Healthy Dietary Intake Behavior Potentially Modifies the Negative Effect of COVID-19 Lockdown on Depression: A Hospital and Health Center Survey

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Background: The COVID-19 pandemic causes a huge burden for affected countries. Several public health interventions were applied to contain the infection. However, the pandemic itself and the lockdown measure negatively influence people’s lifestyles and psychological health.
**INTRODUCTION**

The COVID-19 pandemic is caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which sets the whole world in unprecedented challenges (1–6). It creates a huge burden, in terms of socioeconomic effects (7), morbidity, and mortality (8, 9). Infections and deaths are dramatically increasing in all the affected countries (10). Multidisciplinary and multidimensional approaches are required to contain the pandemic (11–13). In the situation of unavailable effective treatments and vaccination, social and behavioral changes are highly recommended to control the massive global health crisis (14, 15).

Among COVID-19 management strategies, healthy diet and nutrition show potential impacts on immune system and health outcomes (16–18). A diversified and balanced diet can improve the immune response to viral infection (19). Healthy foods have been found as a potential therapy to enhance immunity, to improve the acute respiratory symptoms and health outcomes which may help to protect people during the COVID-19 pandemic (20). Some food groups (e.g., fruits and vegetables, fish and fish oils) and key nutrients (e.g., fiber, vitamins A, B, C, D, and E, selenium, iron, copper, zinc) have shown the benefit for protecting against viral infection (17, 21, 22). Adequate intake of relevant nutrients can help to reduce inflammation and oxidative stress, which further strengthens the immune system of individuals during the COVID-19 pandemic (22, 23).

The COVID-19–induced lockdown or home confinement measure was applied in many countries including Vietnam (24). This measure is a necessary public health approach to protect people from virus infection. However, it has undesirable consequences (25), e.g., negative impacts on psychological consequences (26, 27), eating behavior, and changes in dietary habits (28–31). Fortunately, healthy diet has potential benefits to reduce the risk of severity (32) and complications of COVID-19 (33). People with a better diet quality intake had a lower risk of depression (34, 35). Moreover, assessment of dietary intake behavior is critically important for identifying the comprehensive approach to manage COVID-19 (36) and indicating the sustainable food intake during the lockdown (37). The healthy eating score (HES-5) is a short, simple, and valid tool to quickly assess the overall diet quality which is comparable with the 2015 health eating index (38). The HES-5 has an advantage of timely and easy assessment of healthy dietary intake behavior in the time of COVID-19 pandemic.

Therefore, we investigated the associated factors of healthy dietary intake behavior and depression, as well as examined the interaction of COVID-19 lockdown and healthy dietary intake on depression among people who visited outpatient departments from 18 hospitals and health centers across Vietnam.

**Purpose:** To explore determinants of healthy dietary intake and depression, and examine the interaction between healthy dietary intake and COVID-19 lockdown on depression.

**Methods:** A cross-sectional study was conducted at 18 hospitals and health centers from February 14 to May 31, 2020. Data of 8,291 outpatients were collected including patients’ characteristics, clinical parameters, health literacy, healthy dietary intake (using the healthy eating score, HES), other health-related behaviors, and depression (using the patient health questionnaire, PHQ). Depression was defined as PHQ score ≥ 10.

**Results:** Protective factors of healthy dietary intake and depression were higher education, better medication payment ability, higher social status, more physical activity, and higher health literacy, whereas older age, ever married, own business or other types of occupation, lockdown, suspected COVID-19 symptoms, and comorbidity were associated with lower HES scores and a higher depression likelihood. Besides, overweight/obesity and alcohol drinking were associated with lower HES scores. As compared with patients not under lockdown and with lowest HES score, those who were under lockdown and with lowest HES score had 10.6 times higher depression likelihood (odds ratio, OR, 10.60; 95% CI 6.88, 16.32; \( p < 0.001 \)), whereas people with higher HES score had 15% lower depression likelihood (OR 0.85; 95% CI 0.82, 0.89; \( p < 0.001 \)).

**Conclusions:** Healthy dietary intake and depression were determined by several sociodemographic, clinical, and behavioral factors. Lockdown measure affects people’s dietary intake behavior and depression. Importantly, healthy dietary intake potentially modifies the negative effect of lockdown on depression.

**Keywords:** COVID-19, coronavirus, lockdown, healthy eating, psychological, physical activity, comorbidity, obesity
METHODS

Study Design and Settings
A cross-sectional study was conducted from February 14 to May 31, 2020. Study duration in each hospital/health center was 7–10 days. The study participants were consecutively recruited at outpatient departments (OPDs) from 15 hospitals and three health centers across Vietnam. The study sites were conveniently selected, including 10 hospitals and one health center in the North, one hospital and one health center in the Center, and four hospitals and one health center in the South.

