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Vegetable and fruit consumption during the COVID-19 lockdown: eating habits in Ecuador

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Abstract

This study identifies changes in fruit and vegetable (FV) consumption habits during the COVID-19 pandemic in Quito-Ecuador and observe relationships regarding household income and the relevance of FV nutritional value. The study used an online survey among urban residents (n = 1093) in Quito-Ecuador, regarding FV consumption patterns during the lockdown along with household socioeconomic status. A multiple response logistic model was used to analyse changes in FV eating habits across four income categories. Income had a statistically significant effect over the healthy food consumption of FV for the low- and high-income category. Families did not change eating habits nor decide to maintain a diet based on differences of income. Further, approximately two thirds of the families increased FV consumption during the lockdown. Eating habits changed during the lockdown of urban households in Ecuador. Income explained changes in FV consumption for low- and high-income households but did not for the middle-income group. Households that purchased more FV had a higher perception of their own healthy eating habits. The consumption of FV with high content of vitamin C increased, however, families did not purchase products with the highest vitamin-C content.

Keywords: COVID-19, Food consumption, Fruit and vegetable intake evaluation, Eating habits

Introduction

During the first quarter of 2021, over 120 million people were infected with COVID-19 and 2.6 million died worldwide. In South America alone, COVID-19 has infected 19.2 million people and caused the deaths of almost half a million (Worldometers 2021). Ecuador, with a population of approximately 17 million, experienced a health, economic and social crisis during the pandemic and had one of the highest mortality rates on the continent (Pinheiro et al. 2020).

On 29th February 2020, Ecuador's Ministry of Public Health confirmed the country's first COVID-19 case (Haro 2020; MSP 2021). On 11th March, the government declared a national health emergency and on 12th March, a lockdown was enforced that included

the suspension of classes, in-person work, mass public events and the entry of non-residents from abroad (MSP 2020a). In April 2020, the Committee of Emergency Management implemented inter-city travel restrictions because of the high number of infections and deaths (COE-Ecuador 2020). Additionally, in May, the government established a nationwide curfew from 9:00 pm to 5:00 am. Nevertheless, supermarkets attempted to secure the food supply to avoid shortages (COE-Ecuador 2020), pharmacies remained open and most restaurants operated exclusively for home deliveries.

Containing 18% of Ecuador's total population, Pichincha is its second-largest province, but it registered the highest proportion of COVID-19 infections (24%) (MSP 2020b). After 180 days, the lockdown was officially lifted in Quito (the capital of Pichincha and of the country), except for certain restrictions, such as a 30% capacity limit for restaurants and food markets, meant to reduce infection spread (Quito-Informa 2020; SNGRE 2020).

The pandemic and consequent lockdown severely affected household income. According to the World Bank, the pandemic reduced the Latin American middle class by approximately five million people. Further, over 50% of employees work in the informal sector or self-employment and the lockdown disproportionately affected income generation for many in this region (World Bank 2021). The Economic Commission for Latin America and the Caribbean estimated that Ecuador's economy shrank by 7.8% in 2020 (NU. CEPAL 2021). In addition, unemployment increased considerably: from 3.8% in 2019 to 4.9% in 2020 (INEC 2021).

During the lockdown, the World Health Organization (WHO) and the Food and Agriculture Organization of the United Nations jointly carried out a global public campaign to promote a healthy diet, mainly by consuming fruit and vegetables, to strengthen people's immune systems. The primary motivation of this study was to explore families' responses to these recommendations and to analyse the differences in behavioural reactions by considering the different levels of economic restriction amongst households.

The rest of this study is structured as follows. Section "Literature review" examines other related literature. Section "Methods" details the methods, data collection and model. Section "Results" describes the results from the statistical analyses and tests of significance. Section "Discussion" presents the discussion and, finally, Section "Conclusions" includes conclusions and lays out the study's limitations and future research needs.

Literature review

Ecuador's public health campaign during COVID-19 focused on mask wearing and social distancing; little emphasis was placed on consuming food rich in micronutrients, like citrus fruit and food rich in vitamin C, to strengthen one's immune system and reduce COVID-19 susceptibility (Górnicka et al. 2020).

Healthy food may help enhance the immune system; for instance, fruit and vegetables are sources of fibre, micronutrients (i.e., vitamins and minerals) and phytochemicals. The latter are bioactive compounds from plants that include phenolic compounds, carotenoids, phytosterols, organosulfur compounds, nitrogenous compounds and alkaloids (Liu 2013), which are non-essential nutrients consumed via functional food (Subedi et al. 2021). Fruit and vegetables also contain antioxidant, antimicrobial, antiviral,

anticarcinogenic, anti-inflammatory and immunoregulatory components which activate when interacting with bioactive compounds (Galanakis et al. 2020; Liu 2013; Subedi et al. 2021).

Khoramipour et al. (2021) suggest that a healthy diet may help mitigate COVID-19 and strengthen the immune system through "immunonutrition." Particular micronutrients, such as vitamins A, D, B6, B12 and C, as well as minerals such as Zn, Fe, Se and Cu, contribute to the normal functioning of the immune system (De Faria Coelho-Ravagnani et al. 2021; Richardson and Lovegrove 2021). According to Zabetakis et al. (2020), vitamin D is a particularly potent inhibitor of COVID-19 propagation because of its phenolic compounds. Eating fruit and vegetables, protein-rich foods, polyunsaturated fatty acids and functional food can contribute to fighting diseases like COVID-19 (Zhivikj et al. 2021). A healthy diet and lifestyle, such as sufficient sleep, moderate exercise and stress reduction, may increase resistance to COVID-19 (Khoramipour et al. 2021). Indeed, the WHO recommends a balanced diet to maintain a robust immune system and minimise the risk of chronic diseases and infections, recommending the consumption of five daily portions (400 g) of fruit and vegetables (Khoramipour et al. 2021).

