Ciência & Saúde Coletiva

cienciaesaudecoletiva.com.br
ISSN 1413-8123. v.30, n.4

DOI: 10.1590/1413-81232025304.15782023

Chrononutrition, diet quality and perceived stress: results from two population-based studies in Brazil

Crononutrição, qualidade da dieta e estresse percebido: resultados de dois estudos de base populacional no Brasil

Crononutrición, calidad de la dieta y estrés percibido: resultados de dos estudios poblacionales en Brasil

Micaela Rabelo Quadra (https://orcid.org/0000-0002-6380-7720) [1]
Antônio Augusto Schäfer (https://orcid.org/0000-0002-8834-0434) [2]
Leonardo Pozza Santos (https://orcid.org/0000-0002-3993-3786) [3]
Luana Meller Manosso (https://orcid.org/0000-0003-1987-1730) [4]
Tamara Justin da Silva (https://orcid.org/0000-0002-5806-9567) [2]
Elisabete Borges Maciel (https://orcid.org/0000-0002-9142-3265) [5]
Fernanda Oliveira Meller (https://orcid.org/0000-0002-1174-4721) [2]

Abstract *Chrononutrition and diet quality appear to influence stress, however, evidence on this relationship needs to be better elucidated. We aim to assess the association between chrononutrition, diet quality, and perceived stress in adults from Southern Brazil. Population-based cross-sectional study conducted in two Brazilian cities, with individuals aged ≥18 years. Chrononutrition and diet quality were the exposure, and perceived stress was the outcome. To assess the associations, Poisson regression was used to calculate crude and adjusted prevalence ratio. 2,170 individuals were analyzed: 12.3% did not have breakfast, 27.5% had less than four meals per day, 30.4% presented poor diet quality, 14% referred irregular consumption of healthy foods, and 43.2% had regular consumption of unhealthy foods. Perceived stress was reported by 38.2% of the sample. Individuals who ate less than four meals per day, with poor diet quality, with regular consumption of unhealthy foods, and with irregular consumption of healthy foods were more likely to present perceived stress. These results may contribute to the development of joint actions on nutrition and mental health.*
Key words *Eating, Diet Quality, Mental Health, Pandemics*

Resumo *Crononutrição e qualidade da dieta parecem influenciar o estresse, mas evidências precisam ser melhor elucidadas. O objetivo foi avaliar a associação entre crononutrição, qualidade da dieta e estresse percebido em adultos do Sul do Brasil. Estudo transversal de base populacional conduzido em duas cidades brasileiras, com indivíduos com ≥18 anos. Crononutrição e qualidade da dieta foram as exposições, estresse percebido foi o desfecho. Para avaliar as associações utilizou-se regressão de Poisson para calcular a razão de prevalência bruta e ajustada. Foram analisados 2.170 indivíduos: 12,3% não tomavam café da manhã, 27,5% faziam <4 refeições por dia, 30,4% tinham pior qualidade da dieta, 14% consumiam irregularmente alimentos saudáveis e 43,2% consumiam regularmente alimentos não saudáveis, 38,2% tinham estresse percebido. Aqueles que faziam <4 refeições por dia, com pior qualidade da dieta, consumo regular de alimentos não saudáveis e consumo irregular de alimentos saudáveis tiveram maior probabilidade de apresentar estresse. Os resultados poderão contribuir para o desenvolvimento de ações conjuntas em nutrição e saúde mental.*
Palavras-chave *Alimentação, Qualidade da Dieta, Saúde mental, Pandemias*

Resumen *La crononutrición y la calidad de la dieta parecen influir en el estrés, pero es necesario dilucidar más la evidencia. El objetivo fue evaluar la asociación entre crononutrición, calidad de la dieta y estrés percibido en adultos del sur de Brasil. Estudio transversal de base poblacional realizado en dos ciudades brasileñas, con individuos ≥18 años de edad. La crononutrición y la calidad de la dieta fueron las exposiciones, y el estrés percibido fue el resultado. Para evaluar las asociaciones se utilizó la regresión de Poisson para calcular la razón de prevalencia cruda y ajustada. Se analizaron 2.170 individuos: el 12,3% no desayunaba, el 27,5% hacía <4 comidas al día, el 30,4% tenía una dieta de peor calidad, el 14% consumía alimentos saludables de forma irregular y el 43,2% consumía regularmente alimentos poco saludables. El 38,2% había percibido estrés. Aquellos que comían <4 comidas al día, tenían una calidad de dieta más pobre, consumían regularmente alimentos poco saludables y consumían de manera irregular alimentos saludables, tenían más probabilidades de experimentar estrés. Los resultados pueden contribuir al desarrollo de acciones conjuntas en nutrición y salud mental.*
Palabras clave *Comida, Calidad de la dieta, Salud mental, Pandemias*

[1] Programa de Pós-Graduação em Ciências da Saúde, Universidade do Extremo Sul de Santa Catarina (UNESC). Av. Universitária 1105, Bairro Universitário. 88806-000 Criciúma SC Brasil. micaelarquadra@gmail.com
[2] Programa de Pós-Graduação em Saúde Coletiva, UNESC. Criciúma SC Brasil.
[3] Faculdade de Nutrição, Universidade Federal de Pelotas. Pelotas RS Brasil.
[4] VP Centro de Nutrição Funcional. São Paulo SP Brasil.
[5] Faculdade de Nutrição, UNESC. Criciúma SC Brasil.

Introduction

Stress can be defined as a non-specific response, derived from actions that affect the individual's physical and psychological integrity. Stress is responsible for increasing the activity of the hypothalamic-pituitary-adrenal (HPA) axis and, consequently, the plasma cortisol levels[1]. During the COVID-19 pandemic, the occurrence of emotional disturbances, including stress, was commonly observed[2]. A study, with participants from 57 countries including Mexico, Argentina, Canada, the United Kingdom, Germany, the United States, China, and Brazil, recruited via social media, reported an average perceived stress score of 19.08. This score reflects a moderate level of stress[3]. In Brazil, another study found that 34.2% of participants had symptoms of post-traumatic stress during the COVID-19 pandemic[4].

Multiple biological, environmental, social, and behavioral factors, including already-known factors, such as violence, abuse, family conflicts, trauma, anxiety, and depression, may influence stress[5]. Recently, the hypothesis that the circadian cycle and stress may share biological mechanisms has been explored[6]. The circadian cycle, one of the main regulators of the body, can affect various metabolic processes, including the energy balance of an individual. This regulation may be influenced by behavioral factors, such as dietary intake, for example[7].

Chrononutrition is the area that aims to associate the study of nutrition and chronobiology, through the analysis of the influence of the feeding moment on the circadian cycle and health. Chrononutrition considers three main aspects: regularity of meals, food frequency, and mealtime[8]. Diet quality similarly influences brain functioning, cognitive functions, and mental health[9,10]. For instance, the consumption of ultra-processed foods, consistently associated with poor diet quality, has been correlated with an increase in depressive symptoms[11].

Even before the COVID-19 pandemic, urbanization had already induced changes in eating patterns, impacting the regularity and frequency of meals[8]. Skipping breakfast has been associated with weight gain[12], increasing the risk of cardiovascular diseases[13]. Conversely, a higher daily meal frequency appears linked to a lower prevalence of hypertension[14], while a lower frequency of the population's meals seems to increase this prevalence[15]. However, research on the association between chrononutrition and mental health is limited. Regarding diet quality, studies indicate a positive association between perceived stress and inadequate food consumption. Stressed individuals tend to have higher consumption of added sugar, saturated fats, processed meats, and nutritionally inadequate snacks[16,17].

Evidence on the relationship and mechanisms by which diet and mental health interact needs to be better elucidated. In this way, studies assessing the association of different dietary variables with mental health, specifically stress, are extremely necessary nowadays[9]. Therefore, this study aimed to assess the association between chrononutrition, diet quality, and perceived stress in adults using data from population-based studies conducted amid the COVID-19 pandemic in Southern Brazil.

Methods

Setting, study sample, and data collection

This is a cross-sectional population-based study with data from the project entitled "Mental COVID: impact of COVID-19 on the mental health of the population", conducted in two Brazilian Southern cities: Criciúma (Santa Catarina state) and Rio Grande (Rio Grande do Sul state). Criciúma has approximately 217,311 inhabitants, a Human Development Index (HDI) of 0.788, a population density of 815.87 inhabitants per km², and a literacy rate of 96,8%, with 59,9% of residents being adults and 15,7% being elderly[18-20]. Rio Grande has 211,965 inhabitants, an HDI of 0.744, a population density of 72.79 inhabitants per km², and a literacy rate of 96,1%, with 55,5% of residents being adults and 19,8% being elderly[18-20]. This study was conducted amid the COVID-19 outbreak, between October 2020 and January 2021, with individuals aged 18 years or older who were living in the urban areas of both cities. Subjects who were physically or cognitively unable to complete the survey were excluded.