Study Sample
Participants were those who visited the OPDs of selected hospitals and health centers. The recruited participants were those aged 18 to 85 years, understood Vietnamese, and without emergency conditions. After excluding 60 individuals with age <18 years (26 cases), more than 85 years (19 cases), and incomplete survey (15 cases), a total sample of 8,291 outpatients were analyzed. Participants in studied hospitals and health centers are presented in Table 1.

Assessments and Measurements
Participants’ Characteristics
Participants self-reported their information, including age (years), gender (women vs. men), marital status (never married vs. ever married), educational attainment (illiterate/elementary, junior high school, senior high school, college/university or higher), occupation (employed, own business, and others), ability to pay for medication (very difficult to very easy), and social status (patients placed themselves into the society regarding education, career, and salary, at three levels from low, middle to high). Vietnam had applied the nationwide lockdown measure from April 1 to 22, 2020 (24, 39). Therefore, the lockdown was defined for patients who took the survey during that period.

Clinical Parameters
Patients were asked to report their body height (cm) and weight (kg). Body mass index (BMI, kg/m^2) was calculated. The suspected COVID-19 symptoms (S-COVID-19-S) were assessed (40), including common symptoms (fever, cough, dyspnea) and less common symptoms (myalgia, fatigue, sputum production, confusion, headache, sore throat, rhinorrhea, chest pain, hemoptysis, diarrhea, and nausea/vomiting). Patients were classified as having S-COVID-19-S if they had any of those symptoms. Items of the Charlson Comorbidity Index were used to screen for comorbidity (41).

Health-Related Behaviors
Patients reported their current behaviors as compared with before the pandemic, including smoking status (never/stop/less vs. unchanged or more), drinking status (never/stop/less vs. unchanged or more), and physical activities (never/stop/less vs. unchanged or more).

Health Literacy
The short-form health literacy questionnaire with 12 items (HLS-SF12) was used to assess health literacy (HL). The tool was

| TABLE 1 | Participants in studied hospitals and health centers. |
|-----------------|--------------------------|-----------------|
| Geographic location | Hospital/health center | Studied participants |
| **North** | | |
| Ha Noi city | Military Hospital 103 | 1,028 |
| | E hospital | 183 |
| | General Hospital of Agricultural | 300 |
| Thai Nguyen province | Thai Nguyen National Hospital | 489 |
| Bac Ninh city | Bac Ninh Obstetrics and Pediatrics Hospital | 500 |
| Hai Phong city | Hai Phong University of Medicine and Pharmacy Hospital | 982 |
| | Kien An Hospital | 492 |
| | Kien Thuy District Health Center | 484 |
| Quang Ninh province | Quang Ninh General Hospital | 309 |
| | Bai Chay Hospital | 364 |
| | Quang Ninh Obstetrics and Pediatrics Hospital | 280 |
| **Center** | | |
| Quang Tri province | Trieu Phong District Health Center | 495 |
| Da Nang city | Da Nang Oncology Hospital | 421 |
| **South** | | |
| Ho Chi Minh city | Thu Duc District Hospital | 489 |
| | Thu Duc District Health Center | 497 |
| | Hospital District 2 | 248 |
| | Tan Phu District Hospital | 242 |
| Can Tho city | Can Tho University Of Medicine and Pharmacy Hospital | 508 |
| **Total** | | 8,291 |
validated and used in Asian countries (42) including Vietnam (43–46). Patients were asked to rate their perceived difficulty of each item based on 4-point Likert scales from 1 = “very difficult” to 4 = “very easy.” The overall score was standardized to an index ranging from 0 to 50, with higher score presenting better HL, using the formula (1):

$$\text{Index} = (\text{Mean} - 1) \times \left( \frac{50}{3} \right)$$  \hspace{1cm} (1)

where Index is the specific index score calculated, Mean is the mean of 12 items for each individual, 1 is the minimal possible value of the mean (leading to a minimum index value of 0), 3 is the range of the mean, and 50 is the chosen maximum value of HL index.

**Health Dietary Intake Behavior**

The 5-item healthy eating score (HES-5) was used to assess healthy dietary intake behavior. HES-5 was validated and used in previous studies (38, 47). The utilization of HES-5 was comparable with the 2015 health eating index and quickly assesses the overall diet quality (38). The tool is expected to be useful for assessing the healthy dietary intake behavior during the sensitive period of the pandemic. The questionnaire was translated into Vietnamese by researchers. The content was then validated by an expert panel (28 medical doctors, 7 nurses, 9 nutrition and public health professionals). The expert panel suggested using the rating and the scoring of the original scale. The unidimensional construct was expressed with all five items loaded on one component (factor loadings ranged from 0.63 to 0.75), which explained 49.43% of the variance. The tool was showed with adequate convergent validity (item–scale correlation ranged from 0.57 to 0.73), satisfactory reliability (Cronbach’s alpha of 0.74), and without floor or ceiling effects (Supplementary Table 1). Participants were asked about how often did they eat/drink fruits, vegetables, whole grains, dairy, and fish over the last 30 days. The rating scale was from 0 = “Rarely or never,” 1 = “1–2 times per week,” 2 = “3–6 times per week,” 3 = “once per day,” 4 = “twice per day,” to 5 = “3 or more times per day.” The total score of healthy dietary intake (HDI-score, or HES) ranged from 0 to 25, with the higher score indicating the better healthy eating behavior.

