

Impact of Nationwide Lockdowns Resulting from the First Wave of the COVID-19 Pandemic on Food Intake, Eating Behaviors, and Diet Quality: A Systematic Review

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ABSTRACT

The lockdowns resulting from the first wave of the coronavirus disease 2019 (COVID-19) pandemic impacted deeply on all life activities, including diet. We performed a systematic review to investigate changes in food intake, eating behaviors, and diet quality during lockdown as compared with before the lockdown. A literature search was performed using 3 electronic databases from inception until 13 June 2021. Observational studies evaluating changes in general populations during the COVID-19 pandemic lockdown were eligible. Of 1963 studies retrieved from the search strategy, 95 met inclusion criteria (85 in adults, 10 in children/adolescents), and the majority were of high quality (72.6%). Most of the studies were web-based surveys using convenience sampling, mainly focused on variations in the consumption of foods and eating behaviors during lockdown, whereas only 15 studies analyzed diet quality through dietary indices. On the basis of the definition of a healthful diet as reflected by a traditional Mediterranean diet, an increase in recommended foods such as fruit and vegetables, legumes, cereals, and olive oil was observed, although a sharp decrease in fish intake and an increase in dairy products were documented. Accordingly, a reduction in foods that should be eaten less frequently was reported—namely, red and processed meat. However, a higher consumption of unhealthy foods (e.g., snacks and sweets) was also observed. Results indicated improved diet quality in Europe, especially among Mediterranean countries, with the exception of France, while a switch to poor nutrient patterns was observed in Colombia and Saudi Arabia. Analyses of eating behaviors suggest an increase in food intake, number of daily meals, and snacking. In conclusion, changes in intake of major food groups, apart from fish intake, were in line with the definition of a traditional Mediterranean diet, indicating a consistent moderate improvement in dietary habits worldwide. This review protocol was registered at <https://www.crd.york.ac.uk/prospero/> as CRD42020225292. *Adv Nutr* 2022;13:388–423.

Statement of Significance: This is the first systematic review to conduct a comprehensive analysis of changes in different aspects of nutrition during the COVID-19 nationwide lockdowns. The present study summarizes evidence from studies published until the first half of 2021.

Keywords: diet quality, dietary changes, eating behaviors, lockdown, confinement, COVID-19, pandemic

Introduction

The coronavirus disease 2019 (COVID-19), induced by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), is a severe respiratory infectious disease that broke out in China in December 2019, and rapidly spread around the world; hence, in March 2020, the WHO Emergency Committee declared a pandemic state (1).

Worldwide governments considered social isolation as the most successful way to limit the infection spread, so many

countries enacted lockdown (also called confinement, stay-at-home, shelter in place, etc.) strategies, limiting access to only essential services in order to flatten the curve of new infections and to prevent the collapse of health care systems (2, 3).

Confinement measures included working from home, digital education, travel ban, and closure of nonessential shops and services, and all nonessential workers were invited to stay home.

The COVID-19 lockdown deeply changed lifestyles of communities, thus having considerable impact on physical and mental health, and on social and economic aspects (4).

Limited access to food due to restricted store opening hours, as well as reduced availability of goods and more time spent at home, could have had effects on food purchasing and preparation and as a result on diet quality (5). Moreover, boredom and feelings of anxiety, triggered by such an adverse scenario, could have impacted food choices, leading to irregular eating and more frequent snacking (6, 7).

Unhealthy diets and concurrent decline in physical activity could negatively affect health status, potentially leading to an increase in obesity and other risk factors (8), which, in turn, may raise vulnerability to complications of COVID-19 (9).

It is well recognized that the maintenance of healthy eating behaviors is fundamental to enhance health. In fact, a balanced nutritional pattern could boost the immune system (10) through both intake of anti-inflammatory nutrients (11) and consumption of food items fermented by gut microbiota providing metabolic compounds involved in homeostasis of the inflammation process (12). Therefore, it is crucial to understand whether the lockdown period may have had an impact on diet quality, and to what extent such modifications may have long-term effects on health at a population level.

To date, there have been several studies worldwide investigating the impact of lockdown resulting from the first wave of the COVID-19 pandemic on dietary changes, although results are mixed; also, the dietary assessment varies largely across studies and, most importantly, a comprehensive assessment of changes in diet quality as reflected by variations in validated dietary indexes is often lacking. A few available reviews of the literature (either systematic or scoping) (13–16) analyzing from 7 to 32 articles published in the year 2020 are concordant in indicating an increase in snacking, meal number, and home cooking, as well as a rise in fruit and vegetable intakes, although data on modification of other foods (e.g., alcohol intake) were conflicting.

Given the mounting evidence on the relation between lockdown and dietary modifications well after the year 2020 and the pivotal role of diet as a major health determinant, we conducted a systematic review of the literature examining the impact of lockdown caused by the COVID-19 pandemic on dietary habits compared with before the pandemic outbreak.

For this purpose, we considered studies that examined variations in 3 main research themes that pertain to diet—that is, 1) changes in food (i.e., foods or food groups) and beverage intake, 2) eating behaviors (e.g., snacking, amount of food eaten, home cooking), and 3) overall diet quality (i.e., assessed through the use of dietary indices).

Methods

This study was conducted according to the recommendations outlined in the Cochrane Handbook for Systematic Reviews of Interventions (17) and adhered to the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) statement (18). The protocol was registered in PROSPERO at <https://www.crd.york.ac.uk/prospero/> as CRD42020225292. Institutional review board approval was not required, as the study did not directly involve human participants.

Search strategy

Electronic databases (PubMed, Web of Science, Google Scholar) were searched to identify all reports regarding 3 main interrelated concepts: diet, COVID-19, and lockdown (**Supplemental Table 1**). A systematic literature search was performed from inception until 10 March 2021, followed by an updated search through 13 June 2021. The following terms were searched with the widest field restriction possible in PubMed and Web of science (i.e., all fields) and with restrictions to all-in-title in Google Scholar: (Diet OR Nutrition OR Food OR “Eating habits” OR “Dietary changes” OR “Dietary behaviour” OR “Mediterranean diet”) AND (Coronavirus OR “Covid” OR “SARS-CoV-2” OR “COVID-19”) AND (lockdown OR confinement OR “shelter in place” OR “stay at home” OR isolation OR “covid restrictions” OR quarantine). A more exhaustive search strategy list for each database is provided in **Supplemental Table 2**.

Study selection

Studies were eligible if they met the following inclusion criteria: 1) outcomes were changes in food and beverages consumption, eating behaviors, and overall diet quality; 2) subjects recruited were from general populations of adults and children; 3) exposure was nationwide lockdown resulting from the first wave of the COVID-19 outbreak as compared with before the lockdown; 4) observational cross-sectional, case-control, cohort, and longitudinal studies; and 5) English-language research articles. A detailed design is summed up in **Supplemental Table 3**, by following the PICOS (Population, Intervention, Comparison, Outcome, Study) format.