The sampling process was conducted in two stages, based on the 2010 Brazilian Demographic Census[21]. First, primary units (census tracts) were randomly selected. Then, secondary units (households) were randomly chosen from the previously selected census tracts. The total number of households was sampled proportionally to the sector size. In Criciúma, 60 census tracts were sampled, resulting in 15,765 households, 607 of them included in this study. In Rio Grande, 90 census tracts were sampled,

resulting in 29,734 households, 900 of them included in the study. All adults living in the selected households were invited to participate in the study. If the residents were not present in the household, two interview attempts were made. If after three attempts, the residents were still not found, the next household on the right was selected.

The sample size calculation was performed with parameters including 80% power, a 95% confidence interval (95%CI), a 50% prevalence for the outcome, a sampling error of five percentage points, a design effect of 1.5, and a 20% increment to account for potential losses and refusals. Ultimately, each study required a sample size of 690 individuals.

Trained personnel were responsible for conducting face-to-face household interviews, who wore personal protective equipment during the fieldwork to avoid SARS-CoV-2 infection. A single, precoded, and standardized questionnaire was used. Data collection was performed using tablets and the RedCap® software. Each interview lasted 30 minutes on average.

Chrononutrition

Chrononutrition was assessed by two of its three aspects, frequency and mealtime, using the following variables: number of daily meals (frequency) and making breakfast (an indirect indicator of the time of the first meal)[14,22]. The individuals interviewed should answer "yes" or "no" for each of the six daily meals (breakfast, morning snack, lunch, afternoon snack, dinner, and evening snack). The variable number of daily meals was dichotomized into <4 and ≥4 meals per day since the main daily meals are usually three (breakfast, lunch, and dinner). The idea of this categorization was to compare individuals who have consumed snacks between the main meals with those who have only eaten the main meals[14].

Diet quality

Diet quality was evaluated by a frequency index of intake of healthy (legumes, vegetables, fruits, and milk) and unhealthy (soda and artificial juice, candies, and red meat) foods. To build it, the following questions were asked to the participants: "How many days a week do you usually eat…?", followed by the foods: "at least one type of raw or cooked vegetable such as lettuce, tomato, cabbage, carrot, chayote, eggplant, zucchini (not including potatoes or cassava)", "legumes such as beans, lentils, peas", "fruit", "milk (not including vegetable milk such as soy, almonds, chestnuts, rice)", "soda or artificial juice", "sweet foods, such as ice cream, chocolates, cakes, cookies or sweets", and "red meat (beef, pork)".

A score from 0 to 4 points was attributed according to the answer's options for each question: "never", "almost never", "1 to 2 days a week", "3 to 4 days a week", "5 to 6 days a week" and "daily (including Saturday and Sunday)". For healthy foods, the higher the frequency of intake the lower the score, varying from 0 (daily) to 4 (never or almost never). For unhealthy foods, the higher the intake the higher the score, also varying from 0 (never or almost never) to 4 (daily) (Chart 1). The final score was the sum of the intake score of each food, varying from 0 (better quality) to 28 points (worst quality), a little different from the original score proposed by Francisco *et al.*[23] (maximum of 32 points), as raw and cooked vegetables were evaluated using the same question. We then categorized the diet quality into tertiles. The 1st tertile corresponded to the best diet quality and the 3rd to the worst diet quality[23,24].

Additionally, we assessed the regularity of consumption for both healthy and unhealthy diet markers, employing the same questions and categorizations as the diet quality score. The distinction lies in evaluating the frequency of food consumption. Individuals reporting the consumption of at least one food item from the healthy or unhealthy groups at least five times a week were categorized as having a regular consumption of the corresponding food markers. Conversely, those consuming at least one food item from these groups less than five times a week were categorized as having irregular consumption[24].

Perceived stress

The perceived stress scale, previously validated for the Brazilian population[25], was used to evaluate stress. It is a self-reported measure designed to deal with the degree to which situations in an individual's life are appraised as stressful. It was developed as a 14-item scale that assessed the perception of stressful experiences over the previous month using a Likert-type scale from 0 to 4 corresponding to the answer options "never", "almost never", "sometimes", "fairly often", and "very often". The total score consisted of the sum of points, ranging from 0 (lower stress) to 56 points (higher stress). We

Chart 1. Healthy and unhealthy food consumption score from the diet quality variable.

Foods	0	1	2	3	4
Legumes	Daily	5 to 6 days a week	3 to 4 days a week	1 to 2 days a week	Never or almost never
Vegetables	Daily	5 to 6 days a week	3 to 4 days a week	1 to 2 days a week	Never or almost never
Fruits	Daily	5 to 6 days a week	3 to 4 days a week	1 to 2 days a week	Never or almost never
Milk	Daily	5 to 6 days a week	3 to 4 days a week	1 to 2 days a week	Never or almost never
Soda	Never or almost never	1 to 2 days a week	3 to 4 days a week	5 to 6 days a week	Daily
Artificial juice	Never or almost never	1 to 2 days a week	3 to 4 days a week	5 to 6 days a week	Daily
Candies	Never or almost never	1 to 2 days a week	3 to 4 days a week	5 to 6 days a week	Daily
Red meat	Never or almost never	1 to 2 days a week	3 to 4 days a week	5 to 6 days a week	Daily

Source: Adapted from Franscisco *et al.*[23] and Meller *et al.*[24].

categorized the total score in quintiles and those individuals classified in the fourth or fifth quintile were considered stressed. This approach to classifying stress has already been used in other published studies[26].

Sociodemographic characteristics, pandemic-related behavioral, and health variables

We also used socioeconomic and demographic characteristics as well as pandemic-related behaviors and health-related characteristics as covariables of our study. They are described in Chart 2.

Statistical analyses

Absolute and relative frequencies were used to describe the characteristics of the sample. Crude analysis of the association of chrononutrition, diet quality, and perceived stress with the covariables, was assessed using Fisher's exact test with a significance level of 5%.

Fisher's exact test was also used to assess the association of chronutrition and diet quality with perceived stress. To evaluate whether crude associations of chrononutrition and diet quality with stress were independent of possible confounders, adjusted Poisson regression models were used, presenting the p-value corresponding to the Wald test for heterogeneity. Regression results were reported as prevalence ratio (PR) with their corresponding 95% confidence intervals (CI). To identify the possible confounders, we used a level hierarchical model of analysis[27]. Level 1 (distal) included demographic characteristics: sex, skin color, and age; Level 2 included socioeconomic and demographic characteristics as well as job situation: wealth index, schooling, marital status, living alone, getting unemployed, started working from home; Level 3 (proximal) included pandemic-related behavioral as well as health-related characteristics: adherence to social distance, going to bars or restaurants, go out for physical activity, contact with someone infected, infodemic, tested positive for COVID-19, fear of COVID-19, presence of COVID-19 symptoms, using online tools to talk to friends and family, excess weight, physical activity, sleep duration and quality, depressive symptoms, feeling of sadness and food insecurity. Variables were selected using the backward method considering each hierarchical level, and those variables with p-value<0.20 remained in the final model (Figure 1).

All analyses were performed in STATA version 12.1 using the svy prefix, which considers the complexity of the sampling process and the effect of the study design.

Ethical Aspects

This study was approved by the Research Ethics Committee of the Federal University of Rio Grande [protocol number 4.055.737]. Verbal informed consent was obtained from all subjects and was witnessed and formally recorded.

Chart 2. Description of the covariables studied.