**Depression**

The patient health questionnaire with 9 items (PHQ-9) was used to assess depression. PHQ-9 is a screening tool that helps clinicians in making the diagnosis of depression, quantifying depression symptom, and monitoring the severity (48). This tool was used in Vietnam (45). Patients were asked about how often they have been bothered by nine symptoms during the last 2 weeks on the scale from 0 (not at all), 1 (several days), 2 (more than half the days), to 3 (nearly every day). The overall PHQ-9 score ranges from 0 to 27. Patients were classified as having depression if their PHQ score ≥ 10 (48).

**Data Collection Procedure**

Before the data collection, we provided research assistants (doctors, nurses, and medical students) a 4 h training session on data collection. Research assistants also received the infection control training from each health facility, e.g., using masks, washing hands, and physical distancing according to guidelines of the Centers for Disease Control and Prevention (49), World Health Organization (50), and Vietnam Ministry of Health (51).

Research assistants contacted and asked patients who visited the OPDs for voluntary participation. The OPD visitors were consecutively invited to the survey. The consent form was obtained from qualified patients before administering the survey. The survey took place during the waiting time, before and/or after physical examination. At the early stage of the pandemic, face-to-face interviews were conducted. At the peak stage of the pandemic, self-administered questionnaires were used via an online version (QR code provided at each OPD) or printed version. It took about 20–30 min to complete survey questionnaires. Finally, data were confidentially analyzed by researchers.

**Ethical Consideration**

The study was reviewed and approved by each participating hospital, and the Institutional Ethical Review Committee of Hanoi University of Public Health, Vietnam (IRB No. 029/2020/YTCC-HD3 for the first period from February 14 to March 31, 2020; and IRB No. 133/2020/YTCC-HD3 for the second period from April 1 to May 31, 2020).

**Statistical Analysis**

First, distributions of studied variables were explored using the $\chi^2$ test and one-way ANOVA test appropriately. Second, associated factors of healthy dietary intake behavior (HES) and depression (PHQ) were examined using linear regression models and logistic regression models, respectively. To minimize residual effects of confounders on the associations, factors associated with HES or PHQ at $p < 0.20$ in the bivariate model were selected into the multivariate model (52). To avoid the multicollinearity in the multivariate models, the correlations of factors were tested using Spearman correlation. If the moderate or high correlations exist, a representative factor was selected to final models. Finally, the interaction analysis was conducted to examine the potential mental health benefits of healthy dietary intake behavior. Data were analyzed using the IBM SPSS version 20.0 (IBM, Armonk, NY, USA). The significance level was set at $p < 0.05$.

**RESULTS**

**Participants’ Characteristics**

Mean values of age, health literacy, and healthy eating score (HES) were 43.6 ± 16.9, 28.1 ± 9.4, and 11.9 ± 4.6, respectively. Proportions of people who participated during the lockdown measure and with depression (PHQ ≥ 10) were 28.7% (2,376/8,291) and 12.5% (1,033/8,291), respectively. The HES was varied by different categories of age, gender, marital status, education, occupation, ability to pay for medication, social status, lockdown, S-COVID-19-S, BMI, comorbidity, smoking, drinking, and physical activity ($p < 0.001$), whereas the prevalence of depression was varied by different categories of age, marital status, education, occupation, ability to pay for...
Participants’ characteristics, healthy dietary intake behavior, and depression.