Exclusion criteria were as follows: 1) no alterations in eating (i.e., changes in food intake or eating behaviors or diet quality were reported; 2) dietary changes not examined during lockdowns; 3) special populations (e.g., subjects on special diets or with pre-existing disease/health conditions; pregnancy; university students); 4) randomized clinical trials, reviews, meta-analyses; and 5) articles not in English. Restrictions in terms of language were applied due to authors' inability to translate non-English-language studies.

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Abbreviations used: AHEI-2010, Alternate Healthy Eating Index–2010; COVID-19, coronavirus disease 2019; HEI-2015, Healthy Eating Index–2015; JBI, Joanna Briggs Institute; KIDMED, Mediterranean Diet Quality Index for children and teenagers; MEDAS, Mediterranean Diet Adherence Screener; PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

Search results from each database were initially exported to Mendeley®, provided by Elsevier, and duplicates were identified and discarded. Thereafter, records were manually screened for titles and abstracts, and nonconforming ones were excluded. Full-text articles were checked for eligibility criteria, and references of included studies were manually screened to obtain additional papers.

Data extraction and quality assessment

Two authors (CM and MB) screened and reviewed articles in line with inclusion criteria. From each study, the following information was extracted: name of first author and year of publication, country, recruitment period, sample size, age, data collection and study design, dietary assessment, main findings, and authors' interpretation of main findings. Data were grouped according to the 3 main research themes (reported changes in food intake, eating behaviors, and diet quality) and analyzed for adults and children separately. Two authors (CM and MB) independently evaluated the methodological quality of the included studies, with disagreements being solved by discussion with a third investigator (SC). Due to heterogeneity in experimental designs of extracted data, it was not possible to perform meta-analysis.

The quality of included studies was evaluated by using the Joanna Briggs Institute (JBI) Critical Appraisal Checklists for Analytical Cross-Sectional Studies and Cohort Studies (19) (Supplemental Tables 4 and 5).

Results

Search results

The initial systematic search of databases identified 1963 potentially pertinent articles, and among them 252 were excluded since they were duplicates. After reviewing titles and abstracts, 1556 papers were further excluded since they were not related to changes in dietary habits during the COVID-19 lockdown. In this selection, papers aiming not to specifically investigate nutritional changes were considered whenever they described or evaluated alterations in lifestyle habits. After that, 155 full-text articles were reviewed and 60 were excluded according to the inclusion criteria. The full PRISMA record management flow diagram is shown in Figure 1.

Finally, 85 articles in adults and 10 in children/adolescents were selected for this systematic review. Subsequently, studies in adults were grouped into 3 main research themes, according to changes in the following outcomes: 1) consumption of food and beverages (Figure 2, Table 2), 2) eating behaviors (Figure 3, Table 3), and 3) overall diet quality as assessed by dietary indices (Table 4). For studies evaluating dietary changes in children/adolescents, an independent assessment was carried out (Table 5).

Studies were mostly carried out in Europe, with the highest number recorded in Italy (4, 20–30) and Spain (31–37) followed by Poland (38–43), France (44–48), the United Kingdom (49–53), Belgium (54, 55), Greece (56, 57), The Netherlands (58), Denmark (59), Croatia (60), Romania

(61), Albania (62), Lithuania (63), Scotland (64), Cyprus (65), and Germany (66). Outside Europe, other surveys were conducted in Kuwait (67), the United Arab Emirates (68, 69), Saudi Arabia (70–73), Jordan (74, 75), Iraqi Kurdistan (76), the United States (77–80), Canada (81), Brazil (82–84), Mexico (85), Colombia (86), Chile (87), Ecuador (88), Uruguay (89), Peru (90), Zimbabwe (91), China (92–95), India (96, 97), Nepal (98), New Zealand (99), and Australia (100, 101). Other studies were conducted as international surveys (102–113). The length of nationwide lockdowns varied across countries, with the longest recorded in the United Kingdom (112 d) and Nepal (120 d) and the shortest in Kuwait and Ecuador (15 d), Iraqi Kurdistan and Cyprus (20 d), and the United Arab Emirates (22 d) (Table 1).

Due to pandemic status limitations, with difficulty in performing person-to-person questionnaires or interviews, all of the studies included data collected through online questionnaires or, on a few occasions, through telephone or web interviews (22, 23, 25, 31, 56).

Most of the studies were carried out during the first 3 mo of lockdown (March to May 2020), when containment measures were stricter worldwide. Otherwise, the recruitment period of some surveys lasted until September (23, 25, 113) (Table 1).

Concerning quality assessment, 26 studies out of 95 (20, 27, 30, 38, 40, 43, 51, 61, 62, 71–73, 75, 83, 84, 90, 91, 95, 97, 98, 100, 102, 104, 106, 112, 113) were considered of low quality (27.4%), having a JBI score <70% (Supplemental Tables 4 and 5).

Change in food and beverage intakes in adults

A total of 76 studies reported differences in consumption of foods and beverages mainly by asking participants to indicate whether their consumption of selected foods and beverages had changed during lockdown as compared with before, mostly in the form of eating less/more/the same of a given food or beverage, with some exceptions otherwise inquiring about changes in frequency of consumption (49, 51) or modifications in line with dietary recommendations (27) (Tables 1 and 2).

With regard to changes in food intake, increased consumption of fruit and vegetables was reported by 31 studies (20, 22, 25, 27, 29, 32, 33, 35, 45, 49, 52, 54, 60–63, 65, 71, 76, 83, 87, 89, 90, 92, 94–96, 103, 111, 113), whereas a decrease was found in 8 studies (59, 73, 77, 82, 86, 91, 99, 110). However, some (4, 26, 81) found an increase only in vegetable consumption, as opposed to a decrease in fruit intake, while a French study (44) found a decrease in fresh fruit and vegetable consumption but an increase in canned and frozen vegetables. Others found an increase (43) and a decrease (41, 42) only in fruit. Increases of fruit intake went from 15.2% to 73.5%, whereas increases in vegetables were in the range 11.9% to 52.0%.