Variables	Description
Sex	Male/female
Age group (years)	Categorized by age group: 18-29, 30-39, 40-49, 50-59, ≥60.
Skin color	Collected as white, black, brown, yellow, indigenous, and dichotomized into white and others.
Marital status	Collected as single, married, separated, widow/widower and categorized in single, married, and separated/widow (combination of the last two categories).
Schooling	Elementary school, high school, and university education.
Wealth index	Built using the analysis of main components, using the variables: number of rooms, number of bathrooms, freezer, clothes dryer, computer, air conditioning, internet, and number of cars in the household. The result was categorized as tertiles.
Living alone	Identify by the question "Counting you, how many people live in this household?". Individuals who responded that they lived alone were categorized as "yes" and those who did not live alone as "no".
Got unemployed	The question "How did social distancing due to the COVID-19 pandemic affect your occupation/work?", with answers options: "I did not work before and I continued without working", "I continued working normally", "I continued working, but at home (home office), "I started working during the pandemic" and "I lost my job or stopped working", was asked. Those who responded that they lost their jobs or stopped working were categorized as "yes" and the others as "no".
Started working from home	The same question of the previous variable was used. Individuals who responded "I continued working, but at home (home office)" were categorized as "yes" and the others as "no".
Adherence to social distance	The following question was used: "During the period of social distancing, when only essential services were open, did you leave home?" considering the answers options no and yes.
Infodemic	Assessed using the question: "How many times a day do you search for or receive information about COVID-19?" with the answer options many times a day, a few times a day, few times a day, only once a day, and a few times a week. Infodemic was considered to occur when an individual searched for or received information about COVID-19 many times a day[66].
Fear of COVID	Assessed by Fear of COVID-19 scale, which is a screening tool developed by Ahorsu *et al.*[67] and validated for use in Brazil[68]. The score was divided into quintiles and those individuals in the highest quintile were classified as having higher fear of COVID-19.
Going to bars or restaurants	Identify by the question "Did you go to bars, restaurants, and malls?", with answer options: No, yes.
Go out for physical activity	Identify through the question "Did you go out to do activities of leisure/physical activity?", with answer options: No, yes.
Contact with someone infected	Identify by the question: "Have you had close personal contact with someone diagnosed with COVID-19?". Categorized as: No, yes.
Presence of COVID-19 symptoms	The presence of the symptoms of cough, sore throat, fever, difficulty breathing, tiredness, diarrhea, loss of taste/smell, chills, and headache were asked and summed. The presence of any reported symptoms was considered "yes" and negative responses for all symptoms as "no".
Tested positive for COVID-19	Identify using the question "What was the test result?", with answer options: negative, positive, do not know, ignored. An affirmative response for the positive result was considered "yes".
Using online tools to talk to friends and family	Identify through the question "Did you interact with your friends and/or family using online tools?", with answer options: No, yes.
Excess weight	Classified by body mass index (BMI) ≥25 Kg/m² for adults[69] and ≥27 Kg/m² for elderly people[70]. The BMI was calculated with self-reported data on weight and height. Categorized in no, yes.

it continues

Chart 2. Description of the covariables studied.

Variables	Description
Physical activity	Assessed using the International Physical Activity Questionnaire (IPAQ) long version, which evaluates commuting, as well as moderate and vigorous physical activities[71]. Classified in "<150 minutes/week" and "≥150 minutes/week" according to the World Health Organization[72].
Sleep quality	Self-reported by the question: "How do you consider the quality of your sleep?", with answers options: very good, good, regular, poor, very poor.
Sleep duration	It was calculated using the information of the following questions: "What time do you usually sleep during the week (Monday to Friday)?" and "What time do you usually wake up during the week (Monday to Friday)?". The sleep duration was classified as inadequate when <7 or ≥9 hours per day, and as adequate when between 7 and 8 hours per day)[73]. Data on weekend sleep duration were unavailable since there were no corresponding questions in the baseline survey questionnaire. Typically, when evaluating self-reported sleep duration, questions focus on weekdays to capture usual patterns, considering that routines often change on weekends.
Food insecurity	Assessed by the short version of the Brazilian Food Insecurity Scale[74]. It is a scale of five questions corresponding to the last three months, used to screen households in food insecurity. Households with at least one affirmative answer to any of the five questions were categorized as having food insecurity ("yes"). Households with negative responses to all questions were considered to have no food insecurity ("no").
Self-reported sadness	Assessed through the faces scale[75], composed of seven faces ranging from very happy (face 1) to very sad (face 7). Individuals who chose faces 5, 6, or 7 were categorized as having feelings of sadness ("yes"), while the ones who chose faces 1, 2, 3, and 4 were classified as not having such feelings ("no").
Depressive symptoms	Assessed using the Patient Health Questionnaire-9 (PHQ-9)[76]. It is a questionnaire with nine questions that assess symptoms for major depressive episodes, such as anhedonia, lack of energy, depressed mood, sleep problems, weight and appetite changes, worthlessness, guilt and restless feelings, and suicidal thoughts, in the previous two weeks. Each question has a Likert-type scale, varying from 0 (never) to 3 (almost every day) points. Individuals who choose as answers "once or more a week" (2 points) or "almost every day" (3 points) for any question, and "less than once a week" (1 point) or "once or more a week" (2 points) or "almost every day" (3 points) for the question on suicidal thoughts, were considered to have a positive response. After, the score was added up and those who presented ≥9 points were considered as having a positive screening for depressive symptoms[76].

Source: Authors.

Results

A total of 2,170 individuals were analyzed (response rate of 75%). Most of them were female (59.7%), self-reported white skin color (84.0%), and did not live alone (89.4%). About a quarter (26.1%) had university education, 31.2% were 60 years old or older, and 49.1% were married (Table 1). Less than 10% became unemployed amid COVID-19 pandemic, while over 90% continued to work in person. More than 80% reported not going out for physical activity during this period. The prevalence of infodemic was 22.0% and of fear of COVID-19 was 19.1% (Table 2). More than half presented excess weight (59.1%) and approximately a quarter were physically active (≥150 minutes/per week) (24.7%). Concerning sleep characteristics, 9.6% reported poor or very poor sleep quality and 53.8% presented inadequate sleep duration. Felling of sadness and depressive symptoms were, respectively, observed in 16.1% and 13.0% of the interviewees (Table 3).

Regarding chrononutrition, 12.3% of the individuals usually skipped breakfast and 27.5% had less than four meals a day (Table 3). Younger ($p<0.001$) and single individuals ($p=0.017$), those who had COVID-19 symptoms ($p=0.027$), who did not use online tools to talk to friends and family ($p=0.038$), who practiced <150 minutes of physical activity per week ($p=0.016$), and had poor sleep quality ($p=0.011$), depressive

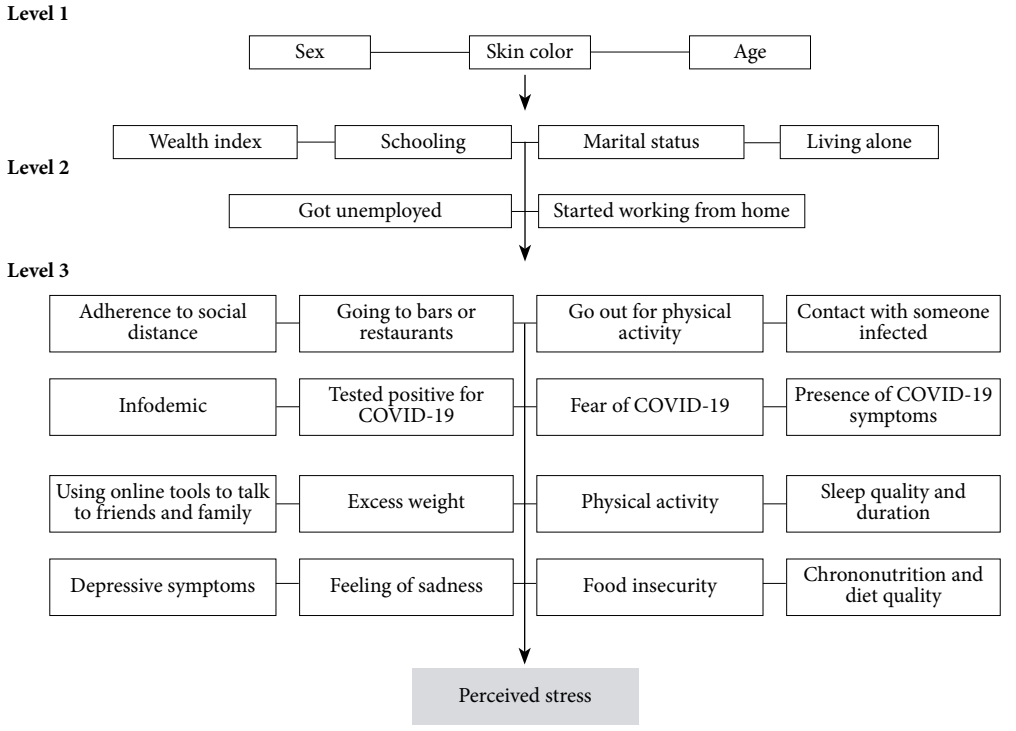

Figure 1. Hierarchical model of the association between chrononutrition, diet quality and perceived stress.

Source: Authors.

symptoms (p<0.001) and sadness (p=0.002) presented higher frequency of skipping breakfast. Higher prevalence of having less than 4 meals a day was associated with being male (p=0.040), younger (p<0.001), single (p<0.001), non-white (p<0.001), having better education (p=0.001), not living alone (p=0.005) and not adhering to social distance (p=0.022), referring infodemic (p=0.003) and fear of COVID-19 (p=0.037), having gone to bars or restaurants amid the pandemic (p<0.001) and had contacted with someone infected (p<0.001), being with excess weight (p=0.006) and depressive symptoms (p<0.001) (Table 4).