| Variables | Overall (N=8,291) | HES (N=8,291) | PHQ < 10 (N=7,258) | PHQ ≥ 10 (N=1,033) |
|-----------|-------------------|---------------|---------------------|-------------------|
| Age, years |                  |               |                     |                   |
| 18–39     | 3,955 (47.7)      | 12.6 ± 4.7    | 3,688 (50.8)        | 267 (25.8)        |
| 40–59     | 2,473 (29.8)      | 11.5 ± 4.5    | 2,220 (30.6)        | 253 (24.5)        |
| 60–85     | 1,863 (22.5)      | 11.3 ± 4.4    | 1,350 (18.6)        | 513 (49.7)        |
| Gender    |                  |               |                     |                   |
| Women     | 4,890 (59%)       | 12.1 ± 4.6    | 4,279 (59.0)        | 611 (59.1)        |
| Men       | 3,401 (41)        | 11.7 ± 4.6    | 2,979 (41.0)        | 422 (40.9)        |
| Marital status |         |               |                     |                   |
| Never married | 1,635 (19.8)   | 12.4 ± 4.5    | 1,496 (20.7)        | 139 (13.5)        |
| Ever married | 6,628 (80.2)    | 11.8 ± 4.6    | 5,734 (79.3)        | 894 (86.5)        |
| Education attainment | |               |                     |                   |
| Elementary school or illiterate | 593 (7.2) | 11.3 ± 4.7 | 480 (6.6) | 113 (10.9) |
| Junior high school | 1,630 (19.7) | 11.1 ± 4.3 | 1,431 (19.8) | 199 (19.3) |
| Senior high school | 2,277 (27.5) | 11.8 ± 4.4 | 1,995 (27.5) | 282 (27.3) |
| College/university or higher | 3,776 (45.6) | 12.5 ± 4.8 | 3,337 (46.1) | 439 (42.5) |
| Occupation |                  |               |                     |                   |
| Employed | 2,390 (28.9)      | 12.2 ± 4.7    | 2,149 (29.7)        | 241 (23.3)        |
| Own business | 3,044 (36.8)   | 11.7 ± 4.6    | 2,709 (37.4)        | 335 (32.4)        |
| Others | 2,843 (34.3)      | 12.1 ± 4.5    | 2,386 (32.9)        | 457 (44.2)        |
| Ability to pay for medication | |               |                     |                   |
| Very or fairly difficult | 4,475 (54) | 11.5 ± 4.7 | 3,710 (51.2) | 765 (74.1) |
| Very or fairly easy | 3,805 (46) | 12.4 ± 4.4 | 3,537 (48.8) | 268 (25.9) |
| Social status |                  |               |                     |                   |
| Low | 1,403 (16.9) | 10.9 ± 4.7 | 1,187 (16.4) | 216 (20.9) |
| Middle or high | 6,879 (83.1) | 12.2 ± 4.5 | 6,062 (83.6) | 817 (79.1) |
| Lockdown measure | |               |                     |                   |
| No | 5,915 (71.3) | 12.4 ± 4.5 | 5,428 (74.8) | 487 (47.1) |
| Yes | 2,376 (28.7) | 10.9 ± 4.6 | 1,830 (25.2) | 546 (52.9) |
| S-COVID-19-S | | | | |
| No | 5,162 (62.3) | 12.7 ± 4.7 | 4,827 (66.5) | 335 (32.4) |
| Yes | 3,129 (37.7) | 11.0 ± 4.6 | 2,431 (33.5) | 698 (67.6) |
| BMI, kg/m² | | 0.026 | | |
| Underweight (BMI < 18.5) | 783 (9.5) | 12.3 ± 4.7 | 709 (9.8) | 74 (7.2) |
| Normal weight (18.5 ≤ BMI < 25.0) | 6,518 (78.8) | 11.9 ± 4.6 | 5,685 (78.4) | 833 (81.0) |
| Overweight/obese (BMI ≥ 25.0) | 974 (11.8) | 11.7 ± 4.6 | 853 (11.8) | 121 (11.8) |
| Comorbidity | | <0.001 | |<0.001 |
| None | 6,415 (77.5) | 12.5 ± 4.6 | 5,877 (81.1) | 538 (52.1) |
| One | 1,458 (17.6) | 10.4 ± 4.1 | 1,132 (15.6) | 326 (31.6) |
| Two or more | 409 (4.9) | 8.7 ± 3.2 | 241 (3.3) | 168 (16.3) |
| Smoking* | | <0.001 | | 0.867 |
| Never, stopped, or smoke less | 7,541 (91.0) | 12.1 ± 4.6 | 6,600 (90.9) | 941 (91.1) |
| Unchanged or smoke more | 750 (9.0) | 10.6 ± 4.6 | 658 (9.1) | 92 (8.9) |
| Drinking alcohol* | | <0.001 | | 0.680 |
| Never, stopped, or drink less | 7,044 (85.1) | 12.1 ± 4.6 | 6,178 (85.1) | 866 (84.7) |
| Unchanged or drink more | 1,235 (14.9) | 11.1 ± 4.6 | 1,078 (14.9) | 157 (15.3) |
| Physical activity* | | <0.001 | | <0.001 |
| Never, stopped, or exercise less | 2,778 (33.6) | 11.6 ± 4.9 | 2,190 (30.3) | 588 (57.1) |
| Unchanged or exercise more | 5,480 (66.4) | 12.1 ± 4.4 | 5,038 (69.7) | 442 (42.9) |
| HL index, 1-score increment | 28.1 ± 9.4 | 28.7 ± 9.3 | 24.1 ± 9.6 |<0.001 |
| HES, 1-score increment | 11.9 ± 4.6 | 12.1 ± 4.6 | 10.9 ± 4.6 |<0.001 |

HES, healthy eating score; PHQ, patient health questionnaire; S-COVID-19-S, suspected corona virus disease-2019 symptoms; BMI, body mass index; HL, health literacy.

*Result of one-way ANOVA test.

**Result of χ² test.

*The suspected COVID-19 symptoms including common symptom (fever, cough, dyspnea), less common symptom (myalgia, fatigue, sputum production, confusion, headache, sore throat, rhinorrhea, chest pain, hemoptysis, diarrhea, and nausea/vomiting).