Sharp changes were observed also for legumes, with 17 studies registering increased consumption from 10.9% to 21.9% (4, 25, 26, 33, 41, 42, 44, 45, 60, 65, 76, 86, 89, 90, 95, 96, 111); in contrast, a reduction from 9.9% to 25.9% was

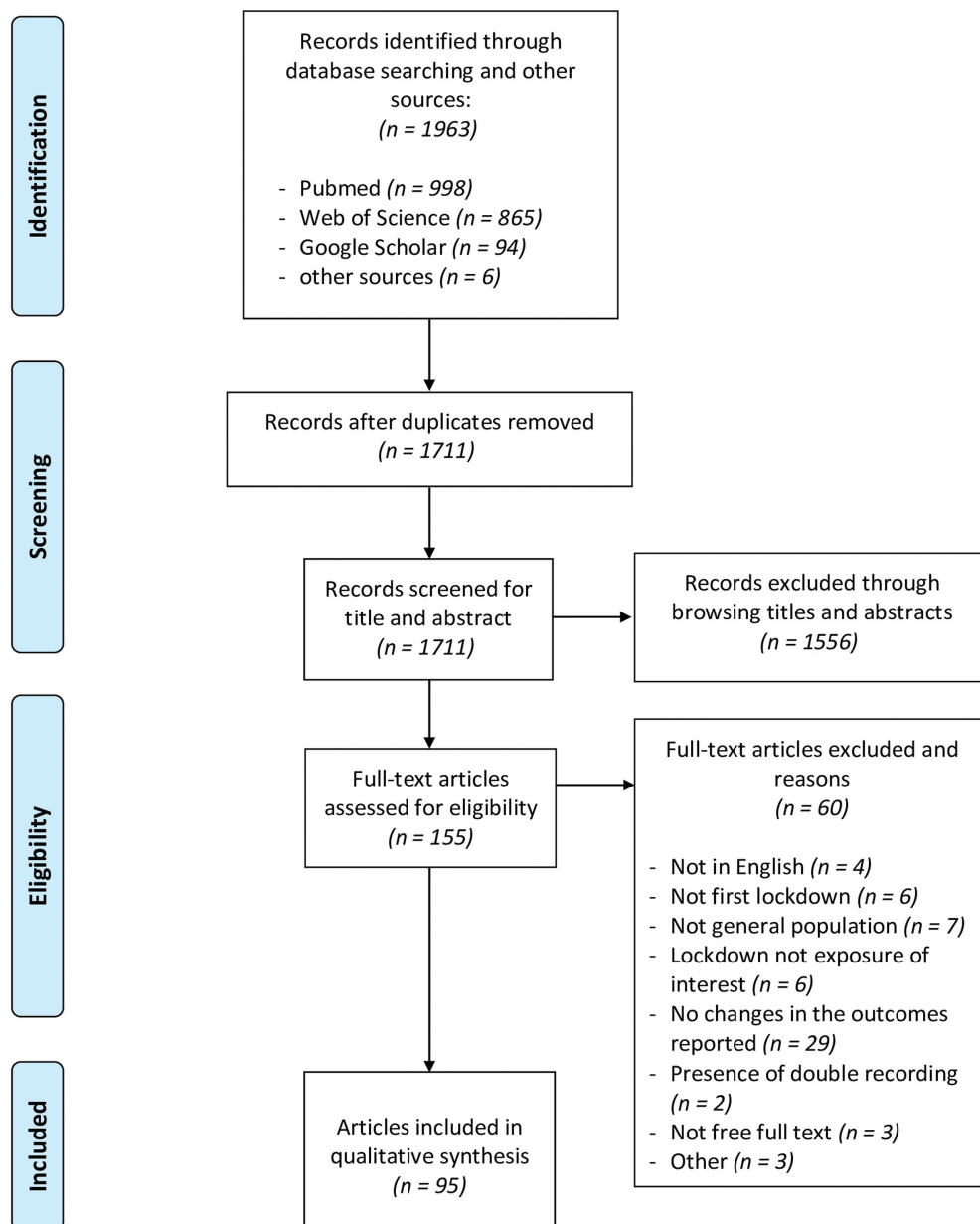


FIGURE 1 PRISMA flow diagram of the search procedure. PRISMA, Preferred Reporting Items for Systematic Reviews and Meta-Analyses.

observed in only 4 of the included studies (22, 59, 82, 99). An increase in red and processed meat consumption from 20.0% to 51.1% was reported by 14 investigations (4, 22, 31, 33, 35, 38, 43, 45, 61, 62, 77, 95, 96, 113), whereas 17 studies pointed to a decreasing consumption from 6.7% to 24.4% (20, 23, 25, 26, 32, 41, 42, 44, 59, 60, 63, 65, 76, 78, 90, 110, 111). Olive oil was consistently found to be increased from 12.4% to 12.6% in all studies addressing this issue (25, 33, 60, 65, 111) As reported by 19 studies (4, 20, 22, 25, 32, 35, 41–44, 60, 63, 67, 76, 77, 86, 110, 111, 113), fish and seafood intakes significantly decreased from 9.4% to 31.3%; conversely, only 6 studies observed an increase (33, 45, 59, 65, 81, 95).

An increase from 7.7% to 51.0% was found for dairy product intake (e.g., yogurt, cheese) compared with

pre-lockdown levels (4, 20, 22, 25, 35, 41–45, 62, 65, 76, 78, 81, 92, 95, 113), whereas 4 studies (33, 77, 91, 110) pointed to a decrease from 21.4% to 44.9%.

Studies investigating cereal intake (e.g., pasta and rice, bread, flour, grains) reported an increased consumption of grains (4, 22, 25, 29, 35, 41–43, 45, 62, 77, 81, 86, 89, 99), and a lower intake of whole-grain products (65, 77, 99). A positive change was found in water consumption, which increased from 3.0% to 70.0% in all studies investigating this issue (23, 25, 41–44, 62, 68, 77, 78, 86, 89, 104, 113).

Unhealthy foods, such as fast food, junk food, and processed food in general, including energy and sweetened drinks, were likely consumed less during the pandemic as compared with the usual intake in 14 studies (4, 32, 42, 56,

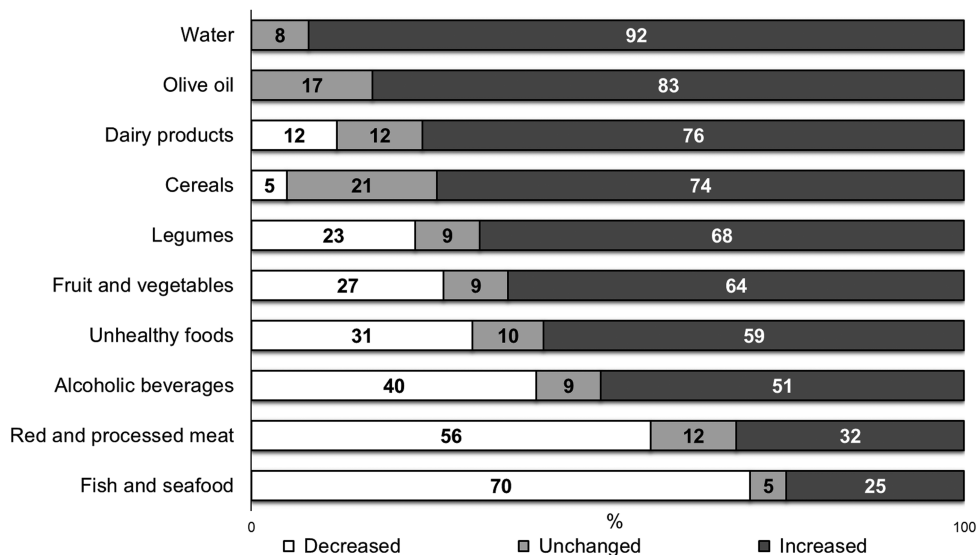


FIGURE 2 Percentages of high-quality and peer-reviewed observational studies from general adult populations reporting increased/decreased/unchanged consumption of food groups and beverages during the lockdown following the first wave of the COVID-19 outbreak as compared to before (corresponding number on the related bars). COVID-19, coronavirus disease 2019.