Concerning diet quality, 30.4% had poor diet quality, 14% referred irregular consumption of markers of a healthy diet, and 43.2% had regular consumption of markers of an unhealthy diet (Table 3). Higher prevalence of poor diet quality was found in individuals males (p<0.001), younger (p<0.001), non-white (p=0.047), single (p<0.001), with better education (p<0.001), who did not live alone (p=0.021), did not adhere to social distancing (p=0.036), went to bars or restaurants (p=0.005), had COVID-19 symptoms (p=0.025) and excess weight (p=0.009), practiced <150 minutes per week of physical activity (p=0.003) and referred poor sleep quality (p=0.001), depressive symptoms (p<0.001) and sadness (p<0.001). Regular consumption of unhealthy foods was more frequent in males (p=0.004), with lowest wealth index (p<0.001), who did not start working from home during the pandemic (p=0.044), did not adhere to social distancing (p=0.003), referred fear of COVID-19 (p=0.003), did not use online tools to talk to friends and family (p<0.001), had excess weight (p=0.010), poor sleep quality (p=0.001), depressive symptoms (p=0.024), sadness (p=0.020) and food insecurity (p=0.046). Younger (p<0.001) and single individuals (p<0.001), who became unemployed (p=0.040), had inadequate sleep duration (p=0.004), depressive symptoms (p=0.029), and food insecurity (p=0.003) presented higher prevalence of irregular consumption of healthy foods (Table 4).

Perceived stress was reported by 38.2% of the sample. Men (p<0.001), single (p<0.001), younger (p<0.001), and non-white individuals (p=0.027) presented a higher prevalence

Table 1. Distribution of demographic and socioeconomic characteristics of the individuals aged 18 years or older. Criciúma-SC and Rio Grande-RS, 2020-2021 (n=2,170).

Variables	n	%
Sex		
Male	875	40.3
Female	1,295	59.7
Age (years)		
18-29	394	18.2
30-39	335	15.4
40-49	354	16.3
50-59	409	18.9
≥60	678	31.2
Skin color		
White	1,815	84.0
Others	347	16.0
Wealth index (tertile)[a]		
First (poor)	719	34.7
Second	673	32.5
Third (richer)	680	32.8
Schooling		
Elementary	881	41.4
High school	692	32.5
University education	555	26.1
Marital status		
Single	751	34.6
Married	1,066	49.1
Separated/widow	353	16.3
Live alone		
No	1,880	89.4
Yes	222	10.6

[a]Variable with highest number of missing data: 4.5% (n=98).

Source: Authors.

Table 2. Distribution of pandemic-related variables in individuals aged 18 years or older. Criciúma-SC and Rio Grande-RS, 2020-2021 (n=2,170).

Variables	n	%
Got unemployed		
No	2,010	92.6
Yes	160	7.4
Started working from home		
No	2,002	92.3
Yes	168	7.7
Adherence to social distancing		
No	75	3.5
Yes	2,095	96.5
Infodemic		
No	1,692	78.0
Yes	478	22.0
Fear of COVID-19[a]		
No	1,740	80.9
Yes	412	19.1
Went to bars or restaurants		
No	1,965	90.5
Yes	205	9.5
Go out for physical activity		
No	1,769	81.5
Yes	401	18.5
Contact with someone infected		
No	1,617	74.5
Yes	553	25.5
Presence of COVID-19 symptoms		
No	1,667	76.9
Yes	500	23.1
Positive test for COVID-19		
No	2,023	93.2
Yes	147	6.8
Using online tools to talk to friends and family		
No	426	19.6
Yes	1,744	80.4

[a]Variable with highest number of missing data: 0.8% (n=18).

Source: Authors.

of stress. Individuals with poor wealth index (p<0.001), who have become unemployed (p<0.001), who had gone to bars or restaurants (p=0.002), who were afraid of COVID-19 (p<0.001), who had contact with someone infected by COVID-19 (p=0.008), and symptoms of the infection (p<0.001) also presented higher prevalence of stress. Moreover, a higher frequency of stress was present in those who did not report infodemic (p<0.001) and did not use online tools to talk to friends and family (p<0.001). Higher prevalence of stress was also related to the practice of <150 minutes per week of physical activity (p=0.038), with poor or very poor sleep quality (p<0.001) and inadequate sleep duration (p<0.001), the presence of depressive symptoms (p<0.001) and feelings of sadness (p<0.001), and with food insecurity (p<0.001) (Table 5).

Table 6 shows the association between chrononutrition, diet quality, and perceived stress. In the crude model, both aspects of chrononutrition were associated with perceived stress. Individuals who usually skipped breakfast and who ate less than four meals per day presented a higher prevalence of perceived stress. However,

Table 3. Distribution of health outcomes and dietary variables in individuals aged 18 years or older. Criciúma-SC and Rio Grande-RS, 2020-2021 (n=2,170).

Variables	n	%
Excess weight[a]		
No	815	40.9
Yes	1,178	59.1
Physical activity (minutes per week)		
<150	1,624	75.3
≥150	532	24.7
Sleep quality		
Very good/good	1,509	69.5
Regular	453	20.9
Poor/very poor	208	9.6
Sleep duration		
Inadequate	1,167	53.8
Adequate	1,003	46.2
Perceived stress		
No	1,330	61.8
Yes	824	38.2
Depressive symptoms		
No	1,879	87.0
Yes	280	13.0
Feeling of sadness		
No	1,816	83.9
Yes	349	16.1
Food insecurity		
No	1,528	70.5
Yes	639	29.5
Breakfast		
No	268	12.3
Yes	1,902	87.7
Daily meals		
<4	597	27.5
≥4	1,573	72.5
Diet quality (tertile)		
Tertile 1 (better)	912	42.1
Tertile 2	596	27.5
Tertile 3 (poor)	659	30.4
Irregular consumption of healthy foods		
No	1,866	86.0
Yes	304	14.0
Regular consumption of unhealthy foods		
No	1,232	56.8
Yes	936	43.2

[a]Variable with highest number of missing data: 8.2% (n=177).

Source: Authors.

after adjustment for confounders, only the frequency remained associated. Individuals who reported eating less than four meals per day were 19% more likely to have perceived stress when compared to those who usually ate four or more meals a day (PR=1.19, CI95% 1.07;1.32).

The association between diet quality and perceived stress showed that, after adjustment for confounders, poor diet quality was associated with a higher prevalence of perceived stress (PR=1.25, CI95% 1.10;1.43). Regarding the association of food markers consumption with perceived stress, irregular consumption of healthy foods was associated with a higher prevalence of perceived stress (PR=1.25, CI95% 1.09;1.44). In turn, regular consumption of unhealthy foods was associated with an increase of 13% in the prevalence of perceived stress (PR=1.13, CI95% 1.02;1.25) (Table 6).

Discussion

This study, which aimed to assess the association of chrononutrition and diet quality with perceived stress amid the COVID-19 pandemic, showed important findings. Less than four meals per day, irregular consumption of healthy foods, regular consumption of unhealthy foods, and poor diet quality increased the prevalence of perceived stress, independent of the variables included as potential confounders in the analysis model.

The relationship between dietary intake and mental health has been explored by other studies, in which poor diet quality was linked to worse mental health, although most papers consider depression as the outcome. Akbaraly *et al.*[28] showed that women with higher scores on the Healthy Eating Index were less likely to have depressive symptoms when compared to women with lower scores. Liu *et al.*[29] observed that the intake of processed foods was positively associated with depression and perceived stress. Research with data from low and middle-income countries showed that fruit intake was associated with lower odds of depression and anxiety, while vegetable intake was associated with lower risk of depression[30].

Regarding perceived stress, a cross-sectional study observed that a higher intake of saturated fats and added sugars was associated with a higher stress score[16]. In the United Kingdom, lower adherence to a Mediterranean Diet was related to higher levels of stress in reproductive-age women[17].

Table 4. Prevalence of chrononutrition and diet quality according to sociodemographic characteristics, pandemic-related variables and health outcomes of individuals aged 18 years or older. Criciúma-SC and Rio Grande-RS, 2020-2021 (n=2,170).