The pandemic has increased interest in consuming healthier foods, including fruit and vegetables, to fortify the immune system (CEPAL 2020). However, Galanakis et al. (2020) point out that as of November 2020, no studies have shown a correlation between consuming bioactive compounds and the direct prevention of or recovery from COVID-19. Similarly, there are few studies on food consumption patterns and their effect on COVID-19 incidence or mortality. Therefore, it is essential to examine whether there is an association between dietary habits and COVID-19 infection that could potentially predict the geographic distribution of the illness (Jayawardena and Misra 2020).

Concerning eating habits, various studies found changes in food consumption patterns during the 2020 lockdowns. In Brazil, Costa et al. (2021) determined that the pandemic led to dietary changes, with a significant increase (4.4%) in the frequency of eating fruit and vegetables. They also showed that the increase was higher for men than women. Ben Hassen et al. (2020) found that 36.7% of a surveyed sample changed their food consumption habits during the lockdown period in Qatar. What is more, Górnicka et al. (2020) found that most people in Poland changed their eating habits: 19.8% actually reduced their fruit and vegetable consumption. Additionally, between 15 and 37% of the population in Poland said their diet was healthier than before the lockdown period and that they had increased fruit and vegetable consumption. On the other hand, those with relatively unhealthy eating habits increased their consumption of unhealthy food and reduced that of fruit and vegetables by 59% and 62.5%, respectively. In another study, Sidor and Rzymski (2020) found that daily fruit and vegetable consumption was generally low for adult respondents during the pandemic in Poland. Meanwhile, Coulthard et al. (2021) showed that positive eating practices in the UK, such as more home-cooked food, fruit and vegetables, were increased as part of adaptive and anticipatory strategies to improve health during lockdown.

In Italy, Spain, Chile, Colombia and Brazil, Ruiz-Roso et al. (2020) found that families spent more time cooking and increased their intake of fruit, vegetables and healthy foods during lockdown. However, the quality of adolescents' diets did not vary significantly, whereas in the United States, individuals with university education reported positive

dietary changes (Jaeger et al. 2021). In contrast, Park et al. (2021) found that people in the United Arab Emirates increased unhealthy eating habits, such as unhealthy snacks between meals. They also established that the lockdown had a negative effect on physical activity, which exacerbated sedentary lifestyles. In Denmark, Germany and Slovenia (Janssen et al. 2021), researchers identified a decrease in the consumption of perishable foods such as fruit, vegetables and meat, as food purchase frequency declined during the pandemic. Consumers were also more inclined to place online orders of fresh vegetables and freshly cut products to be directly delivered by producers (Butu et al. 2020; Maesano et al. 2022).

However, the increased number of not-necessarily healthy daily meals could also be a response to lockdown-induced stress. Several studies have identified comfort eating behaviour in situations of anxiety, sadness, worry or anger, which involve eating food high in salt, sugar or fat (Ammar et al. 2020; Jaeger et al. 2021). These can lead to weight gain, obesity and other nutrition-related disorders. More research is needed to understand changes in eating habits during a lockdown, particularly increased intake of ultra-processed, sugary and high-fat food, in addition to sedentary lifestyles. These eating habits may leave the immune system susceptible to new waves of a virus like COVID-19 (Ammar et al. 2020; Sierra et al. 2003).

Isolation, increasing infections and deaths, economic vulnerability, unemployment and a declining income induced unhealthy emotional responses, like boredom or depression, especially among vulnerable groups, including women, unpartnered individuals and people with young children (Buheji et al. 2020; Havermans et al. 2015; Kowal et al. 2020). Braden et al. (2018), Crockett et al. (2015) and Jaeger et al. (2021) observed that stress-generating conditions may lead to comfort eating or overeating as a coping mechanism. Individuals engaging in emotional eating tend to reduce the number of main meals as well as vegetable consumption (Bourdier et al. 2018; Ma et al. 2017; Rodríguez-Martín and Meule 2015). Stress and boredom contributed to overeating in adults in the United States and France (Koball et al. 2012; Schultchen et al. 2019). Adults prone to emotional eating were 13 times more likely to be overweight than adults with low levels of emotional eating. In the Netherlands, a survey showed that 57.3% of the overweight or obese population tended to increase food consumption as a response to negative emotions (Braden et al. 2018; Chotigo and Kadono 2021).

Studies in Thailand, Brazil and various European countries have shown an increase in meal deliveries to households as a possible result of having less time to prepare food (Frayn and Knäuper 2018; Grunert et al. 2021; Howarth et al. 2001). In Thailand, the frequency of weekly food orders was four to six times higher during the pandemic. Professionals with a bachelor's degree registered the highest use of online food orders for their homes (Chotigo and Kadono 2021). In Ecuador, the interest in food delivery and the use of platforms such as Glovo and Uber Eats increased during the lockdown period, as indicated in Fig. 1 (FAO 2021). The popularity of the use of home delivery platforms increased significantly from February to June 2020, corresponding with the lockdown period.

As for consuming fruit and vegetables in Ecuador, research is minimal. Barragán Ochoa (2019) estimated that fruit intake decreased from 40% in 1960 to 25% in the 2010s, while vegetable intake went from 9 to 4.4%. Tuber consumption decreased from

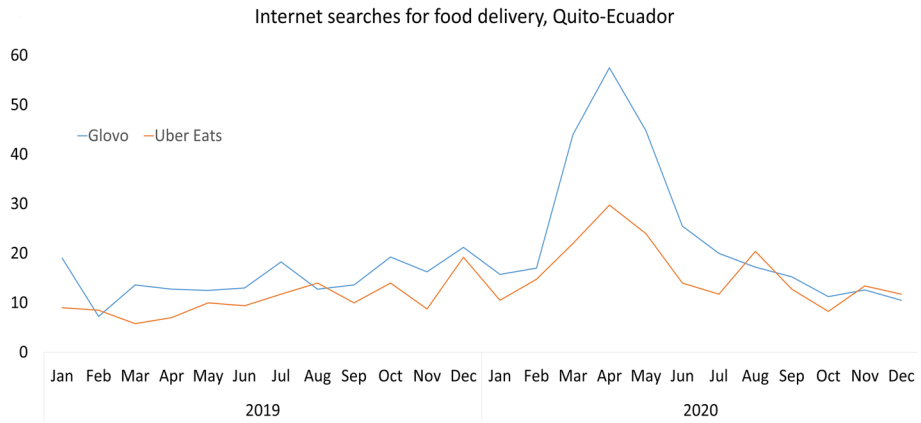

Fig. 1 Internet searches for food delivery in Pichincha, Ecuador. Interest in food delivery and use of Glovo and Uber Eats platforms in 2019 and 2020 in the province of Pichincha during the lockdown, according to the Google Trends platform. In terms of popularity, the maximum value was 100, the median was 50 and the minimum was zero