People were asked whether their health-related behaviors are getting worse, better, or unchanged during COVID-19 pandemic as compared with those before the pandemic.
mediation, social status, lockdown, comorbidity \((p < 0.001)\), and BMI \((p = 0.028; \text{Table 2})\).

**Associated Factors of Healthy Dietary Intake**

In bivariate analysis, patients with lower HES were those with older age, being male, ever married, having own business, during the lockdown period, with S-COVID-19-S, underlying comorbidity, and smoking and drinking at unchanged or more level \((p < 0.001)\). In contrast, patients with higher HES were those with higher educational attainment, better ability to pay for medication, higher social status, doing physical activity at unchanged or more level, and higher health literacy \((p < 0.05; \text{Table 3})\). Correlations among covariates were checked to eliminate the multicollinearity. Moderate correlations were found between age and marital status \((\rho = 0.38)\), education \((\rho = -0.42)\), comorbidity \((\rho = 0.31)\), and health literacy \((\rho = -0.32)\); between S-COVID-19-S and comorbidity \((\rho = 0.31)\); between lockdown measure and physical activity \((\rho = -0.38)\); and between smoking and drinking \((\rho = 0.45)\); **Supplementary Table 2**. Therefore, age, gender, occupation, ability to pay for medication, social status, lockdown, S-COVID-19-S, BMI, and drinking alcohol were selected to multivariate models. Results showed that as compared with counterparts, people with lower HES were those with older age \((\text{regression coefficient, } B, -0.81; 95\% \text{ CI } -1.03, -0.58, p < 0.001 \text{ for age } 40–59 \text{ years}; \text{and } B, -0.70; 95\% \text{ CI } -0.95, -0.44, p < 0.001 \text{ for age } 60–85 \text{ years})\), having own business \((B; 95\% \text{ CI } -0.53, -0.04; p = 0.021)\), during the lockdown period \((B, -1.35; 95\% \text{ CI } -1.57, -1.13; p < 0.001)\), with S-COVID-19-S \((B, -1.14; 95\% \text{ CI } -1.35, -0.94; p < 0.001)\), being overweight/obese \((B, -0.34; 95\% \text{ CI } -0.64, -0.04; p = 0.025)\), and drinking alcohol at unchanged or more level \((B, -1.29; 95\% \text{ CI } -1.57, -1.00; p < 0.001; \text{Table 3})\). On the other hand, people with higher HES were those with better ability to pay for medication \((B, 0.26; 95\% \text{ CI } 0.05, 0.47; p = 0.016)\) and higher social status \((B, 0.92; 95\% \text{ CI } 0.65, 1.19; p < 0.001; \text{Table 3})\).

**Associated Factors of Depression**

In bivariate analysis, odds of depression were significantly higher in older people, those ever married, other types of occupation, in lockdown period, with S-COVID-19-S, and underlying comorbidity as compared with their counterparts \((p < 0.001)\). Odds of depression were significantly lower in people with higher education, better ability to pay for medication, higher social status, being overweight, doing physical activity at unchanged or more level, higher health literacy, and higher HES as compared with their counterparts \((p < 0.01)\). To avoid multicollinearity, age, gender, occupation, ability to pay for medication, social status, lockdown measure, S-COVID-19-S, BMI, comorbidity, physical activity, and HES were included in multivariate models. The results showed that people with higher odds of depression were those with older age \((\text{odds ratio, } OR, 1.33; 95\% \text{ CI } 1.10, 1.60, p = 0.004 \text{ for age } 40–59 \text{ years}; \text{OR } 3.03, 95\% \text{ CI } 2.52, 3.64, p < 0.001 \text{ for age } 60–85 \text{ years})\) as compared with age 18–39 years, other type of occupation \((OR 1.27; 95\% \text{ CI } 1.05, 1.54; p = 0.013)\) as compared with employed group, during lockdown \((OR 1.85; 95\% \text{ CI } 1.56, 2.18; p < 0.001)\) as compared with not during the lockdown period, with S-COVID-19-S \((OR 2.40; 95\% \text{ CI } 2.05, 2.81; p < 0.001)\) as compared with those without S-COVID-19-S, and those with comorbidity \((OR 1.51, 95\% \text{ CI } 1.26, 1.80, p < 0.001; \text{OR } 2.19, 95\% \text{ CI } 1.68, 2.85, p < 0.001)\) as compared with those without chronic conditions. In contrast, people with lower odds of depression were those with better ability to pay for medication \((OR 0.66; 95\% \text{ CI } 0.56, 0.78; p < 0.001)\) and doing physical activity at unchanged or more level \((OR 0.62; 95\% \text{ CI } 0.53, 0.73; p < 0.001; \text{Table 4})\).

**Mental Health Benefits of Healthy Dietary Intake**

The results of interaction analysis showed that as compared with people who were not under the lockdown period and lowest HES, those who were under the lockdown period and lowest HES score had 10.6 times higher likelihood of depression \((OR 10.60; 95\% \text{ CI } 6.88, 16.32; p < 0.001)\), whereas during the lockdown period, people with one score increment of HES resulted in 15% lower depression likelihood \((OR 0.85; 95\% \text{ CI } 0.82, 0.89; p < 0.001; \text{Table 5})\).