Variables	Not having breakfast		Less than 4 meals a day		Poor diet quality		Regular consumption of unhealthy foods		Irregular consumption of healthy foods	
	%	p-value[a]	%	p-value[a]	%	p-value[a]	%	p-value[a]	%	p-value[a]
Sex		0.350		0.040		<0.001		0.004		0.797
Male	14.9		45.8		35.7		30.7		12.8	
Female	13.4		41.3		26.7		25.2		12.2	
Age (years)		<0.001		<0.001		<0.001		0.064		<0.001
18-29	19.3		61.9		42.4		32.2		21.1	
30-39	16.1		51.8		41.3		25.7		13.1	
40-49	16.9		49.1		37.6		29.9		11.6	
50-59	10.8		36.3		23.3		27.1		11.7	
≥60	10.3		29.1		18.6		24.6		7.7	
Skin color		0.540		<0.001		0.047		0.540		0.344
White	14.2		41.4		29.5		27.2		12.0	
Non-white[b]	13.0		52.4		34.9		28.8		13.8	
Wealth index (tertile)		0.449		0.919		0.700		<0.001		0.924
First (poor)	15.3		43.1		29.9		33.2		12.7	
Second	14.2		43.1		32.0		23.3		12.0	
Third (richer)	12.9		44.1		31.0		25.7		12.6	
Schooling		0.109		0.001		<0.001		0.322		0.121
Elementary	12.1		39.1		25.8		27.5		10.7	
High school	14.7		48.0		35.8		29.0		13.4	
University education	15.9		45.3		31.8		25.2		13.9	
Marital status		0.017		<0.001		<0.001		0.213		<0.001
Single	16.9		53.2		36.8		28.8		16.6	
Married	12.7		38.8		28.7		27.9		10.8	
Separated/widow	11.9		35.1		21.9		23.8		7.9	
Live alone		0.739		0.005		0.021		0.270		0.099
No	14.0		44.5		31.4		27.8		12.9	
Yes	14.9		34.7		23.9		24.3		9.0	
Got unemployed		0.186		0.858		0.438		0.199		0.040
No	13.7		43.2		30.2		27.2		11.9	
Yes	17.5		42.5		33.1		31.9		17.5	
Started working from home		0.302		0.689		0.611		0.044		0.855
No	13.8		43.0		30.3		28.1		12.4	
Yes	16.7		44.6		32.1		20.8		11.9	
Adherence to social distancing		0.128		0.022		0.036		0.003		0.925
No	20.0		56.0		41.3		42.7		12.0	
Yes	13.8		42.7		30.0		27.0		12.4	
Infodemic		0.137		0.003		0.546		0.862		0.996
No	14.6		41.5		30.7		27.4		12.3	
Yes	11.9		49.2		29.3		27.8		12.3	
Fear of COVID-19		0.594		0.037		0.673		0.003		0.959
No	13.8		42.3		30.3		26.1		12.5	
Yes	14.8		47.9		31.4		33.2		12.4	
Went to bars or restaurants		0.365		<0.001		0.005		0.057		0.335
No	13.8		41.9		29.5		26.9		12.6	
Yes	16.1		55.1		39.0		33.1		10.2	

it continues

Table 4. Prevalence of chrononutrition and diet quality according to sociodemographic characteristics, pandemic-related variables and health outcomes of individuals aged 18 years or older. Criciúma-SC and Rio Grande-RS, 2020-2021 (n=2,170).

Variables	Not having breakfast		Less than 4 meals a day		Poor diet quality		Regular consumption of unhealthy foods		Irregular consumption of healthy foods	
	%	p-value[a]	%	p-value[a]	%	p-value[a]	%	p-value[a]	%	p-value[a]
Go out for physical activity		0.442		0.834		0.805		0.649		0.804
No	13.7		43.1		30.3		27.3		12.3	
Yes	15.2		43.6		30.9		28.4		12.7	
Contact with someone infected		0.289		<0.001		0.383		0.231		0.965
No	14.5		40.7		29.9		26.8		12.4	
Yes	12.7		50.4		31.9		29.5		12.3	
Presence of COVID-19 symptoms		0.027		0.050		0.025		0.378		0.403
No	13.1		42.0		29.1		27.0		12.0	
Yes	17.0		47.0		34.4		29.0		13.4	
Positive test for COVID-19		0.523		0.144		0.382		0.298		0.063
No	14.1		43.6		30.6		27.8		12.7	
Yes	12.2		37.4		27.2		23.8		7.5	
Using online tools to talk to friends and family		0.038		0.549		0.242		<0.001		0.211
No	17.1		41.9		28.1		38.7		10.6	
Yes	13.2		43.5		31.0		24.8		12.8	
Excess weight		0.669		0.006		0.009		0.010		0.159
No	14.6		39.2		27.5		24.2		11.3	
Yes	13.9		45.5		32.9		29.4		13.4	
Physical activity (minutes per week)		0.016		0.078		0.003		0.196		0.261
<150	15.1		44.2		32.1		28.3		12.7	
≥150	10.9		39.8		25.4		25.4		10.9	
Sleep quality		0.011		0.300		0.001		0.001		0.058
Very good/good	12.5		42.2		28.1		25.2		11.3	
Regular	17.2		46.4		34.9		32.7		14.3	
Poor/very poor	17.8		43.0		37.7		33.2		15.9	
Sleep duration		0.153		0.972		0.385		0.389		0.004
Inadequate	15.0		43.1		29.6		28.3		14.2	
Adequate	12.9		43.2		31.3		26.6		10.2	
Depressive symptoms		<0.001		<0.001		<0.001		0.024		0.029
No	12.9		41.0		28.6		26.8		11.8	
Yes	21.8		57.0		43.4		33.2		16.4	
Feeling of sadness		0.002		0.946		<0.001		0.020		0.118
No	13.0		43.2		28.9		26.6		11.9	
Yes	19.2		43.4		38.5		32.6		14.9	
Food insecurity		0.257		0.520		0.430		0.046		0.003
No	13.5		42.7		29.5		26.3		11.0	
Yes	15.3		44.2		31.7		30.5		15.6	

[a]Exact Fisher's test. [b]Black, brown, yellow, indigenous skin color.

Source: Authors.

Table 5. Prevalence of perceived stress according to sociodemographic characteristics, pandemic-related variables and health outcomes of individuals aged 18 years or older. Criciúma-SC and Rio Grande-RS, 2020-2021 (n=2,170).

Variables	Perceived stress	
	%	p-value[a]
Sex		<0.001
Male	43.1	
Female	31.1	
Age (years)		<0.001
18-29	48.5	
30-39	39.5	
40-49	42.7	
50-59	36.4	
≥60	30.4	
Skin color		0.027
White	37.1	
Non-white[b]	43.4	
Wealth index (tertile)		<0.001
First (poor)	47.5	
Second	37.1	
Third (richer)	31.3	
Schooling		0.736
Elementary	36.9	
High school	37.8	
University education	39.0	
Marital status		<0.001
Single	44.0	
Married	34.5	
Separated/widow	37.5	
Live alone		0.097
No	39.2	
Yes	33.5	
Got unemployed		<0.001
No	36.6	
Yes	59.2	
Started working from home		0.708
No	38.4	
Yes	36.9	
Adherence to social distancing		0.061
No	48.6	
Yes	37.9	
Infodemic		<0.001
No	40.3	
Yes	30.9	
Fear of COVID-19		<0.001
No	32.3	
Yes	62.7	
Went to bars or restaurants		0.002
No	37.2	
Yes	48.3	
Go out for physical activity		0.731
No	38.4	
Yes	37.5	
Contact with someone infected		0.008
No	36.6	
Yes	43.0	
Presence of COVID-19 symptoms		<0.001
No	34.1	
Yes	51.8	
Positive test for COVID-19		0.311
No	38.0	
Yes	42.2	
Using online tools to talk to friends and family		<0.001
No	48.8	
Yes	35.7	
Excess weight		0.656
No	37.2	
Yes	38.2	
Physical activity (minutes per week)		0.038
<150	39.5	
≥150	34.5	
Sleep quality		<0.001
Very good/good	32.3	
Regular	49.0	
Poor/very poor	58.0	
Sleep duration		<0.001
Inadequate	42.1	
Adequate	33.8	
Depressive symptoms		<0.001
No	31.4	
Yes	83.2	
Feeling of sadness		<0.001
No	32.3	
Yes	69.3	
Food insecurity		<0.001
No	34.9	
Yes	46.3	

[a]Exact Fisher's test. [b]Black, brown, yellow, indigenous skin color.

Source: Authors.

it continues

Table 6. Crude and adjusted analysis of association between chrononutrition, diet quality and perceived stress in individuals aged 18 years or older during the COVID-19 pandemic. Criciúma-SC and Rio Grande-RS, 2020-2021.