67, 68, 78, 89, 90, 96, 97, 104, 106, 111), although 33 studies found an increase (20–22, 26, 29, 31, 33–35, 40, 45, 47, 49, 50, 52, 54, 55, 58, 62, 65, 69, 71, 76, 77, 79, 82–84, 92, 95, 99, 102, 110). In addition, some investigations (23, 27, 38, 41, 43, 44, 59, 60, 63, 73, 86, 113) reported both an increase and a lower intake of unhealthy foods.

Reduced alcohol intake (12.1–57.3%) was reported by 17 studies (4, 20, 32, 35, 46, 55, 56, 60, 65, 76, 85, 96, 97, 98, 102, 106, 111), whereas 25 investigations observed an increase (14.6–81.2%) (22, 26, 31, 33, 34, 38–45, 47, 52, 59, 64, 66, 77, 80, 82, 91, 99, 110, 112).

Results were unchanged in a narrower analysis restricted to 51 high-quality-assessment studies. Indeed, an increase in recommended foods such as fruit and vegetables, legumes, and cereals was observed by 64%, 68%, and 74% of the studies, respectively, along with a sharp decrease in fish (70%). For foods that should be eaten less frequently, studies reported a decrease in red and processed meat (56.0%) while suggesting higher consumption of dairy products (76%) and unhealthy foods (59%) (Figure 2). Analyses of changes in food-group intakes by geographic areas revealed some differences between countries. Specifically, fruit and vegetable intake was found to be increased worldwide, although increases were more pronounced in European and Asian populations as compared with North American settings (Supplemental Figures 1–4). Unhealthy food consumption was higher during lockdown worldwide, with the exception of South America, where decreased, unchanged, and increased options were equally distributed. The greatest increase in alcoholic beverages was observed among Europeans and North Americans, whereas Asian studies reported exclusively a decrease. Red meat intake was sharply lowered in Europe but not in Asian and South American countries, whereas fish

and seafood intake was consistently found to be reduced. Last, consumption of dairy products increased markedly in Europe and North America while being less evident in Asian countries.

Change in eating behaviors in adults

Fifty-nine studies analyzed changes in eating behaviors, as reflected by amount of food eaten, home cooking, snacking, and consumption of take-away or delivered food (Table 3). The majority of study respondents reported to have increased the number of meals per day (23, 25, 34, 38, 49, 65, 68, 102, 104) and amount of food eaten (4, 20, 21, 24, 38–42, 49–51, 53, 61, 63, 70, 72, 78, 86, 87, 89, 100, 102, 106, 109). Additionally, during lockdown, home cooking increased (4, 23–25, 32–34, 39, 44, 45, 52, 59–61, 63, 67–70, 76, 86, 87, 99, 103, 104, 109, 111), home-cooked food was eaten more frequently (4, 22, 33, 41, 42, 68–70, 76, 85, 89, 99, 104, 111), and concurrent reductions in eating outside (32, 38, 44, 67, 68, 81, 103, 104), ready-made meals (20, 23, 25, 38, 68, 78, 103, 104), and consumption of take-away or delivered food (4, 25, 38, 40, 41, 70, 76, 78, 103) were observed. Of 59 studies, 17 documented increased snacking (32, 38, 39, 44, 46, 49, 50, 59, 60, 63, 67, 72, 78, 86, 102, 111, 112).

Results remained substantially the same when analysis was limited to 42 high-quality studies (Figure 3), confirming an increase in food intake (81%), number of daily meals (67%) and snacking (87%).

Analysis by geographic areas highlighted substantial similarities across countries worldwide for changes in eating behaviors, although the increase in the number of daily meals was less marked in Asian studies as compared with others (Supplemental Figures 5–8).

TABLE 1 Descriptive characteristics of included observational studies from general populations analyzing changes in food intake, eating behaviors, and diet quality during nationwide lockdowns resulting from the first wave of the COVID-19 pandemic¹

First author, year (ref)	Country	Nationwide lockdown timeline (length in days)	Survey period	Study design	Data collection	Dietary assessment	Sample size	Age (mean ± SD), y
Aguilar-Martínez et al., 2021 (37)	Spain	March 14/May 9, 2020 (56)	June–July 2020	Cross-sectional/retrospective	Web-based survey on DESK cohort participants	Changes by food quantity and frequency of eating behaviors	303	16.4 ± 1.11
López-Moreno et al., 2020 (34)	Spain	March 14/May 9, 2020 (56)	May 28–June 21, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	675	39.1 ± 12.9
Medrano et al., 2020 (36)	Spain	March 14/May 9, 2020 (56)	September–December 2019/March–April 2020	Longitudinal	Web-based survey	KIDMED	106	12.0 ± 2.6
Rodríguez-Pérez et al., 2020 (32)	Spain	March 14/May 9, 2020 (56)	From March 20, 2020, for 3 wk	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown MEDAS (score 0–14)	7514	≥ 18
Romeo-Arroyo et al., 2020 (35)	Spain	March 14/May 9, 2020 (56)	Last week of April 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	600	42.6 ± 12.2
Sánchez-Sánchez et al., 2020 (33)	Spain	March 14/May 9, 2020 (56)	May 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown MEDAS (score 0–14)	1065	38.7 ± 12.4
Sánchez et al., 2021 (31)	Spain	March 14/May 9, 2020 (56)	May 26–June 20, 2020	Cross-sectional/retrospective	Computer-assisted telephone interviews on a representative sample	Eating more/less/the same	1000	51 ± 18
Bonaccio et al., 2021 (23)	Italy	March 9/May 18, 2020 (70)	May–September 2020	Cross-sectional/retrospective	Telephone-based survey (Moli-LOCK cohort) and web-based survey on convenience sample (ALTRISCOVID-19 cohort)	Eating more/less/the same	2992	57.9 ± 15.3

(Continued)

TABLE 1 (Continued)