**DISCUSSION**

In the current study, people who were under the lockdown period had lower healthy dietary intake scores. This was similar to previous studies which illustrated that lockdown or home confinement measure negatively influenced dietary eating behaviors and habits \((28–31, 54, 55)\). In addition, overweight and obese people ate less healthy than normal-weight individuals, which was found in the current study and previous studies \((30)\). Besides, people with older age, being ever married, with S-COVID-19-S, comorbidity, and smoking and drinking behaviors also had worse dietary intake behavior. Social and environmental factors were found as determinants of eating behavior in a previous study \((56)\). Therefore, nutrition support programs are important for vulnerable people to improve their dietary intake behavior \((57, 58)\), especially during the pandemic and home confinement \((30, 31)\).

Our study shows that people who were under the lockdown period had a higher likelihood of depression. Previous studies found that the proportion of psychological problems \((e.g., \text{depression, anxiety, and stress})\) has risen during the lockdown in general populations \((27, 59)\) and in psychiatric patients \((26)\). People with S-COVID-19-S had higher depression likelihood that was found in the current study and the previous one \((45)\). In addition, people with older age and comorbidity were vulnerable to depression in the present study. The psychological consequence of COVID-19 pandemic was well-reported \((53, 60)\), especially in the elderly \((61, 62)\). Besides, people with underlying health conditions had a worse clinical course that was also reported \((63, 64)\). Strategic mental health interventions are highly recommended to manage the psychological consequence of COVID-19 pandemic \((65–68)\).
### TABLE 3 | Associated factors of healthy dietary intake behavior via linear regression analysis (N = 8,291).

| Variables                        | Bivariate | HES | Multivariate |
|----------------------------------|-----------|-----|--------------|
|                                  | B (95% CI) | p   | B (95% CI)   | p    |
| Age, years                       |           |     |              |      |
| 18–39                            | 0.00       |     | 0.00         |      |
| 40–59                            | -1.09 (-1.32, -0.86) | <0.001 | -0.81 (-1.03, -0.58) | <0.001 |
| 60–85                            | -1.27 (-1.52, -1.02) | <0.001 | -0.70 (-0.95, -0.44) | <0.001 |
| Gender                           |           |     |              |      |
| Women                            | 0.00       |     | 0.00         |      |
| Men                              | -0.37 (-0.57, -0.17) | <0.001 | -0.04 (-0.24, 0.17) | 0.710 |
| Marital status                   |           |     |              |      |
| Never married                    | 0.00       |     | 0.00         |      |
| Ever married                     | -0.56 (-0.81, -0.31) | <0.001 |             |      |
| Education attainment             |           |     |              |      |
| Elementary school or illiterate  | 0.00       |     | 0.00         |      |
| Junior high school               | -0.16 (-0.59, 0.27) | 0.460 |             |      |
| Senior high school               | 0.54 (0.13, 0.96) | 0.010 |             |      |
| College/university or higher     | 1.16 (0.77, 1.56) | <0.001 |             |      |
| Occupation                       |           |     |              |      |
| Employed                         | 0.00       |     | 0.00         |      |
| Own business                     | -0.51 (-0.76, -0.27) | <0.001 | -0.28 (-0.53, -0.04) | 0.021 |
| Others                           | -0.12 (-0.37, 0.13) | 0.383 | 0.02 (-0.23, 0.27) | 0.878 |
| Ability to pay for medication    |           |     |              |      |
| Very or fairly difficult         | 0.00       |     | 0.00         |      |
| Very or fairly easy              | 0.94 (0.74, 1.14) | <0.001 | 0.26 (0.05, 0.47) | 0.016 |
| Social status                    |           |     |              |      |
| Low                              | 0.00       |     | 0.00         |      |
| Middle or high                   | 1.31 (1.05, 1.57) | <0.001 | 0.92 (0.65, 1.19) | <0.001 |
| Lockdown measure                 |           |     |              |      |
| No                               | 0.00       |     | 0.00         |      |
| Yes                              | -1.51 (-1.72, -1.29) | <0.001 | -1.30 (-1.57, -1.13) | <0.001 |
| S-COVID-19-S<sup>a</sup>         |           |     |              |      |
| No                               | 0.00       |     | 0.00         |      |
| Yes                              | -1.46 (-1.67, -1.26) | <0.001 | -1.14 (-1.35, -0.94) | <0.001 |
| BMI, kg/m<sup>2</sup>            |           |     |              |      |
| Underweight (BMI < 18.5)         | 0.33 (-0.01, 0.67) | 0.059 | 0.14 (-0.19, 0.47) | 0.410 |
| Normal weight (18.5 ≤ BMI < 25.0) | 0.00   |     | 0.00         |      |
| Overweight/obese (BMI ≥ 25.0)    | -0.27 (-0.58, 0.04) | 0.091 | -0.34 (-0.64, -0.04) | 0.025 |
| Comorbidity                      |           |     |              |      |
| None                             | 0.00       |     | 0.00         |      |
| One                              | -2.15 (-2.40, -1.89) | <0.001 |             |      |
| Two or more                      | -3.86 (-4.30, -3.41) | <0.001 |             |      |
| Smoking<sup>b</sup>              |           |     |              |      |
| Never, stopped, or smoke less    | 0.00       |     | 0.00         |      |
| Unchanged or smoke more          | -1.48 (-1.82, -1.13) | <0.001 |             |      |
| Drinking alcohol<sup>c</sup>     |           |     |              |      |
| Never, stopped, or drink less    | 0.00       |     | 0.00         |      |
| Unchanged or drink more          | -0.99 (-1.27, -0.71) | <0.001 | -1.29 (-1.57, -1.00) | <0.001 |
| Physical activity<sup>c</sup>    |           |     |              |      |
| Never, stopped, or exercise less | 0.00       |     | 0.00         |      |
| Unchanged or exercise more       | 0.54 (0.33, 0.75) | <0.001 |             |      |