	Perceived stress			
	Crude analyses[a]		Adjusted analyses[b]	
	%	p-value	PR (95% CI)	p-value
Breakfast		0.043		0.695
No	44.0		1.04 (0.85;1.28)	
Yes	37.5		1.00	
Daily meals		<0.001		0.001
<4	48.6		1.19 (1.07;1.32)	
≥4	34.4		1.00	
Diet quality (tertile)		<0.001		0.001
Tertile 1 (best)	32.1		1.00	
Tertile 2	37.3		1.07 (0.93;1.23)	
Tertile 3 (worst)	47.6		1.25 (1.09;1.43)	
Regular consumption of unhealthy foods		<0.001		0.021
No	54.0		1.00	
Yes	35.7		1.13 (1.02;1.25)	
Irregular consumption of healthy foods		<0.001		0.002
No	44.1		1.00	
Yes	33.8		1.25 (1.09;1.44)	

PR: Prevalence ratio. 95%CI: 95% confidence interval. [a]Exact Fisher's test. [b]Adjusted Poisson regression for sex, age, skin color, wealth index, schooling, marital status, live alone, got unemployed, started working from home, adherence to social distancing, infodemic, fear of COVID-19, went to bars or restaurants, go out for physical activity, contact with someone infected, presence of COVID-19 symptoms, positive test for COVID-19, using online tools to talk to friends and family, excess weight, physical activity, sleep quality, sleep duration, perceived stress, depressive symptoms, feeling of sadness and food insecurity.

Source: Authors.

Our results agree with the literature. Poor diet quality, including irregular consumption of healthy foods and regular consumption of unhealthy foods, was associated with a higher prevalence of perceived stress. Nonetheless, our study has the advantage of being carried out amid the COVID-19 pandemic. The COVID-19 pandemic, with its unpredictability and numerous changes in daily life, left the population vulnerable to mental health issues, including stress[31]. While data on dietary changes during this period show contradictions, there is evidence of an increase in the number of daily snacks and meals. This increase is often associated with poor nutrition quality, primarily as a coping strategy for the stressful environment of the pandemic[32,33].

On the other hand, studies evaluating the association between chrononutrition and stress are almost unknown. An Italian study conducted with elderly adults evaluated the influence of time-restricted feeding on mental health. Aged-stratified analysis showed that individuals aged 70 and over, who had time-restricted feeding of 8 hours presented less mental distress than those without time-restrict feeding, but this association disappeared after controlling for having breakfast. Moreover, there was no association between time-restricted feeding and mental health after adjusting for confounding variables in the non-stratified analysis by age[34].

Circadian circle and stress systems are related for being responsible for energy and metabolic regulation and are involved mainly by neural mechanisms. While stressful actions activate the HPA axis and release catecholamines and glucocorticoids, the circadian circle receives information from the external environment through clocks located in peripheral tissues. This external information sends signals to the circadian clock located in the central nervous system (CNS), regulating the metabolism. These signals can activate circadian clocks from the HPA axis, releasing glucocorticoids and creating a stress response. Diet and feeding behaviors are external influencers of the circadian circle, also known as *zeitgebers*[6,35].

Inadequate food intake and behavior can disrupt metabolic homeostasis. Nutritional inadequate meals (in composition and time) can

disrupt the secretion of glucocorticoids such as cortisol, increasing it to superior levels from those normally indicated by the CNS[36]. Glucocorticoids, along with other hormones such as glucagon and ghrelin, are released during fasting status. As previously stated, its secretion is controlled by circadian clocks, including those existing in CNS, and is responsible for signaling the peripheral tissues indicating the feeding time[36,37].

Glucocorticoids increase their levels right after fasting beginning[38]. This could be due to the activation of the HPA axis, especially in short periods of fasting[37], once this status is seen as a stressful condition. In response, adrenocorticotrophin hormone is released to stimulate cortisol production, a stress hormone. During fasting, glucocorticoids act in favor of lipolysis, protein degradation, and glucose synthesis[39]. Therefore, is possible to hypothesize that less than four meals a day might be accompanied by longer periods of fasting, favoring the secretion of stress response mediators, such as glucocorticoids.

Regarding diet quality, it is important to establish that healthy dietary patterns are essential to prevent non-communicable chronic diseases[40,41]. These patterns are generally higher in plant-based foods, including fruits, vegetables, whole grains, legumes, seeds, and nuts, and lower in animal-based foods, processed meats, and ultra-processed, high-fat, and high-sugar foods[40]. Ultra-processed foods are industrially manufactured containing food additives and little or no whole foods. They usually have high amounts of trans fat and sugar, and low amounts of fiber, vitamins, and minerals[42]. Cross-sectional analysis of the Longitudinal Study of Adult Health Brazil pointed out that high ultra-processed food intake was associated with higher C-reactive protein (CRP) levels in women[43].

Meals high in saturated fat can increase inflammatory markers, including CRP levels[44], interleukin-6 (IL-6)[45], tumor necrosis factor-alpha[45], intercellular adhesion molecule-1 (ICAM-1)[44,46], and vascular cell adhesion molecule-1[44]. Also, meals high in saturated fat increase nuclear factor kappa B (NFκB) activation[47]. In line with this, palmitic acid (the most abundant saturated fatty acid in the Western diet) activates the proinflammatory response in microvascular endothelial cells, elevating the expression of IL-6, IL-8, ICAM-1, and toll-like receptor 2[48]. This effect occurs, at least in part, by TLR4 - NFκB signaling pathway[48]. A high-fat meal intake also alters the expression of circadian clock-, inflammation-, and oxidative stress-related genes in human skeletal muscle[49]. A high-fat, high-carbohydrate meal raises endotoxin (lipopolysaccharide) levels postprandially and induces an inflammatory response in normal-weight men[50].

On the other hand, healthy eating patterns are associated with lower circulating concentrations of inflammatory markers[51,52]. A study showed that two years of a Mediterranean-style diet, with daily consumption of whole grains, fruits, vegetables, nuts, and olive oil, reduced CRP, IL-6, and IL-18 compared to the control diet[53]. Also, the dietary intake alters the human gut microbiota[54,55], with a Mediterranean diet and dietary components, such as fruits, vegetables, fiber, and polyphenols, positively modulating the gut microbiota, decreasing inflammation, and improving the gut barrier[56,57].

Circadian rhythm disruption can lead to gut microbiota dysbiosis, with an increase in pathobionts and a decrease in beneficial bacteria, in addition to the disrupted gut barrier and blood-brain barrier[58]. The microbiota rhythms are regulated by diet and feeding time, which can alter both microbiota and gut activity, affecting host immune and metabolic function[59]. The disruption to microbiota homeostasis (dysbiosis) can alter innate and adaptive immunity, contributing to inflammation[60]. Also, the gut microbiota is essential for modulating brain functions[61,62]. Indeed, the microbiota can impact several neurological diseases, including stress and stress-related disorders[63]. Literature shows that host feeding rhythms synchronize with the microbiota to promote rhythms in intestinal innate immunity that anticipate exogenous microbial exposure[64]. A preclinical study evidenced that the microbiota coordinates with the circadian clock to generate rhythms in the expression of genes that govern lipid metabolism and absorption[65].

It is important to highlight the methodological limitations of our study. The cross-sectional design does not allow establishing causality and temporality of associations, which increases the risk of reverse causality. Moreover, the assessment of perceived stress was through a screening tool and cannot be used as a diagnostic. However, the PSS instrument is widely used in population-based studies due to its easy application[25,26]. Finally, we were only able to evaluate two of the three chrononutrition aspects, once data on regularity of food was not available in the applied questionnaire.

As a strength, this is a population-based study conducted amid the COVID-19 pan-

demic with a sampling process conducted in two stages, representing an important epidemiological assessment. In addition, unlike most studies conducted during the pandemic, interviews take place face-to-face, at the participants' households. Moreover, chrononutrition is a recent topic of study and there are few studies evaluating its association with stress in literature. Finally, surveys conducted during the pandemic have provided insights into how such an event can impact various aspects of people's lives. This enables the planning of policies and actions targeted at the most affected individuals, and it also contributes to the accumulation of knowledge. This information will be valuable in addressing possible future pandemic events.

In conclusion, the study showed that less than four meals per day, poor diet quality, irregular consumption of healthy foods, and regular consumption of unhealthy foods were associated with a higher prevalence of stress in two Brazilian cities amid the COVID-19 pandemic. These findings demonstrated an important association between dietary aspects and stress, which can contribute to the development of joint actions on nutrition and mental health.

Collaborations

All authors have made substantial contributions to analysis and interpretation of data and approved the contents of the submitted manuscript.

Funding

This work was supported by the Fundação de Amparo à pesquisa do Estado do Rio Grande do Sul (FAPERGS, Brasil) [Edital nº 06/2020].