First author, year (ref)	Country	Nationwide lockdown timeline (length in days)	Survey period	Study design	Data collection	Dietary assessment	Sample size	Age (mean ± SD), y
Cancello et al., 2020 (21)	Italy	March 9/May 18, 2020 (70)	April 15–May 4, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	490	≥18
Cicero et al., 2021 (22)	Italy	March 9/May 18, 2020 (70)	February–April 2020 and after the quarantine	Cohort study; longitudinal	Telephone-based survey	Daily/weekly frequency before and during lockdown; DQI	359	64.6 ± 13.3
Di Renzo et al., 2020 (4)	Italy	March 9/May 18, 2020 (70)	April 5–24, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	3533	40.0 ± 13.5
Ferrante et al., 2021 (26)	Italy	March 9/May 18, 2020 (70)	April 21–June 7, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	7847	48.6 ± 13.9
Maffoni et al., 2021 (27)	Italy	March 9/May 18, 2020 (70)	April 30–May 10, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Dietary recommendations	1304	≥18
Mastorci et al., 2021 (28)	Italy	March 9/May 18, 2020 (70)	September–October 2019/April 2020	Longitudinal	Web-based survey	KIDMED	1289	12.5 ± 1.2
Prete et al., 2021 (29)	Italy	March 9/May 18, 2020 (70)	22 April–3 May, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	604	29.8 ± 10.4
Ruggiero et al., 2021 (25)	Italy	March 9/May 18, 2020 (70)	May–September 2020	Cross-sectional/retrospective	Telephone-based survey (Moli-Lock cohort) and web-based survey on convenience sample (ALTRISCOVID-19 cohort)	Eating more/less/the same	3161	57.7 ± 15.4
Scacchi et al., 2021 (24)	Italy	March 9/May 18, 2020 (70)	May 6–31, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1865	Median 29 (IQR 16.0)
Scarmozzino et al., 2020 (20)	Italy	March 9/May 18, 2020 (70)	April 3–15, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1932	NA
Segre et al., 2021 (30)	Italy	March 9/May 18, 2020 (70)	May 18–June 7, 2020	Cross-sectional/retrospective	Online interview	Eating more/less/the same	82	6–14

(Continued)

TABLE 1 (Continued)

First author, year (ref)	Country	Nationwide lockdown timeline (length in days)	Survey period	Study design	Data collection	Dietary assessment	Sample size	Age (mean \pm SD), y
Pfeifer et al., 2021 (60)	Croatia	March 18/April 19, 2020 (32)	April 7–May 4, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown/MEDAS (score 0–14)	4281	≥ 18
Mittitelu et al., 2021 (61)	Romania	March 25/May 12, 2020 (48)	July 8–26, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	805	≥ 20
Troka et al., 2021 (62)	Albania	March 13/June 1, 2020 (80)	March–May 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	325	NA
Androutsos et al., 2021 (57)	Greece	March 23/May 4, 2020 (42)	April 30–May 24, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	397	7.8 ± 4.1
Tsigkas et al., 2021 (56)	Greece	March 23/May 4, 2020 (42)	April 13–30, 2020	Cross-sectional/retrospective	Telephone-based survey	Eating more/less/the same	1014	≥ 35
Kolokotroni et al., 2021 (65)	Cyprus	March 24/April 13, 2020 (20)	April 10–May 12, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown/MEDAS (score 0–14)	745	39 (median)
Deschaseaux-Tanguy et al., 2020 (44)	France	March 17/May 11, 2020 (55)	April–May 2020	Cohort study; longitudinal	Web-based survey	Web-based 24h dietary records; AHEI-2010 score and UPF (% food weight)	9372	52.1 ± 16.6
Marty et al., 2020 (45)	France	March 17/May 11, 2020 (55)	End of April 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency and amount before and during lockdown SPNNS-GS2 (score –17 to 11.5) to assess compliance to French dietary recommendations	938	38.7 ± 11.6
Constant et al., 2020 (46)	France	March 17/May 11, 2020 (55)	April 8–20, 2020	Cross-sectional/retrospective	Web-based survey among panelists from the Arcade Research Institute	Eating more/less/the same	4005	≥ 18

(Continued)

TABLE 1 (Continued)

First author, year (ref)	Country	Nationwide lockdown timeline (length in days)	Survey period	Study design	Data collection	Dietary assessment	Sample size	Age (mean ± SD), y
Philippe et al., 2021 (48)	France	March 17/May 11, 2020 (55)	April 30–May 10, 2020	Retrospective	Web-based survey among panelists from a French agency	Daily/weekly frequency before and during lockdown	498	7.3 ± 2.2
Rolland et al., 2020 (47)	France	March 17/May 11, 2020 (55)	March 25–30, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	11,391	≥16
Steffen et al., 2021 (66)	Germany	March 22/April 20 to May 11, 2020 (29 to 50)	March–April 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	2067	25.6 ± 10.6
Drieskens et al., 2021 (55)	Belgium	March 18/May 4, 2020 (47)	April 16–23, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	28,029	≥18
Vandevijvere et al., 2020 (54)	Belgium	March 18/May 4, 2020 (47)	March–May 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	8640	≥18
Biaszyk-Bębenek et al., 2020 (38)	Poland	March 13/April 11, 2020 (29)	April–May 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	312	41.1 ± 13.0
Dobrowolski et al., 2021 (40)	Poland	March 13/April 11, 2020 (29)	NA	Cross-sectional/retrospective	Computer-assisted web interview on convenience sample	Eating more/less/the same	183	33 ± 11
Drywień et al., 2021 (41)	Poland	March 13/April 11, 2020 (29)	April–May 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1769 women	≥18
Górnicka et al., 2020 (42)	Poland	March 13/April 11, 2020 (29)	April 30–May 23, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	2381	≥18
Kowalczyk et al., 2021 (43)	Poland	March 13/April 11, 2020 (29)	March 20–May 30, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	926	≥18
Sidor et al., 2020 (39)	Poland	March 13/April 11, 2020 (29)	April 17–May 1, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1097	27.7 ± 9.0
Giacalone et al., 2020 (59)	Denmark	March 12/April 13, 2020 (33)	April 24–May 5, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	2462	≥18

(Continued)

TABLE 1 (Continued)