HES, healthy eating score; B, regression coefficient; PHQ, patient health questionnaire; S-COVID-19-S, suspected coronavirus disease-2019 symptoms; BMI, body mass index; HL, health literacy.

<sup>a</sup>The suspected COVID-19 symptoms including common symptom (fever, cough, dyspnea), less common symptom (myalgia, fatigue, sputum production, confusion, headache, sore throat, rhinorrhoea, chest pain, hemoptysis, diarrhoea, and nausea/vomiting).

<sup>b</sup>People were asked whether their health-related behaviors are getting worse, better, or unchanged during COVID-19 pandemic as compared with those before the pandemic.
TABLE 4 | Associated factors of depression via logistic regression analysis (N = 8,291).

| Variables                        | Depression (PHQ ≥ 10) |       |       |
|----------------------------------|-----------------------|-------|-------|
|                                  | Bivariate             |       |       |
|                                  | OR (95% CI)           | p     |       |
| Age, years                       |                       |       |       |
| 18–39                            | 1.00                  |       |       |
| 40–59                            | 1.57 (1.32, 1.88)     | <0.001|       |
| 60–85                            | 5.25 (4.47, 6.16)     | <0.001|       |
| Gender                           |                       |       |       |
| Women                            | 1.00                  |       |       |
| Men                              | 0.99 (0.87, 1.13)     | 0.906 |       |
| Marital status                   |                       |       |       |
| Never married                    | 1.00                  |       |       |
| Ever married                     | 1.68 (1.39, 2.02)     | <0.001|       |
| Education attainment             |                       |       |       |
| Elementary school or illiterate  | 1.00                  |       |       |
| Junior high school               | 0.59 (0.46, 0.76)     | <0.001|       |
| Senior high school               | 0.60 (0.47, 0.76)     | <0.001|       |
| College/university or higher     | 0.56 (0.44, 0.70)     | <0.001|       |
| Occupation                       |                       |       |       |
| Employed                         | 1.00                  |       |       |
| Own business                     | 1.10 (0.93, 1.31)     | 0.273 |       |
| Others                           | 1.71 (1.45, 2.02)     | <0.001|       |
| Ability to pay for medication    |                       |       |       |
| Very or fairly difficult         | 1.00                  |       |       |
| Very or fairly easy              | 0.37 (0.32, 0.43)     | <0.001|       |
| Social status                    |                       |       |       |
| Low                              | 1.00                  |       |       |
| Middle or high                   | 0.74 (0.63, 0.87)     | <0.001|       |
| Lockdown measure                 |                       |       |       |
| No                               | 1.00                  |       |       |
| Yes                              | 3.33 (2.91, 3.80)     | <0.001|       |
| S-COVID-19-S                     |                       |       |       |
| No                               | 1.00                  |       |       |
| Yes                              | 4.14 (3.60, 4.75)     | <0.001|       |
| BMI, kg/m²                       |                       |       |       |
| Underweight (BMI < 18.5)         | 0.71 (0.55, 0.91)     | 0.008 |       |
| Normal weight (18.5 ≤ BMI < 25.0)| 1.00                  |       |       |
| Overweight/obese (BMI ≥ 25.0)    | 0.97 (0.79, 1.19)     | 0.755 |       |
| Comorbidity                      |                       |       |       |
| None                             | 1.00                  |       |       |
| One                              | 3.15 (2.70, 3.66)     | <0.001|       |
| Two or more                      | 7.61 (6.14, 9.45)     | <0.001|       |
| Smoking                          |                       |       |       |
| Never, stopped, or smoke less    | 1.00                  |       |       |
| Unchanged or smoke more          | 0.98 (0.78, 1.23)     | 0.867 |       |
| Drinking alcohol                 |                       |       |       |
| Never, stopped, or drink less    | 1.00                  |       |       |
| Unchanged or drink more          | 1.04 (0.87, 1.25)     | 0.680 |       |
| Physical activity                |                       |       |       |
| Never, stopped, or exercise less | 1.00                  |       |       |
| Unchanged or exercise more       | 0.33 (0.29, 0.37)     | <0.001|       |
| HL index, 1-score increment      | 0.95 (0.94, 0.96)     | <0.001|       |
| HES, 1-score increment           | 0.94 (0.93, 0.95)     | <0.001|       |

PHQ, patient health questionnaire; OR, odds ratio; S-COVID-19-S, suspected corona virus disease-2019 symptoms; BMI, body mass index; HL, health literacy; HES, healthy eating score.