12% in the 1970s to 4% in the 2010s, while legumes went from 1.7 to 0.3% in the same period. According to the 2018 Health and Nutrition Survey (Romero-Martínez et al. 2021), an average Ecuadorian eats 160 g of fruit and vegetables per day. There were no significant differences in consumption for age or gender, but there were observable economic disparities: only 5.4% of the population consumed the recommended 400 g or more and intake was highly correlated with income. Globally, the daily average consumption is 286 and 123 g per person for vegetables and fruit, respectively (Romero-Martínez et al. 2021).

The consumption of agri-food products per capita is relatively higher in Ecuador than in neighbouring countries. For example, fruit intake in Ecuador is 2.1, 2.6 and 4 times higher than in Colombia, Peru and the world, respectively (Kalmpourtzidou et al. 2020). Data from the FAO and the World Bank suggest a positive association between vegetable consumption and income. This relationship may be explained by the fact that vegetables are a normal good; that is, as incomes rise, demand for vegetables increases. Although Ecuador has a relatively high intake of fruit and vegetables compared to other countries, the country faces food deprivation: 20% and 29% of children in urban and rural areas, respectively, suffer from high levels of chronic malnutrition (Moreta Colcha et al. 2019). Conversely, 37% and 33% of urban and rural children, respectively, are overweight or obese. For adults, the obesity rate reached 63% in 2020 (Barragán Ochoa 2019; INEC 2021). These differences may be explained by multiple factors, including limited access to food, lack of nutritional knowledge, poverty and inadequate supply chains.

In Latin America, there are few studies that link the impact of COVID-19 with the consumption of fruit and vegetables that may lead to more healthy lifestyles. Food and nutrition research has centred on diets, healthy lifestyle habits and food consumption patterns, without specifically addressing the economic determinants of fruit and vegetable consumption (Cavagnari et al. 2022; Durán-Agüero et al. 2022; Valdés-Badilla et al. 2022).

This study aimed to identify changes in fruit and vegetable consumption habits during the COVID-19 pandemic in the urban area of Quito, Ecuador, using a survey that

was conducted during the country's lockdown period. There was a particular focus on changes in consumption according to household income, the importance of the nutritional value of fruit and vegetables and the conditions associated with improved eating habits.

Methods

Data collection

This cross-sectional study was conducted using an online survey based on Górnicka et al. (2020). It was administered using the Google Forms web survey platform and was conducted exclusively in Quito, with households as responding units. Quito is the capital of Ecuador with approximately 2.8 million inhabitants and much of the city's economic activity revolves around commerce and services (INEC 2013).

The questionnaire included the study's objective and description and the online survey link was shared via social media and email. Survey responses were anonymous and confidential, with no personal or IP address information collected. The research group designed the survey and the questionnaire was reviewed by a group of five experts in food science with experience in nutrition, postharvest technology, food safety and agricultural economics. The survey was tested for validation through a pilot examination with 30 respondents before the final application. The 30 initial respondents were unsystematically selected from work colleagues and homemakers to ensure that the survey questions were concise for all audiences. The online survey did not require approval from an ethics committee because of its anonymous nature and the inability to track sensitive personal data.

The online survey collected 1096 responses from 1st to 30th September 2020. Five responses were eliminated because the information was incomplete and the final sample size was $n = 1091$. This sample size considers a margin of error of 5% and a 95% confidence level and it is statistically significant for the metropolitan population of Quito. The online survey was conducted during the transition period between lockdown and social distancing. The questionnaire included 11 questions that were divided into two sections: socioeconomic conditions and dietary habits.

The first section of the questionnaire included information on the respondent's age, gender, residence during lockdown (rural or urban), occupation and type of work (i.e. unemployed, part- or full-time, online or on-site and/or private or public sector work). The survey included a question about monthly household income differentiated into four segments: ≤ 500, 501–1000, 1001–2000 and ≥ 2001 USD, corresponding to low, low-middle, high-middle and high income, respectively. The second section focused on information regarding dietary habits during the lockdown period, including:

- If respondents currently eat healthily and if they started any diet;
- Number of meals per day: 1–5 and ≥ 5 and how often they purchase fruit and vegetables (daily, once/week or 1 or 2 times/month);
- Dollar expenditure on fruit and vegetables (≤ 5, 5.01–10, 10.01–20, 20.01–30, 30.01–40, 40.01–50 and > 50 USD) per week; and

- Increase in fruit and vegetable consumption with specific products during the pandemic.

Multiple response model

Survey data were analysed using a multiple-response logistic model to determine if household fruit and vegetable intake changed during the COVID-19 lockdown based on the qualitative responses. This probability model indicates the probability of success of an event based on a linear function with independent variables. The model was built upon literature that used dichotomous outcomes as a function of independent variables divided into nonoverlapping categories. For example, Soteriades and Di Franza (2003) used logistic regression models to estimate binary responses as a function of income, De Maris (1995) explained marital status and Merlo et al. (2016) used response models to study responses based on age group. The explicit model can be represented by the following expression:

$$P(y = 1|x) = \beta_0 + \beta_1 x_1 + \beta_2 x_2 + \ldots + \beta_k x_k,$$

where y is the dependent variable and x_i with $i \in \{1, 2..., k\}$ corresponds to independent categorical variables, with a linear probability response $P(y=1|x)$ in the parameters given by β_i, where $i \in \{1, 2..., k\}$ with $y=1$ as the result of a successful event. The coefficient β measures the change in the probability of success after a change in the independent variable x_i, which can be explained by the following equation:

$$\Delta P(y = 1|x) = \beta_i \Delta x_i.$$

This expression indicates the linear changes in the probability of household consumption under specified categories of independent variable x, during the COVID-19 lockdown. The estimation of coefficients β is carried out using the least squares method. This logistic model was used to evaluate four questions regarding household decisions to pursue a healthy diet in response to the pandemic using the logistic regression with the income category as the independent variable. Healthy habits, changes in eating habits and an increase in fruit and vegetable consumption are dichotomous response dependent variables. The assumption is that these responses can be modelled as a function of household income. The fourth regression sought the association of healthy eating behaviour (dependent variable) with expenditure on fruit and vegetables (independent variable).