First author, year (ref)	Country	Nationwide lockdown timeline (length in days)	Survey period	Study design	Data collection	Dietary assessment	Sample size	Age (mean ± SD), y
Kriauciuniene et al., 2020 (63)	Lithuania	March 16/June 18, 2020 (94)	From April 14, 2020 for 2 wk	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	2447	≥18
Poelman et al., 2020 (58)	The Netherlands	March 15/April 6, 2020 (22)	April 22–28, 2020	Cross-sectional/retrospective	Web-based survey on a representative sample of adults	Eating more/less/the same	1030	49.9 ± 17.0
Buckland et al., 2020 (49)	United Kingdom	March 23/July 13, 2020 (98 to 112)	May 15–June 27, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Changes by frequency of intake	588	33.4 ± 12.6
Coulthard et al., 2021 (52)	United Kingdom	March 23/July 13, 2020 (98 to 112)	April 22–May 22, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	620	39.9 ± 13.9
Herle et al., 2021 (53)	United Kingdom	March 23/July 13, 2020 (98 to 112)	March 28–June 4, 2020	Longitudinal	Web-based survey on convenience sample	Eating more/less/the same	22,374	≥18
Robinson et al., 2020 (51)	United Kingdom	March 23/July 13, 2020 (98 to 112)	April 19–22, 2020	Cross-sectional/retrospective	Web-based survey among Prolific Researcher panelists	Changes by frequency of intake	723	30.7 ± 9.6
Robinson et al., 2020 (50)	United Kingdom	March 23/July 13, 2020 (98 to 112)	April 28–May 22, 2020	Cross-sectional/retrospective	Web-based survey among Prolific Researcher panelists	Changes by frequency of intake	2002	34.7 ± 12.3
Ingram et al., 2020 (64)	Scotland	March 23/June 29, 2020 (98)	March–May 2020	Cross-sectional/retrospective	Web-based survey on convenience sample among Prolific Academic users	Eating more/less/the same	399	32.4 ± 11.4
Bin Zarah et al., 2020 (77)	USA	March–June, 2020 (20 to 89)	April–June 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	3133	≥18
Cummings et al., 2021 (79)	USA	March–June, 2020 (20 to 89)	March 2020	Comparison with a similar cohort recruited in February 2019	Web-based survey on convenience sample	Palatable Eating Motives Scale; National Cancer Institute's Dietary Screener Questionnaire; Modified Yale Food Addiction Scale 2.0	868	≥18

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TABLE 1 (Continued)

First author, year (ref)	Country	Nationwide lockdown timeline (length in days)	Survey period	Study design	Data collection	Dietary assessment	Sample size	Age (mean \pm SD), y
Chenarides et al., 2020 (78)	USA	March–June, 2020 (20 to 89)	May 13–30, 2020	Cross-sectional/retrospective	Web-based survey	Eating more/less/the same	861	53 \pm 18
Zhang et al., 2021 (80)	USA	March–June, 2020 (20 to 89)	May/June 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1276	45 \pm 17
Lamarche et al., 2021 (81)	Canada	March 17/May 18, 2020 (58 to 61)	June 2019 and February 2020 (before lockdown)	Open cohort study; longitudinal	Web-based survey	Web-based 24-h dietary recall	853	\geq 18
Christofaro et al., 2021 (83)	Brazil	March 17/May 20, 2020 (21 to 47)	April 15–May 12, 2020 (during lockdown)	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1874	\geq 18
Malta et al., 2020 (82)	Brazil	March 17/May 20, 2020 (21 to 47)	April 24–May 24, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown; self-rated changes for alcohol consumption	45,161	\geq 18
Tebar et al., 2021 (84)	Brazil	March 17/May 20, 2020 (21 to 47)	May 5–17, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1897	37.9 \pm 13.3
Martínez-Vázquez et al., 2021 (85)	Mexico	March 23/June 1, 2020 (70)	April 13–May 16, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown; DOQI	8289	\geq 18
Pertuz-Cruz et al., 2021 (86)	Colombia	March 25/June 30, 2020 (97)	April 6–May 22, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	2745	\geq 18
Ramos-Padilla et al., 2021 (88)	Ecuador	March 16–31, 2020 (15)	June–July 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	9522	18–69

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TABLE 1 (Continued)

First author, year (ref)	Country	Nationwide lockdown timeline (length in days)	Survey period	Study design	Data collection	Dietary assessment	Sample size	Age (mean ± SD), y
Ares et al., 2021 (89)	Uruguay	No restrictions	March 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1725	≥18
Huanchaure-Vega et al., 2020 (90)	Peru	March 16/June 30, 2020 (106)	July 16–August 31, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	1176	≥18
Reyes-Olavarría et al., 2020 (87)	Chile	Partial lockdowns	May–June 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	700	Median 31 (18–62)
Jia et al., 2020 (93)	China	January 23/April 8, 2020 (76)	May 9–12, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Self-recall food consumption before and during lockdown	10,082	19.8 ± 2.3 (15–28)
Wang et al., 2020 (92)	China	January 23/April 8, 2020 (76)	March–April 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Weekly frequency and amount before and during lockdown	2289	27.8 ± 12.0
Yang et al., 2021 (94)	China	January 23/April 8, 2020 (76)	February 23–March 4, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	2702	37.3 ± 12.0
Zhu et al., 2021 (95)	China	January 23/April 8, 2020 (76)	March 29–April 5, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	889	31.8 ± 11.4
Chopra et al., 2020 (96)	India	March 25/June 7, 2020 (74)	August 15–30, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	995	33.3 ± 14.5
Singh et al., 2021 (97)	India	March 25/June 7, 2020 (74)	May 11–20, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1008	24 (median)
Shrestha et al., 2020 (98)	Nepal	March 24/July 21, 2020 (120)	March 30/July 31, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	667	≥18
Husain et al., 2020 (67)	Kuwait	March 14–29, 2020 (15)	March–April 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	415	38.5 ± 12.7
Alfawaz et al., 2021 (73)	Saudi Arabia	March 9/June 21, 2020 (84 to 104)	May 11–June 6, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	1965	35.2 ± 13.1

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TABLE 1 (Continued)

First author, year (ref)	Country	Nationwide lockdown timeline (length in days)	Survey period	Study design	Data collection	Dietary assessment	Sample size	Age (mean ± SD), y
Alhousseini et al., 2020 (70)	Saudi Arabia	March 9/June 21, 2020 (84 to 104)	May 5–15, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency; Food Quality score (score 5–25) Food Quantity score (score 0–24)	2706	≥18
Aljohani, 2020 (72)	Saudi Arabia	March 9/June 21, 2020 (84 to 104)	April–June 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	782	≥16
Mumena, 2020 (71)	Saudi Arabia	March 9/June 21, 2020 (84 to 104)	April 13–22, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during curfew	879	35.8 ± 12.1
Radwan et al., 2020 (69)	United Arab Emirates	March 26/April 17, 2020 (22)	May 5–18, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	2060	≥18
Cheikh Ismail et al., 2020 (68)	United Arab Emirates	March 26/April 17, 2020 (22)	April–May 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	1012	≥18
Al-Domi et al., 2021 (75)	Jordan	March 18/April 30, 2020 (43)	March and April 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Self-rated	4473	≥18
Al Hourani et al., 2021 (74)	Jordan	March 18/April 30, 2020 (43)	June 15–30, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	447	6–17
Galali, 2021 (76)	Iraqi Kurdistan	March 22/April 11, 2020 (20)	June 1–14, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	2137	NA
Matsungu et al., 2020 (91)	Zimbabwe	March 30/May 2, 2020 (33)	May 11–25, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	507	31–40
Curtis et al., 2021 (101)	Australia	March 23/May 15, 2020 (52)	February 2020/April 2020	Cohort study/longitudinal	Web-based survey	Dietary Questionnaire for Epidemiological Studies	64	41.3 ± 5.8
Phillipou et al., 2020 (100)	Australia	March 23/May 15, 2020 (52)	From April 1, 2020 for 1 wk	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	5289	40.6 ± 13.7

