown.<sup>36</sup> Another study in Scotland and the United Kingdom indicated higher consumption of alcohol among 35% of participants.<sup>34</sup> Likewise, a French study concluded 15% increased alcohol consumption, while 12% reported decreased alcohol consumption during lockdown.<sup>21</sup> Freiberg et al. also reported that the alcohol consumption increased during quarantine and lockdown.<sup>20</sup> An Italian study showed a decrease of alcohol use during lockdown.<sup>9</sup> Our study revealed no significant change in alcohol use before and during COVID-19. The differences might be attributed to the Islamic culture of Saudi Arabia, which prohibits alcohol use. Also, the availability and legal purchase of alcoholic differences can play a significant role in the consumption during lockdown.

There were several limitations of our study to consider. The cross-sectional nature of the study limits any causal inferences. Since these data were self-reported at one time point, recall bias is another major limitation of the study especially in reporting the dietary habits before the pandemic. Another limitation is that people's behavior and habits might change frequently, especially during a long period of time. Moreover, since the survey was conducted through social media, the age distribution is not representative of the Saudi Arabia population. Only 2% of the sample was 65+. However, this study reveals essential changes in the lifestyle factors among the residents of Saudi Arabia. Further studies are highly needed to achieve generalizability among the entire population.



## Conclusion

This study revealed major changes in lifestyle factors, negative shifts were revealed in dietary habits and smoking patterns. Positive changes were shown in physical activity, drinking water, and sleeping patterns. Our findings suggest that COVID-19 played a major role in changing lifestyle factors among adults in Saudi Arabia. Healthcare providers and public health officials are encouraged to increase awareness of healthy lifestyle factors that strengthen the immune system to combat COVID-19. The Saudi population needs increased awareness programs about healthy lifestyles to be prepared during pandemics.

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## Authors contributions

NA was responsible for the preparation, conduct, and administration of the research, including data collection, writing the research results and publication, and dissemination of research report. Other authors were co-responsible of research preparation and administration. MR was responsible for data coding and analysis.

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## Ethical approval

This study was approved by the Institutional Review Board of Alfaisal University IRB-20121.

## Significance to public health

The population's lifestyle factors have a significant role in maintaining a healthy community. During COVID-19, major shifts in lifestyles were revealed leading to various unwanted consequences. Healthcare providers and public health officials are encouraged to increase awareness of healthy lifestyle factors that strengthen the immune system to combat COVID-19. Routine awareness campaigns directed toward the general population are essential to enhance the public health especially during pandemics.

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## Availability of data and material

The survey was sent online, and all answers were kept in a safe place with limited access to the authors only.

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