The estimated coefficient β of the logistic regression indicates the odds ratio of probabilities of success and no success events. In other words, the ratio of the probability of success p divided by the probability of no success *(1-p)*. Therefore, the regression models the following functional equation:

$$log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_i x_i$$

where the logarithmic transformation can be written as $\left(\frac{p}{1-p}\right) = \exp(\beta_0 + \beta_i x_i)$, where $\frac{p}{1-p}$ represents the odds ratio of success over failure events and $\exp(\bullet)$ indicates the natu-

ral number e to the power of expression (•). Thus, the coefficient β is interpreted using the odds ratio. The Wald test is used to determine the statistical significance of the set of predictors.

Results

Descriptive profile of participants

The survey sample included 1091 participants. The largest proportion (80%) corresponded to the working-age population (21–50 years old) (Table 1). Most respondents were women (59% of the sample), whilst men accounted for 41%. Approximately 33% of participants corresponded to the low-income category, that is, with a monthly income of less than $500; 31.8% were in the low-middle group (a monthly income of between $500 and $1000), 22.5% were in the high-middle group (a monthly income of $1000–2000) and 13% belonged to the high-income category (an income greater than $2000 per month). Additionally, 21.1% of women and 11.4% of men reported having a low income, while only 5.4% of women and 7.6% of men corresponded to the high-income group.

Other key socioeconomic variables indicate that nine out of ten respondents lived in urban areas. Regarding employment, four times as many respondents worked in the private rather than the government sector. Additionally, almost a quarter of the sample was unemployed, one out of five participants worked full-time and on-site and two out of five participants worked remotely.

Table 1 Socio-demographic characteristics of the sample (n (%))

	Family income monthly ($)					
	Ranges/Groups	**Total (100%) (n = 1091)**	**< 500 (32.5%) (n = 355)**	**500–1000 (31.9%) (n = 348)**	**1000–2000 (22.5%) (n = 246)**	**> 2000 (13%) (n = 142)**
Age (years)	17–20	37 (3.4)	20 (1.8)	13 (1.2)	1 (0.1)	3 (0.3)
	21–30	389 (35.6)	194 (17.7)	132 (12.0)	54 (4.9)	9 (0.8)
	31–40	277 (25.4)	58 (5.3)	85 (7.8)	91 (8.3)	43 (3.9)
	41–50	206 (18.9)	46 (4.2)	58 (5.3)	53 (4.9)	49 (4.5)
	51–60	130 (11.9)	27 (2.5)	41 (3.7)	37 (3.4)	25 (2.3)
	61–70	42 (3.8)	10 (0.9)	12 (1.1)	9 (0.8)	11 (1.0)
	> 70	10 (0.9)	0 (0)	7 (0.6)	1 (0.1)	2 (0.2)
Gender	Female	643 (58.9)	230 (21.0)	206 (18.9)	148 (13.6)	59 (5.4)
	Male	448 (41.1)	125 (11.4)	142 (13.0)	98 (8.9)	83 (7.6)
Zone	Rural	132 (12)	59 (5.4)	43 (3.9)	17 (1.6)	13 (1.2)
	Urban	959 (88)	296 (27.0)	305 (27.9)	229 (21.0)	129 (11.8)
Occupation	Housewives	93 (8.5)	44 (4.0)	25 (2.3)	15 (1.4)	9 (0.8)
	Students	219 (20.1)	146 (13.3)	49 (4.5)	17 (1.5)	8 (0.7)
	Government	158 (14.7)	10 (0.9)	66 (6.1)	60 (5.5)	22 (2.0)
	Private	621 (56.8)	155 (14.1)	208 (19.0)	155 (14.2)	103 (9.4)
Work status	Without work	282 (25.7)	160 (14.6)	74 (6.8)	27 (2.5)	21 (1.9)
	Online	435 (39.9)	88 (8.0)	146 (13.4)	127 (11.6)	74 (6.8)
	Partial on-site	158 (14.5)	66 (6.0)	33 (3.0)	34 (3.1)	25 (2.3)
	Full time on-site	216 (19.8)	41 (3.7)	95 (8.7)	58 (5.3)	22 (2.0)

Table 2 Healthy food consumption and decision to start a diet according to income categories

Variable	Coef	Std. error	Pr(|z|)	Factor	Wald test: *P*(> X)
a Healthy food consumption					
Intercept	1.1099	0.1229	< 2e−16***	3.03	0.033
Low middle	0.1154	0.1774	0.515663	1.12	
High middle	0.2067	0.1987	0.29829	1.23	
High	0.8200	0.2806	0.00347**	2.27	
b Decision to start a diet					
Intercept	−0.7357	0.1134	8.76e−11***	0.48	0.17
Low middle	−0.4896	0.1710	0.0042**	0.61	
High middle	−0.2063	0.1817	0.2561	0.81	
High	−0.3818	0.2253	0.0902	0.68	
c Change in eating habits					
Intercept	1.3863	0.1327	< 2e−16***	4	0.24
Low middle	−0.3181	0.1808	0.0786 .	0.73	
High middle	−0.3199	0.1973	0.1050	0.73	
High	−0.3433	0.2327	0.1402	0.71	