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TABLE 1 (Continued)

First author, year (ref)	Country	Nationwide lockdown timeline (length in days)	Survey period	Study design	Data collection	Dietary assessment	Sample size	Age (mean ± SD), y
Gerritsen et al., 2020 (99)	New Zealand	March 26/May 14, 2020 (49)	April 24–May 13, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	3028	44.3 ± 14.0
Abouzid et al., 2021 (113)	Middle East and North Africa (MENA) region	March–June, 2020 (varying by regions)	August–September 4, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	5896	≥18
Ammar et al., 2020 (102)	Europe, North-Africa, Western Asia, and the Americas	Varying by country	April 6–11, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Dietary behaviours before and during lockdown by the use of the SDBO-L (score 0–15; the highest the worst)	1047	≥18
Bahatheg, 2021 (108)	Saudi Arabia, Britain, and Turkey	Varying by country	NA	Cross-sectional/retrospective	Web-based survey on convenience sample	Self-rated	330	4–7
Cavagnari et al., 2021 (107)	Spain and 11 Latin American countries ²	Varying by country	April 15–May 4, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	10,552	Median 33 (18–86)
Cheikh Ismail et al., 2020 (104)	Middle East and North Africa (MENA) region	March–June, 2020 (varying by regions)	April 15–29, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown	2970	≥18
Dou et al., 2021 (109)	China and USA	Varying by country	April 17–27, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1547 in the USA; 1732 in China	Median 41 (29–57) (USA) Median 26 (23–33) (China)
Janssen et al., 2021 (110)	Denmark, Germany, and Slovenia	Varying by country	April 22–May 6, 2020	Cross-sectional/retrospective	Web-based survey among consumer panel agencies with quota sampling	Daily/weekly frequency before and during lockdown	2680	54.9 ± 14.1 (Denmark) 48.9 ± 16.0 (Germany) 44.1 ± 13.5 (Slovenia)
Molina-Montes et al., 2021 (111)	16 European countries ³	Varying by country	March 20–May 5, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency before and during lockdown MEDAS (score 0–14)	36,185	≥18
Papandreou et al., 2020 (112)	Spain, Greece	Spain: March 14/May 9, 2020 (56) Greece: March 23/May 4, 2020 (42)	April–May 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	1002 (Spain) 839 (Greece)	46.1 ± 13.3 (Spain) 42.4 ± 11.7 (Greece)

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TABLE 1 (Continued)

First author, year (ref)	Country	Nationwide lockdown timeline (length in days)	Survey period	Study design	Data collection	Dietary assessment	Sample size	Age (mean \pm SD), y
Pišot et al., 2020 (106)	Bosnia and Herzegovina, Croatia, Greece, Kosovo, Italy, Serbia, Slovakia, Slovenia, and Spain	Varying by country	April 15–May 3, 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Eating more/less/the same	4108	32.0 \pm 13.2
Ruiz-Roso et al., 2020 (105)	Italy, Spain, Brazil, Chile, Colombia	Varying by country	April–May 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Self-recall food consumption before and during lockdown by using a modified version of the National School Health Survey—PeNSE questionnaire	820	10–19
Murphy et al., 2020 (103)	New Zealand, USA, Great Britain, and the Island of Ireland	Varying by country	May–June 2020	Cross-sectional/retrospective	Web-based survey on convenience sample	Daily/weekly frequency and portions before and during lockdown	2360	\geq 18

¹AHEI-2010, Alternate Healthy Eating Index–2010 score; ALTRISCOVID-19, Analysis of Long Term Risk of COVID-19; COVID-19, coronavirus disease 2019; DQI, Dietary Quality Index; HEI-2015, Healthy Eating Index-2015; KIDMED, Mediterranean Diet Quality Index for children and teenagers; MEDAS, PREDIMED (PREvención con Dieta MEDiterránea) Mediterranean Diet Adherence Screener; NA, not available; ref, reference; SDBQ-L, Short Diet Behaviours Questionnaire for Lockdowns; sPNNIS-GS2, Simplified Programme National Nutrition Santé—guidelines score 2; UPF, ultra-processed food.

²Argentina, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Mexico, Peru, Paraguay, Panama, and Uruguay.

³Bosnia and Herzegovina, Croatia, Denmark, Germany, Greece, Ireland, Italy, Lithuania, Montenegro, North Macedonia, Poland, Portugal, Serbia, Slovenia, Spain, and Turkey.

TABLE 2 Main findings of included observational studies from general adult populations evaluating changes in consumption of foods and beverages during the lockdown resulting from the first wave of the COVID-19 outbreak¹

First author, year (ref)	Country	Main findings		Authors' interpretation
		Increased	Decreased	
European studies Sánchez-Sánchez et al., 2020 (33)	Spain	Olive oil, vegetables, fruits, red and processed meat, butter, margarine and cream, carbonated/sugary beverages, alcoholic drinks and wine, legumes, fish or seafood, industrial bakery, nuts, sofrito	Preference for white meat	Despite an increase in Mediterranean diet adherence, the consumption of "unhealthy" food also increased
Sánchez et al., 2021 (31)	Spain	Sugar-sweetened and alcoholic beverages, and other snacks (44.4%); bakery products (46.2%); red meat (26.4%)	—	No overarching interpretation provided
Rodríguez-Pérez et al., 2020 (32)	Spain	—	Alcohol (57.3%), fried food (20.3%), fast food (34.9%)	An improvement in dietary behaviors was observed
Romeo-Arroyo et al., 2020 (35)	Spain	Fruit, vegetables, sweets, milk and dairy products, meat and processed meat, pasta, and bread	Fish (33%), alcoholic beverages	No overarching interpretation provided
López-Moreno et al., 2020 (34)	Spain	Fast food (25.6%), fresh food (55.7%), alcoholic beverages (18.3%)	—	Mixed effects
Bonaccio et al., 2021 (23)	Italy	Pizza (31.2%), biscuits (18%), chocolate (18.6%), bread substitutes (11.8%), fruit yogurt (7.7%), water (17.2%)	Breakfast cereals, cereal bars (5.6%), sweet packaged snacks (12.7%), ready-to-heat potatoes and potato croquettes (9.9%), packaged bread (10.9%), fruit drinks (e.g., nectars) (7.9%), savory packaged snacks (12.5%), fish nuggets and sticks (9.4%), reconstituted meat products (11.1%), ready-to-heat vegetables (11.4%), soft drinks (12.3%), croissants (14.2%), instant sauces (11.4%), plant-based meat substitutes (10.2%), plant-based cheese substitutes (10.4%)	About 40% of our population switched to unfavorable eating as reflected by increased UPF intake
Canello et al., 2020 (21)	Italy	Snack/appetizers	—	No overarching interpretation provided
Cicero et al., 2021 (22)	Italy	Bread and bread-like products, pasta, rice, vegetables, fruit, milk and yogurt, simple sugars and sweets, low-fat meat, cured meats, cheeses, eggs, healthy vegetable oils, mixed seed oils, nuts, coffee, alcoholic drinks, dietary supplements (19.2%)	Fish, mussels and shellfish, legumes	A trend towards decreasing diet quality