References

1. Fink G. Stress: Definition and History. In: *Encyclopedia of Neuroscience*. Elsevier; 2009. p. 549-555.
2. Barros MBA, Lima MG, Malta DC, Szwarcwald CL, Azevedo RCS, Romero D, Souza Júnior PRB, Azevedo LO, Machado ÍE, Damacena GN, Gomes CS, Werneck AO, Silva DRP, Pina MF, Gracie R. Relato de tristeza/depressão, nervosismo/ansiedade e problemas de sono na população adulta brasileira durante a pandemia de COVID-19. *Epidemiol Serv Saude* 2020; 29(4):e2020427.
3. Adamson MM, Phillips A, Seenivasan S, Martinez J, Grewal H, Kang X, Coetzee J, Luttenbacher I, Jester A, Harris OA, Spiegel D. International Prevalence and Correlates of Psychological Stress during the Global COVID-19 Pandemic. *Int J Environ Res Public Health* 2020; 17(24):9248.
4. Goularte JF, Serafim SD, Colombo R, Hogg B, Caldieraro MA, Rosa AR. COVID-19 and mental health in Brazil: Psychiatric symptoms in the general population. *J Psychiatr Res* 2021; 132:32-37.
5. Schneiderman N, Ironson G, Siegel SD. Stress and Health: Psychological, Behavioral, and Biological Determinants. *Annu Rev Clin Psychol* 2005; 1(1):607-628.
6. Oster H. The interplay between stress, circadian clocks, and energy metabolism. *J Endocrinol* 2020; 247(1):R13-R25.
7. Serin Y, Acar Tek N. Effect of Circadian Rhythm on Metabolic Processes and the Regulation of Energy Balance. *Ann Nutr Metab* 2019; 74(4):322-330.
8. Pot GK. Sleep and dietary habits in the urban environment: the role of chrono-nutrition. *Proc Nutr Soc* 2018; 77(3):189-198.
9. Adan RAH, Beek EM, Buitelaar JK, Cryan JF, Hebebrand J, Higgs S, Schellekens H, Dickson SL. Nutritional psychiatry: Towards improving mental health by what you eat. *Eur Neuropsychopharmacol* 2019; 29(12):1321-1332.
10. Oike H, Oishi K, Kobori M. Nutrients, Clock Genes, and Chrononutrition. *Curr Nutr Rep* 2014; 3(3):204-212.
11. Louzada MLC, Costa CS, Souza TN, Cruz GL, Levy RB, Monteiro CA. Impacto do consumo de alimentos ultraprocessados na saúde de crianças, adolescentes e adultos: revisão de escopo. *Cad Saude Publica* 2021; 37(Supl. 1):e00323020.
12. Almoosawi S, Vingeliene S, Karagounis LG, Pot GK. Chrono-nutrition: a review of current evidence from observational studies on global trends in time-of--day of energy intake and its association with obesity. *Proc Nutr Soc*. 2016;75(4):487–500.
13. Chen H, Zhang B, Ge Y, Shi H, Song S, Xue W, Li J, Fu K, Chen X, Teng W, Tian L. Association between skipping breakfast and risk of cardiovascular disease and all cause mortality: A meta-analysis. *Clin Nutr* 2020; 39(10):2982-2988.
14. Quadra MR, Santos LP, Schäfer AA, Meller FO. Influence of sleep and chrononutrition on hypertension and diabetes: a population-based study. *Cad Saude Publica* 2022; 38(7):e00291021.
15. Domingos TB, Pereira AF, Yokoo EM, Salles-Costa R. Low fruit consumption and omission of daily meals as risk factors for increased blood pressure in adults. *Br J Nutr* 2016; 116(4):683-691.
16. López-Cepero A, O'Neill J, Tamez M, Falcón LM, Tucker KL, Rodríguez-Orengo JF, Mattei J. Associations Between Perceived Stress and Dietary Intake in Adults in Puerto Rico. *J Acad Nutr Diet* 2021; 121(4):762-769.
17. Khaled K, Hundley V, Tsofliou F. Poor Dietary Quality and Patterns Are Associated with Higher Perceived Stress among Women of Reproductive Age in the UK. *Nutrients* 2021; 13(8):2588.
18. Instituto Brasileiro de Geografia e Estatística (IBGE). *Censo Demográfico 2022: Principais Resultados*. Rio de Janeiro: IBGE; 2023.
19. Instituto Brasileiro de Geografia e Estatística (IBGE). *Censo Demográfico 2010: Características da População e dos Domicílios*. Rio de Janeiro: IBGE; 2011.
20. Instituto Brasileiro de Geografia e Estatística (IBGE). *Conheça cidades e estados do Brasil*. Rio de Janeiro: IBGE; 2022.
21. Instituto Brasileiro de Geografia e Estatística (IBGE). *Metodologia do Censo Demográfico 2010*. Rio de Janeiro: IBGE; 2011.
22. O'Neil CE, Byrd-Bredbenner C, Hayes D, Jana L, Klinger SE, Stephenson-Martin S. The Role of Breakfast in Health: Definition and Criteria for a Quality Breakfast. *J Acad Nutr Diet* 2014; 114(12):S8-S26.
23. Francisco PMSB, Assumpção D, Borim FSA, Senicato C, Malta DC. Prevalence and co-occurrence of modifiable risk factors in adults and older people. *Rev Saude Publica* 2019; 53:86.
24. Meller FO, Manosso LM, Schäfer AA. The influence of diet quality on depression among adults and elderly: A population-based study. *J Affect Disord* 2021; 282:1076-1081.
25. Reis RS, Ferreira Hino AA, Rodriguez Añez CR. Perceived Stress Scale. *J Health Psychol* 2010; 15(1):107-114.
26. Schäfer AA, Santos LP, Manosso LM, Quadra MR, Meller FO. Relationship between sleep duration and quality and mental health before and during COVID-19 pandemic: Results of population-based studies in Brazil. *J Psychosom Res* 2022; 158:110910.
27. Victora CG, Huttly SR, Fuchs SC, Olinto MT. The role of conceptual frameworks in epidemiological analysis: a hierarchical approach. *Int J Epidemiol* 1997; 26(1):224-227.
28. Akbaraly TN, Sabia S, Shipley MJ, Batty GD, Kivimaki M. Adherence to healthy dietary guidelines and future depressive symptoms: evidence for sex differentials in the Whitehall II study. *Am J Clin Nutr* 2013; 97(2):419-427.
29. Liu Z min, Ho SC, Xie YJ, Chen Y jun, Chen Y ming, Chen B, Wong SY, Chan D, Wong CK, He Q, Tse LA, Woo J. Associations between dietary patterns and psychological factors: a cross-sectional study among Chinese postmenopausal women. *Menopause* 2016; 23(12):1294-1302.