(***) significance at 0.1% ; (**) significance at 1% ; (.) significance at 10%

P(> X): *p*-value associated to the Wald test statistic

Logistic model regression

Healthy food and behavioural changes as a function of income

The results showed that income is positively associated with healthy food consumption. The logistic regression results in Table 2 reveal that a high-income household ate 2.3 times more healthy food compared to a low-income household. The results also suggest no statistically significant differences regarding healthy eating between middle- and high-income households and low-income households. Every table of results includes the coefficient β (Coef.), the standard error that evaluates the average difference from the regression line (Std. error) and the p-value associated with the probability of rejecting the null hypothesis (H_0: $\beta = 0$). The Factor column indicates the odds ratio of results given by $\frac{p}{1-p}$. The general effect of income on healthy eating habits was statistically significant and is evaluated by the Wald test (0.033), appended in the last column of every table. The Wald test examines if the estimated parameters in a model are equal to a specific value. In the null hypothesis case, the test evaluates if the parameters are equal to or different than zero. If the test fails to reject the null hypothesis, removing the variables from the model does not significantly affect the fit of the model (Diggle et al. 2002; Hosmer Jr et al. 2013).

Table 2 also includes the results of behavioural changes of households during the pandemic, using income as a predictor of such changes. For the latter, Table 2b households may start a diet that could help enhance their immune systems. Table 2b indicates that the decision to start or maintain a diet during the lockdown did not vary significantly across income categories either. The logistic regression results show that only the low-income group appeared to have significant variation with respect to the low-income group. Additionally, the Wald test indicated a significant overall association between diet decisions and income category.

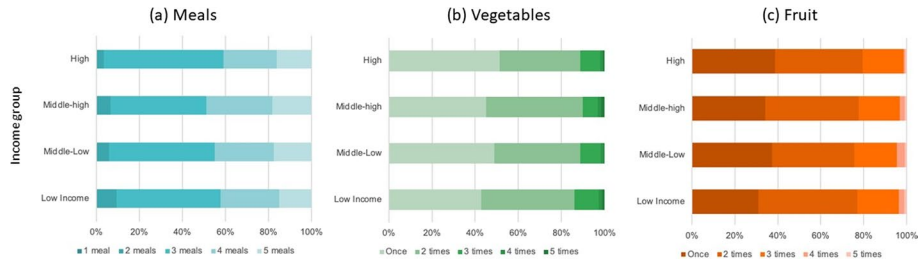

Fig. 2 Consumption of **a** meals and portions of vegetables **b** and **c** fruit per day during the pandemic according to income category

Table 3 Effect of on fruit and vegetables spending on the perception of healthy eating habits

Variable	Coef	Std. error	Pr(|z|)	Factor	Wald test: P(> X)
Intercept	0.2647	0.2314	0.25733	1.3030	3.1e−08
$5–$9.99	0.4651	0.2715	0.090907	1.5921	
$10–$19.99	1.2190	0.2854	1.94e−05***	3.3837	
$20–$29.99	1.6466	0.3290	5.58e−07***	5.1893	
$30–$39.99	2.2176	0.6434	0.000477***	9.4651	
$40–$49.99	1.6448	0.5836	0.004826**	5.1802	
$50 or more	1.8147	0.7849	0.020773*	6.1395	

Significance levels Pr(|z|): 0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

P(> X): *p*-value associated to the Wald test statistic

The third behavioural change corresponds to changes in household eating habits. Table 2b indicates that economic status had a less clear relationship with changes in eating habits during the lockdown. Higher earnings were not associated with a well-defined shift in eating habits during the lockdown in Ecuador. The Wald test also demonstrated that income is a predictor that failed to explain differences in eating habits.

Healthy dietary behaviours and fruit and vegetable spending

Figure 2 presents a visual summary of the number of meals (2a) and number of times fruit and vegetables were eaten (Fig. 2b and c, respectively) per day. Of the respondents, 48.7% and 27.7% indicated eating three and four meals daily. Regarding the number of times fruit was consumed per day, 34.7% and 42% of respondents consumed it once or twice, respectively. For vegetables, 46.4% and 41.7% consumed them once or twice, respectively. According to economic income, approximately 50% of the low-middle and high-income groups consumed vegetables once per day, while 45% of the low- and high-income groups ate fruit twice daily.

In connection with Fig. 2, Table 3 summarises the results regarding the effect of fruit and vegetable spending on the respondents' belief that they had healthy eating habits. Spending 5.01–10 USD weekly on fruit and vegetables was related to a 1.6 increase in this belief versus spending the minimum amount, that is, 5 USD or less. The odds of a respondent believing that they had healthy eating habits increased by 3.4 when fruit and vegetable spending increased to 10.01–20 USD. These results suggest that the maximum gain in a healthy-eating belief is reached by spending 30.01–40 USD, for which the

Table 4 Fruit and vegetable consumption per day during the pandemic according to income category

Variable	Coef	Std. error	Pr(|z|)	Factor	Wald test: P(> X)
a Fruit consumption per day					
Intercept	0.8008	0.1148	3.01e−12***	2.22727	0.23
Low middle	−0.2838	0.1595	0.0752	0.7529	
High middle	−0.144	0.1768	0.4153	0.86588	
High	−0.3736	0.207	0.0983	0.7102	
b Vegetable consumption per day					
Intercept	0.28933	0.10726	0.00699**	1.33552	0.23
Low middle	−0.24334	0.15167	0.10863	0.784	
High middle	−0.09358	0.16710	0.57545	0.91066	
High	−0.34568	0.19924	0.08274 .	0.70774	