*a The suspected COVID-19 symptoms including common symptom (fever, cough, dyspnea), less common symptom (myalgia, fatigue, sputum production, confusion, headache, sore throat, rhinorrhea, chest pain, hemoptysis, diarrhea, and nausea/vomiting).

*b People were asked whether their health-related behaviors are getting worse, better, or unchanged during COVID-19 pandemic as compared with those before the pandemic.
The most important finding of our study was that people with better healthy dietary intake behavior had lower depression likelihood during the lockdown period. This could be explained that better diet quality had benefits for lower risk of depression (34, 35). Anti-oxidant and anti-inflammatory nutrients from healthy foods can boost the immune function, reduce infection risk, and modulate the prognosis of COVID-19 disease (16, 17, 22, 23). In addition, depression has been protected and improved by doing the physical activity which was found in the current study and previous studies (69, 70). Furthermore, physical activity was linked to healthier eating behavior in the current study which further protects the people's mental health. Dietary intake and exercise was recognized as a key to healthy living (71). The findings provide important evidence to governments and organizations to develop strategic nutrition support programs to contain the pandemic and its adverse psychological consequences (21). HES-5 tool is suggested to use in clinical settings to quickly assess people's healthy eating behavior (38, 47), especially during the sensitive time of COVID-19 pandemic.

The current study shows that people with higher health literacy scores had a lower likelihood of depression. Health literacy has demonstrated an important role in evaluating online health information (72) in the digital world with diverse information and sources (73). Therefore, it is a critical skill for people during the COVID-19 pandemic and lockdown period. In addition, higher HL scores were independently associated with healthier behaviors (e.g., exercise, balanced diet) (74, 75) which further contribute to improve mental health (76). The policy-makers should be aware of and emphasize the roles and interplay between information providers and receivers which can improve people's understanding of medication information (77). Moreover, improving people's health literacy can help fight the infodemic and flatten the curve during the global health crisis (78, 79).

The current study has some limitations. First, research assistants and patients were vulnerable to virus infection during the pandemic. It was required to strictly follow the guidelines during the survey. Fortunately, researchers received great support from participating hospitals and health centers. In addition, there was no new case detected in the study settings during the data collection period (51). Second, the cross-sectional design with a non-random sample cannot generate a causal relationship. We have conducted the study on a large sample from 18 hospitals and health centers across Vietnam which can help in exploring the associations and interactions, and the findings can be cautiously generalized. Third, subjective measures with patients’ self-reported information (e.g., height, weight) potentially bias the analysis. Therefore, findings should be interpreted with caution. Even though the HES-5 questionnaire was used for assessing the quality of the diet, and lack specificity, it is fast and easier than other validated questionnaires to measure healthy dietary intake, especially during the pandemic. Despite the mentioned limitations, findings of the current study substantially provide the evidence and direction for future research and practices to contain the COVID-19 disease and its related consequences.

**CONCLUSIONS**

The COVID-19–induced lockdown or home confinement is a necessary measure to contain the viral infection. It shows negative impacts on dietary intake behavior and mental health. Fortunately, healthy dietary intake behavior can protect people's psychological health during the pandemic, especially during the lockdown period. The strategic public health approaches are required to develop nutritional support programs to improve the healthy eating behavior which further improves people's mental health and response to the pandemic.

**DATA AVAILABILITY STATEMENT**

The raw data supporting the conclusions of this article will be made available on reasonable request to the corresponding author.

**ETHICS STATEMENT**

The study protocol was approved by each participating hospital, and the Institutional Ethical Review Committee of Hanoi School.
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AUTHOR CONTRIBUTIONS

KP and TVDu analyzed the data and drafted the article. KP, LP, DP, TT, HoaN, MN, HooN, TH, HD, PN, MT, ThinD, HooN, TN, NN, CT, KT, TranD, LN, ThaoD, TV, BD, ThaiD, TP, TL, ND, HooaN TM, DH, HooN, KN, S-HY, JC, and TuyeD contributed to conceptualization, investigation, methodology, validation, writing review, and editing. KP, LP, DP, TT, HoaN, MN, HooN, TH, HD, PN, MT, ThinD, HooN, TN, NN, CT, KT, TranD, LN, ThaoD, TV, BD, ThaiD, TP, TL, ND, HooaN, TM, DH, HooN, KN, and TuyeD conducted data curation. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

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Conflict of Interest: The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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