30. Liu MW, Chen QT, Towne Jr. SD, Zhang J, Yu HJ, Tang R, Gasevic D, Wang PG, He QQ. Fruit and vegetable intake in relation to depressive and anxiety symptoms among adolescents in 25 low- and middle-income countries. *J Affect Disord* 2020; 261:172-180.
31. Penninx BWJH, Benros ME, Klein RS, Vinkers CH. How COVID-19 shaped mental health: from infection to pandemic effects. *Nat Med* 2022; 28(10):2027-2037.
32. Bennett G, Young E, Butler I, Coe S. The Impact of Lockdown During the COVID-19 Outbreak on Dietary Habits in Various Population Groups: A Scoping Review. *Front Nutr* 2021; 8:626432.
33. Arora T, Grey I. Health behaviour changes during COVID-19 and the potential consequences: A mini-review. *J Health Psychol* 2020; 25(9):1155-1163.
34. Currenti W, Godos J, Castellano S, Caruso G, Ferri R, Caraci F, Grosso G, Galvano F. Time-restricted feeding is associated with mental health in elderly Italian adults. *Chronobiol Int* 2021; 38(10):1507-1516.
35. Dumbell R, Matveeva O, Oster H. Circadian Clocks, Stress, and Immunity. *Front Endocrinol* 2016; 7:37.
36. Challet E. The circadian regulation of food intake. *Nat Rev Endocrinol* 2019; 15(7):393-405.
37. Nakamura Y, Walker BR, Ikuta T. Systematic review and meta-analysis reveals acutely elevated plasma cortisol following fasting but not less severe calorie restriction. *Stress* 2016; 19(2):151-157.
38. Kim BH, Joo Y, Kim MS, Choe HK, Tong Q, Kwon O. Effects of Intermittent Fasting on the Circulating Levels and Circadian Rhythms of Hormones. *Endocrinol Metab* 2021; 36(4):745-756.
39. Guia RM. Stress, glucocorticoid signaling pathway, and metabolic disorders. *Diabetes Metab Syndr* 2020; 14(5):1273-1280.
40. Cena H, Calder PC. Defining a Healthy Diet: Evidence for the Role of Contemporary Dietary Patterns in Health and Disease. *Nutrients* 2020; 12(2):334.
41. Neuhouser ML. The importance of healthy dietary patterns in chronic disease prevention. *Nutr Res* 2019; 70:3-6.
42. Juul F, Vaidean G, Parekh N. Ultra-processed Foods and Cardiovascular Diseases: Potential Mechanisms of Action. *Adv Nutr* 2021; 12(5):1673-1680.
43. Lopes AESC, Araújo LF, Levy RB, Barreto SM, Giatti L. Association between consumption of ultra-processed foods and serum C-reactive protein levels: cross-sectional results from the ELSA-Brasil study. *Sao Paulo Med J* 2019; 137(2):169-176.
44. Kiecolt-Glaser JK, Fagundes CP, Andridge R, Peng J, Malarkey WB, Habash D, Belury MA. Depression, daily stressors and inflammatory responses to high-fat meals: when stress overrides healthier food choices. *Mol Psychiatry* 2017; 22(3):476-482.
45. Rocha DMUP, Lopes LL, Silva A, Oliveira LL, Bressan J, Hermsdorff HHM. Orange juice modulates proinflammatory cytokines after high-fat saturated meal consumption. *Food Funct* 2017; 8(12):4396-4403.
46. Peairs AD, Rankin JW, Lee YW. Effects of acute ingestion of different fats on oxidative stress and inflammation in overweight and obese adults. *Nutr J* 2011; 10(1):122.
47. Bellido C, López-Miranda J, Blanco-Colio LM, Pérez-Martínez P, Muriana FJ, Martín-Ventura JL, Marín C, Gómez P, Fuentes F, Egido J, Pérez-Jiménez F. Butter and walnuts, but not olive oil, elicit postprandial activation of nuclear transcription factor κB in peripheral blood mononuclear cells from healthy men. *Am J Clin Nutr* 2004; 80(6):1487-1491.
48. Pillon NJ, Azizi PM, Li YE, Liu J, Wang C, Chan KL, Hopperton KE, Bazinet RP, Heit B, Bilan PJ, Lee WL, Klip A. Palmitate-induced inflammatory pathways in human adipose microvascular endothelial cells promote monocyte adhesion and impair insulin transcytosis. *Am J Physiol Endocrinol Metab* 2015; 309(1):E35-E44.
49. Budai Z, Balogh L, Sarang Z. Short-term high-fat meal intake alters the expression of circadian clock-, inflammation-, and oxidative stress-related genes in human skeletal muscle. *Int J Food Sci Nutr* 2019; 70(6):749-758.
50. Ghanim H, Abuaysheh S, Sia CL, Korzeniewski K, Chaudhuri A, Fernandez-Real JM, Dandona P. Increase in Plasma Endotoxin Concentrations and the Expression of Toll-Like Receptors and Suppressor of Cytokine Signaling-3 in Mononuclear Cells After a High-Fat, High-Carbohydrate Meal. *Diabetes Care* 2009; 32(12):2281-2287.
51. Calder PC, Ahluwalia N, Brouns F, Buetler T, Clement K, Cunningham K, Esposito K, Jönsson LS, Kolb H, Lansink M, Marcos A, Margioris A, Matusheski N, Nordmann H, O'Brien J, Pugliese G, Rizkalla S, Schalkwijk C, Tuomilehto J, Wärnberg J, Watzl B, Winklhofer-Roob BM. Dietary factors and low-grade inflammation in relation to overweight and obesity. *Br J Nutr* 2011; 106(S3):S5-S78.
52. Tosti V, Bertozzi B, Fontana L. Health Benefits of the Mediterranean Diet: Metabolic and Molecular Mechanisms. *J Gerontol* 2018; 73(3):318-326.
53. Esposito K, Marfella R, Ciotola M, Di Palo C, Giugliano F, Giugliano G, D'Armiento M, D'Andrea F, Giugliano D. Effect of a Mediterranean-Style Diet on Endothelial Dysfunction and Markers of Vascular Inflammation in the Metabolic Syndrome. *JAMA* 2004; 292(12):1440.
54. David LA, Maurice CF, Carmody RN, Gootenberg DB, Button JE, Wolfe BE, Ling AV, Devlin AS, Varma Y, Fischbach MA, Biddinger SB, Dutton RJ, Turnbaugh PJ. Diet rapidly and reproducibly alters the human gut microbiome. *Nature* 2014; 505(7484):559-563.
55. Guo Y, Zhu X, Zeng M, Qi L, Tang X, Wang D, Zhang M, Xie Y, Li H, Yang X, Chen D. A diet high in sugar and fat influences neurotransmitter metabolism and then affects brain function by altering the gut microbiota. *Transl Psychiatry* 2021; 11(1):328.
56. Beam A, Clinger E, Hao L. Effect of Diet and Dietary Components on the Composition of the Gut Microbiota. *Nutrients* 2021; 13(8):2795.

57. Merra G, Noce A, Marrone G, Cintoni M, Tarsitano MG, Capacci A, Lorenzo A. Influence of Mediterranean Diet on Human Gut Microbiota. *Nutrients* 2020; 13(1):7.
58. Li Y, Shao L, Mou Y, Zhang Y, Ping Y. Sleep, circadian rhythm and gut microbiota: alterations in Alzheimer's disease and their potential links in the pathogenesis. *Gut Microbes* 2021; 13(1):1957407.
59. Voigt RM, Forsyth CB, Green SJ, Engen PA, Keshavarzian A. Circadian Rhythm and the Gut Microbiome. *Int Rev Neurobiol* 2016; 131:193-205.
60. Levy M, Kolodziejczyk AA, Thaiss CA, Elinav E. Dysbiosis and the immune system. *Nat Rev Immunol* 2017; 17(4):219-232.
61. Cryan JF, O'Riordan KJ, Sandhu K, Peterson V, Dinan TG. The gut microbiome in neurological disorders. *Lancet Neurol* 2020; 19(2):179-194.
62. Foster JA. Modulating brain function with microbiota. *Science* 2022; 376(6596):936-937.
63. Foster JA, Rinaman L, Cryan JF. Stress and the gut-brain axis: Regulation by the microbiome. *Neurobiol Stress* 2017; 7:124-136.
64. Brooks JF, Behrendt CL, Ruhn KA, Lee S, Raj P, Takahashi JS, Hooper LV. The microbiota coordinates diurnal rhythms in innate immunity with the circadian clock. *Cell* 2021; 184(16):4154-4167.e12.
65. Wang Y, Kuang Z, Yu X, Ruhn KA, Kubo M, Hooper L V. The intestinal microbiota regulates body composition through NFIL3 and the circadian clock. *Science* 2017; 357(6354):912-916.
66. Pulido CM, Villarejo-Carballido B, Redondo-Sama G, Gómez A. COVID-19 infodemic: More retweets for science-based information on coronavirus than for false information. *Int Sociol* 2020; 35(4):377-392.
67. Ahorsu DK, Lin CY, Imani V, Saffari M, Griffiths MD, Pakpour AH. The Fear of COVID-19 Scale: Development and Initial Validation. *Int J Ment Health Addict* 2022; 20(3):1537-1545.
68. Medeiros ED, Reis LM, Guimarães CLC, Silva PGN, Monteiro RP, Coelho GLH, Guimarães CMC, Martins ERDS, França LLA. Psychometric properties of the Brazilian version of the fear of COVID-19 scale (FCV-19S). *Curr Psychol* 2023; 42(2):980-989.
69. World Health Organization (WHO). *WHO Expert Committee on Physical Status: the Use and Interpretation of Anthropometry. Report of a WHO Expert Committee*. Geneva: WHO; 1995.
70. Lipschitz DA. Screening for nutritional status in the elderly. *Prim Care* 1994; 21(1):55-67.
71. IPAQ Research Committee. *Guidelines for Data Processing and Analysis of the International Physical Activity Questionnaire (IPAQ) – Short and Long Forms*. IPAQ; 2005.
72. World Health Organization (WHO). Global recommendations on physical activity for health. Geneva: WHO; 2010.
73. Chaput JP, Dutil C, Featherstone R, Ross R, Giangregorio L, Saunders TJ, et al. Sleep duration and health in adults: an overview of systematic reviews. *Appl Physiol Nutr Metab* 2020; 45(10):S218-S231.
74. Santos LP, Costa MG, Santos JV, Lindemann IL, Gigante DP. Comparação entre duas escalas de segurança alimentar. *Cien Saude Colet* 2014; 19(1):279-286.
75. Andrews FM, Withey SB. *Social Indicators of Well-Being: Americans' Perceptions of Life Quality*. Boston: Springer US; 2012.
76. Santos IS, Tavares BF, Munhoz TN, Almeida LSP, Silva NTB, Tams BD, Patella AM, Matijasevich A. Sensibilidade e especificidade do Patient Health Questionnaire-9 (PHQ-9) entre adultos da população geral. *Cad Saude Publica* 2013; 29(8):1533-1543.

Article submitted 25/10/2023
Approved 19/03/2024
Final version submitted 21/03/2024

Chief editors: Maria Cecília de Souza Minayo, Romeu Gomes, Antônio Augusto Moura da Silva