(***) significance at 0.1% ; (**) significance at 1% ; (.) significance at 10%

P(> X): *p*-value associated to the Wald test statistic

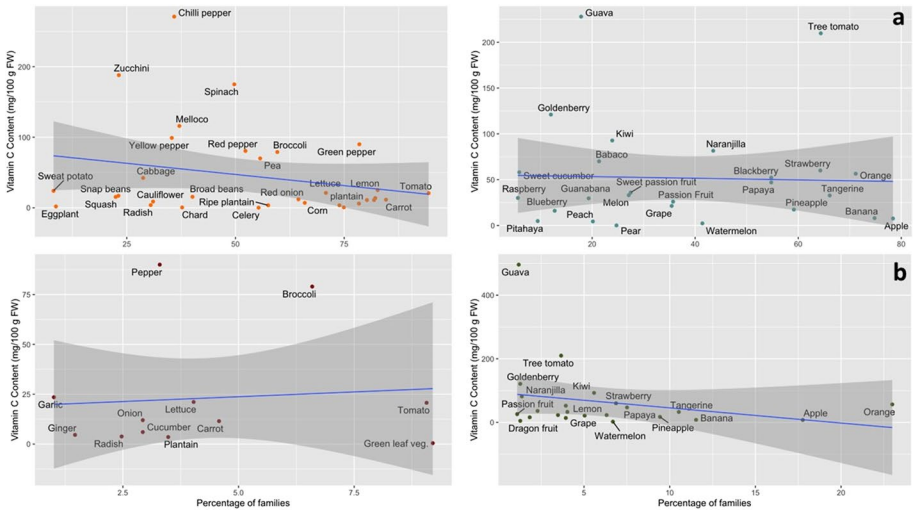

Fig. 3 **a** Regular and **b** new consumption of fruit and vegetables during the pandemic

belief increased by 9.5-fold in comparison to the minimum spending level. The Wald test showed that the overall effect was statistically significant.

Daily fruit and vegetable consumption and products eaten

Table 4 indicates the probability of increased fruit consumption per day based on income category. The null hypothesis—that changes in daily fruit consumption (Table 4a) are influenced by income level—was not rejected for any income categories, which means there was no statistical evidence of a significant influence of income level on increased fruit consumption. A similar result holds for vegetable consumption, as shown in Table 4b. In both cases, the *p*-value associated with the Wald

test suggested that the overall models failed to explain changes in fruit and vegetable consumption as a function of income categories.

Figure 3 presents the percentages of households that consumed vegetables (3a) and fruit (3b) before COVID-19. The most frequently consumed types of fruit were apples (78%), bananas (74%), oranges (71%), tangerines (66%), tree tomatoes or tamarillos (*Solanum betaceum*), strawberries (64%), pineapples (59%) and blackberries and papayas (55%). Other types of fruit had values of less than 50%, including naranjillas, passion fruit, kiwis, blueberries and goldenberries. Regarding vegetables, 94% of households ate tomatoes, followed by carrots (84%), lemons and avocadoes (82%), potatoes (81%), white onions (80%), green peppers and cucumbers (78%), spring onions (74%), green plantains (73%) and lettuce (70%). Other less consumed products were corn, broccoli, peas, radishes, courgettes and ripe plantains.

With the pandemic, families began to consume new products. Figure 3 shows the change in consumption patterns for fruit and vegetables after the pandemic began. A relatively small proportion of families began to consume new vegetables. For instance, 9% started consuming green leafy vegetables (chard, spinach and celery) and a similar proportion for tomatoes. Only 6.6% of those surveyed started eating broccoli and less than 5% started eating carrots, lettuce, plantains, peppers, cucumbers, onions and radishes. Fewer than 2% of households began consuming garlic and ginger. The visualisation shows that a small proportion started consuming new fruit that is not necessarily rich in vitamin C. Oranges were the most consumed new fruit (22% of those surveyed), followed by apples (17.7%), bananas (11%) and tangerines (10.5%). Products such as pineapples, papayas, kiwis, grapes, tree tomatoes and citrus fruit accounted for less than 10%. Blueberries, naranjillas, goldenberries and pitayas (dragon fruit) represented approximately 1% each. Also, fresh fruit consumption was led by two types: apples and oranges and less than 5% of families started consuming guavas, golden berries, tree tomatoes, lemons, naranjillas and passion fruit.

Overall, the results suggest no income level was significantly associated with increased fruit and vegetable consumption. Table 5 presents the logistic regression results showing that no income group had a statistically significant relationship to explain the increase in fruit and vegetable consumption. As highlighted in the results table, all categories of income have coefficients that are not statistically significant and the Wald test also suggested that the model failed to pass the overall joined test of significance.

Table 5 Increase in consumption of vegetables and fruit during the pandemic according to income category

Variable	Coef	Std. error	Pr(|z|)	Factor	Wald test: P (> X)
Intercept	0.9222	0.1176	4.52E−15***	2.51485	0.33
Low middle	−0.1102	0.1653	0.5049	0.89561	
High middle	−0.2654	0.1786	0.1373	0.76687	
High	−0.3736	0.2102	0.0755 .	0.68822	

(***) significance at 0.1% ; (.) significance at 10%

P(> X): *p*-value associated to the Wald test statistic

Discussion

This section discusses the study's most important results and highlights the current mismatch between families' perceptions and practical responses during the emergency. Also, this section emphasises the importance of the nutritional value of diets for preparation against health emergencies beyond income. This study obtained results that deserve to be analysed individually, considering the families' particular socioeconomic conditions. The results indicate, for example, that some families, mainly low- and high-income families, experienced a change in eating habits during the lockdown period that depended on their income, while the middle class did not change practices in a statistically significant manner. Additional factors, such as educational level, particularly of the mother, nutritional education and access to fresh products, may be critical to changing food habits.

Although vital, household income is not the only deciding factor for changing purchasing habits. Food is considered a normal good in economics: consumption increases when income increases. For example, for a household with a 10% income increase, meat intake increases by 10% (Zhang et al. 2018). COVID-19 led to a drop in individual income of over 9% between 2019 and 2020 in Ecuador, the most substantial income drop in real terms since the 1990s (Caribbean 2020). Unemployment also rose from 3.8 to 4.9% during the same period. Households' responses to these losses varied; some directly reduced food consumption, for instance, by eating vegetables four days per week instead of the pre-pandemic seven days.

Another response could be substitution, that is, increasing the consumption of alternative, generally lower-priced food. These goods, bought as ready meals or cooking ingredients, may be of lower nutritional quality, such as high-carbohydrate food like rice, potatoes and pasta or convenience food (Belik 2020). If households switched to eating more low-price staples, their capacity to change to more healthy eating habits was limited. Thus, this period of economic hardship may have led to fewer households following healthy eating habits, mainly in the low-income category. The results from this study support this argument. Access to healthy food is another factor that deserves attention. During the lockdown period, families limited visits to supermarkets and local street markets due to the fear of contagion and government restrictions. Indeed, Janssen et al. (2021) found that fruit and vegetable consumption decreased owing to mobility restrictions and lack of access to supermarkets. Ben Hassen et al. (2020) also observed that reduced exports negatively impacted access to healthy food. Conversely, Di Renzo et al. (2020) Górnicka et al. (2020) and Sidor and Rzymski (2020) observed that people with healthy pre-pandemic diets did not change their habits despite agricultural supply chain problems in Poland and Italy.

Another critical result of this study is that the probability of beginning or maintaining a diet during the pandemic was unrelated to the income category and additional decision variables were determinants (Table 2). Priority strategies to fight COVID-19 were not focused on diet, rather the most immediate and most affordable strategy was mask wearing and social distancing, as also pointed out by Skrajnowska et al. (2021).

Working from home also shaped eating decisions. During the lockdown in Ecuador, 40% of respondents went from working in-person to online (Table 1). This change might have increased the number of online working hours online, which could have reduced

time spent on food preparation. Belik (2020) indicates that even though home cooking increased, the effect on the families' nutritional status was not well defined after the lockdown. One may argue that with no commuting time, people had more time to prepare food, but more research is needed to explore an answer for the case in Ecuador. The results also indicate that it was difficult for respondents to eat the number of WHO-recommended meals per day: approximately one in six people ate five meals per day, one in four ate four and one in two ate three. The nutritional recommendation is four to five meals per day (Azcona 2013), including five servings of fruit and vegetables. Frank et al. (2019) and Siegel (2019) highlight the need for policies to promote the consumption of fruit and vegetables, especially at early ages, to prevent non-communicable diseases.

Analysing changes in eating habits according to a household economic stratum is one of this study's most important original contributions. Nevertheless, more complex and long-term mechanisms also generate changes in eating habits, for example, education level, age and time dedicated to food preparation. Household income is critical, but it is not the only factor determining household nutrition.

Households who purchased more fruit and vegetables tended to perceive that they had healthier eating patterns. When fruit and vegetable spending was 10–20 USD per week, the respondents' belief that they had healthy eating habits was 3.4 times higher. If the household spent between 30 and 40 USD, the respondents' belief that in having healthy eating habits was 9.47 times higher (Table 4). Darmon and Drewnowski (2008) found that low-income individuals are less likely to report healthy eating habits and that better-quality diets are, in general, consumed by better-educated and higher-income individuals.

The importance of the nutritional value of diets for preparation against health emergencies beyond income should also be emphasised. At the beginning of the pandemic, the FAO and WHO recommended consuming nourishing food as a complementary strategy to strengthen the immune system and fight COVID-19 (De Faria Coelho-Ravagnani et al. 2021; Liu 2013). It is recommended to increase the intake of plant-based foods rich in vitamins, minerals, fibre, protein and antioxidants, such as fruit, vegetables, seeds, whole grains, honey and ginger (Khoramipour et al. 2021). Our results show that apples, bananas, tomatoes and carrots were the most consumed fruit and vegetables during the lockdown. Apples (*Malus domestica*) contain vitamins C and E, beta-carotene, calcium, iron, potassium and zinc, as well as bioactive compounds like polyphenols, polysaccharides, phytosterol and triterpenes. Bananas (*Musa cavendish*) have high potassium, calcium, magnesium, sodium, phosphorus and fibre contents. Tomatoes (*Solanum lycopersicum*) are an essential source of vitamin C, potassium, folic acid and carotenoids such as lycopene. Finally, carrots (*Daucus carota*) are high in provitamin A, fibre, minerals (e.g. molybdenum [involved in iron absorption], magnesium and manganese), flavonoids (e.g. kaempferol, quercetin and luteolin) and other phenols. Consuming these products increases antioxidant, anticarcinogenic and immunomodulatory effects in the body and they reduce the risk of developing obesity, hyperglycaemia, hypercholesterolemia and cardiovascular disorders (Da Silva Dias 2014; Oyeyinka and Afolayan 2019; Patocka et al. 2020; Perveen et al. 2015).

In addition, fruit such as oranges, tangerines, lemons, tree tomatoes (*Solanum betaceum*), strawberries, pineapples and blackberries have high vitamin C content. This

compound is the main micronutrient associated with strengthening the immune system (Alarcon-Barrera et al. 2018; Ali et al. 2020; Ganhão et al. 2019; Maugeri et al. 2019; Singh et al. 2021). Oranges stand out for their hesperidin content, a flavonoid with antiviral, antioxidant and infection-modulating properties, which binds to the key proteins of the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (Bellavite and Donzelli 2020).

Highly consumed vegetables included avocadoes, potatoes, white onions, peppers, cucumbers and plantains. Avocadoes (*Persea americana*) are characterised by their content of potassium, beta-carotene, tocopherol, retinol and ascorbic acid (Bhuyan et al. 2019). Potatoes (*Solanum tuberosum*) are a source of starch and are low in fat in addition to providing high-quality protein, dietary fibre, polyphenols, minerals and vitamins, mainly vitamin C (Liang et al. 2019; Tierno et al. 2016). White onions (*Allium cepa*) contain vitamins B and C and traces of iron and calcium (Sunusi and Gambo 2019). Peppers (*Capsicum annum*) are especially valued for their high vitamin C content and other antioxidant micronutrients, such as vitamin E and carotenoids. Cucumbers (*Cucumis sativus*) contain good levels of thiamine, niacin, vitamin C, phosphorus, iron, calcium and potassium (Soare et al. 2017). Raw and cooked plantains (*Musa paradisiaca*) have a high content of resistant starch, polyphenols (when cooked) and minerals, such as phosphorus, potassium and sodium. Thus, the chemical composition of these products gives them antioxidant, anticancer, anti-inflammatory and antimicrobial properties (Borges et al. 2020; Liang et al. 2019; Satpal et al. 2021; Soare et al. 2017; Sunusi and Gambo 2019; Tierno et al. 2016; Uthpala et al. 2020).

In terms of fruit, another significant finding from the survey is that households began to consume more kiwis (*Actinidia deliciosa*) and grapes (*Vitis vinifera*). These are high in vitamin C, dietary fibre and phytochemicals, such as flavonoids and anthocyanins, and also have antimicrobial, antiviral and immunomodulatory properties (Satpal et al. 2021; Isci et al. 2015). Additionally, watermelons (*Citrullus lanatus*) and papayas (*Carica papaya*) are both extensively grown in Ecuador and are important sources of bioactive compounds, such as lycopene, citrulline, unsaturated fatty acids, polyphenols and vitamin C (Alara et al. 2020; Zamuz et al. 2021).

Regarding vegetables, households began eating broccoli, ginger and garlic. Broccoli (*Brassica oleracea*) has high nutritional value and is a source of vitamins C, A and E. It contains polyphenols, flavonoids, carotenoids, sulforaphanes, glucosinolates, selenium, zinc, potassium, sodium and phosphorus. Glucosinolates have bactericidal, fungicidal and anticancer properties (Nagraj et al. 2020). Ginger and garlic are traditional remedies used to treat colds (Imo and Za'aku 2019). Ginger (*Zingiber officinale*) contains calcium, iron, magnesium, manganese, phosphorus, zinc and a high concentration of polyphenols that contribute to its antioxidant activity (Shahrajabian et al. 2019). In vitro studies have been conducted using ginger combined with other medicinal plants.

Garlic (Allium sativum) is one of the most efficient natural antibiotics against a variety of viruses and bacteria. It contains organosulfur compounds (allicin and alliin) and flavonoids (quercetin), which have immunomodulatory effects. The daily consumption of garlic and derived products is recommended to complement therapies that can improve the side effects and toxicity of COVID-19 medications and reduce the necessary dose (Khubber et al. 2020). Further, garlic bioactive compounds can potentially decrease

proinflammatory cytokine activity and revert immunological abnormalities to an acceptable level (Donma and Donma 2020).

Echinacea (*Echinacea angustifolia*), moreover, has been tested for treating clinical symptoms of COVID-19 patients (Mesri et al. 2021). Its combination with citron or lemon citron (*Citrus medica*) has a significant impact on the spike protein of the SARS-CoV-2 virus and the angiotensin-converting enzyme receptor in the host. Nevertheless, more studies are needed to determine its efficacy in humans in mitigating COVID-19 (Mesri et al. 2021).

Just 1% of those surveyed began consuming vegetables, such as broccoli, and fruit, such as goldenberries (*Physalis peruviana*), naranjillas (*Solanum quitoense*) and guavas (*Psidium guajava*). Locally, these products are infrequently sold and consumed, but goldenberry and guava producers have sought alternative export markets, mainly the United States and Europe (Andrade-Cuvi et al. 2017). These products are characterised by a high content of phytochemicals, vitamins, minerals and fibre and are beneficial for health because of their antioxidant and immunomodulatory activity. These kinds of fruit contain vitamin C with values comparable to or higher than that of oranges (Carrillo-Perdomo et al. 2015), but their nutritional value is poorly promoted.

Finally, Ecuador has made reasonable efforts to reduce malnutrition, but it remains as a public health challenge. Households have limited nutritional education. It is fundamental to develop public policies focused on nutritional education to promote the benefits of consuming fresh fruit and vegetables as part of a healthy lifestyle and, more importantly, as an effective approach for health emergency preparedness to events like COVID-19.

Conclusions

This study of urban household eating habits during the lockdown in Ecuador found a positive association between household income and the perception of a healthy diet. However, the results were not consistent for all income groups. Income explained changes in fruit and vegetable consumption for low- and high-income households but did not for the middle-income group. Additionally, the changes in eating habits did not correspond to an increase in fruit and vegetable consumption, nor were they related to the number of daily meals or recommended servings of fruit and vegetables. Income does not explain differences in the frequency of meals or intake of fruit and vegetables per day. However, the consumption of fruit and vegetables with high vitamin C content, such as oranges, tangerines, lemons and tomatoes, increased. New fruit and vegetables started to be consumed during the pandemic but the newly chosen items did not have the highest levels of vitamin C content. The study highlights the need for nutritional education as part of the formal educational curriculum in Ecuador, since it is essential to educate parents and students regarding the number of meals, daily fruit and vegetable servings and consumption of nutritious locally produced food to promote healthy habits and help prepare for infection-related emergencies like COVID-19. The findings in this research constitute a basis for the development of subsequent studies that relate the practice of consuming fruit and vegetables to various aspects, such as level of education and a healthy lifestyle (BMI, physical activity and mental health). Finally, the study also suggests that households that spend $30 to $40 per week on fruit and vegetables

experience the largest gain in healthy lifestyle perception. This study contributes two novel implications for academic literature. Firstly, contrary to the increase of expected economic conditions, income does not explain differences in healthy eating habits for the urban population in Quito, Ecuador. Secondly, households increased their fruit and vegetable consumption during the pandemic. Still, this emerging consumption seemed to be uninformed due to a lack of knowledge about the best options for high vitamin content.

On the other hand, one limitation of this study was the respondents' beliefs about healthy eating habits due to stressful conditions during confinement. Additionally, the survey included only the urban population in the capital. Lastly, further research is needed to compare the behavioural response of consumers in a post-lockdown period to establish whether lifestyle changes remained temporary or permanent.

Abbreviations

FV Fruit and vegetables
WHO World Health Organization
FAO Food and Agriculture Organization

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CM contributed to investigation, data curation, methodology, and writing. MJAC and CM were involved in conceptualisation, writing, reviewing, and editing. All authors read and approved the final manuscript.

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The data that support the findings of this study are available on request from the corresponding author.

Declarations

Competing interests
The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this research.

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