(Continued)

TABLE 2 (Continued)

First author, year (ref)	Country	Main findings		Authors' interpretation
		Increased	Decreased	
Di Renzo et al., 2020 (4)	Italy	Cereals, legumes, red and white meat, fresh vegetables, dairy products, eggs, hot beverages	Fresh fruit, fresh fruit, packaging sweets and baked products, baked products, alcohol, junk food (29.8%)	No overarching interpretation provided
Ferrante et al., 2021 (26)	Italy	Sweets (45.1%), alcohol (17.3%), vegetables (40.3%), legumes (21.9%) whole grains (15.5%)	Processed meat (24.4%)	A meaningful proportion of respondents reported a worsening of eating habits, especially among women
Maffoni et al., 2021 (27)	Italy	Fruit and vegetables, sweet/desserts	Water, sandwich/pizza	Negative changes in eating behaviors were documented
Prete et al., 2021 (29)	Italy	Sweets, cakes and pastry products (51%), bread/pasta/rice (30%), fresh fruit (28%), vegetables (27%)	Dried fruit (73%)	Prolonged lockdown promotes unhealthy lifestyle changes
Ruggiero et al., 2021 (25)	Italy	Fresh vegetables (26.1%), cereals (25.7) fresh fruits (22.8), olive oil (12.6%) legumes (14.9%), white meat (15.1%), soft (12.5%) and hard cheese (10.7%), water (17.9%)	Fresh/frozen fish (23.2%), reconstituted meat products (6.7%)	Higher intake of foods characterizing a Mediterranean dietary pattern, healthier lifestyle and more sustainable food choices
Scarmozzino et al., 2020 (20)	Italy	Fresh fruit and vegetables (21.2%), sweet food (42.5%), salty snacks (23.5%), milk/yogurt (14.3%), cheese (13.3%), coffee, tea, infusions (29.8%)	Red and processed meat (14.9%), fresh or canned fish (13.7%), alcohol (36.8%)	No overarching interpretation provided
Pfeifer et al., 2021 (60)	Croatia	Olive oil (12.4%), vegetables (21.2%), fruit (21.7%) legumes (10.9%), commercial pastries (21.5%), homemade pastries (33.5%)	Red meat (21.9%), soft drinks (25.6%), fish (15.2%), alcohol (27.7%), fast food (54.2%), fried foods (24.1%)	No overarching interpretation provided
Mittell et al., 2021 (61)	Romania	Vegetables and fruit (34.2%), meat and meat products (27.1%)	—	Positive changes reflected by increases in homemade food, fruit and vegetables
Troka et al., 2021 (62)	Albania	Bread (52%), dairy (51%), fruit (73.5%), vegetables (52%), meat (51.1%), sweets (56%), water (70%), homemade baked sweets (65.5%)	—	No overarching interpretation provided
Tsigkas et al., 2021 (56)	Greece	—	Alcohol (34.3%), junk food (25.5%), snack (18.8%), salt (10.3%)	Significant lifestyle changes
Kolokotroni et al., 2021 (65)	Cyprus	Fruit, vegetables, olive oil, butter, margarine, or cream, sweet beverages, legumes, fish, milk, yogurt, or cheese, commercial sweets and pastries, nuts, sofrito, caffeinated drinks, infusions/herbal teas	Red meat, whole cereals, alcohol	Though participants reported eating more, their quality of diet did not seem to change

(Continued)

TABLE 2 (Continued)

First author, year (ref)	Country	Main findings		Authors' interpretation
		Increased	Decreased	
Deschaux-Tanguy et al., 2020 (44)	France	Canned vegetables (14.2%), frozen vegetables (14.3%), potatoes (15.3%), legumes (14.5%), cheese (17.8%), sweets and chocolate (21.7%), biscuits and cakes (20.4%), tap water (13%), alcohol (15.4%), tea and herbal tea (19.5%)	Fresh fruit (17.2%), fresh vegetables (17.7%), fish or shellfish (31.3%), fresh red meat (22.4%), sandwiches, pizza and savory pies (17.4%)	The lockdown led, in a substantial part of the population, to unhealthy nutritional behaviors
Marty et al., 2020 (45)	France	Fruits and vegetables, pulses, whole-grain food, dairy products, fish and seafood, processed meat, sugary food, sugary beverages, alcohol, salt	—	Decrease in the nutritional quality of diet on average, which could be partly explained by changes in food choice motives
Constant et al., 2020 (46)	France	—	Alcohol (21.1%)	Less than 4 in 10 respondents reported healthy changes over the same period, mostly in relation to better eating habits
Roland et al., 2020 (47)	France	Caloric/salty food (28.3%), alcohol (15.4%)	—	Widespread increases in addiction-related habits
Steffen et al., 2021 (66)	Germany	—	Alcohol (40.2%)	Alcohol consumption was altered in an age-dependent manner
Driessens et al., 2021 (55)	Belgium	Sweet or salty snacks (33.2%), sugared-sweetened beverages (9.2%)	Alcohol (17.7%)	No overarching interpretation provided
Vandevijvere et al., 2020 (54)	Belgium	Fruit and vegetables (15.2% and 11.9%), sweet and salty snacks (33.4%), sugared soft drinks (8.8%)	—	No overarching interpretation provided
Błaszczak-Bębenek et al., 2020 (38)	Poland	Salty snacks (31.4%), eggs potatoes, sweets, canned meat, alcohol	Fast food, instant soups, energy drinks	Nutrition behavior did not change during lockdown, nor did it increase the proportion of healthy products in the diet
Dobrowolski et al., 2021 (40)	Poland	Sweetened and confectionery products (36.2%), fast food and salty snacks (32.4%), alcohol (26.6%)	—	Increase in the consumption of total food and products with high energy density.
Drywień et al., 2020 (41)	Poland	Whole-grain products, low-fat meat and/or egg, pulses, milk and milk products, confectionary, homemade pastry, ice cream and pudding, alcohol, water	Fruit, fish and seafood, processed meat, fast food, commercial pastry, energy drinks	No overarching interpretation provided
Górnicka et al., 2020 (42)	Poland	Whole-grain products, low-fat meat and/or egg, pulses, milk and milk products, confectionary, homemade pastry, alcohol, water	Fruit, fish and seafood, processed meat, fast food, commercial pastry, ice cream and pudding, sugar-sweetened beverages, energy drinks	Positive and negative on dietary–lifestyle changes

(Continued)

TABLE 2 (Continued)

First author, year (ref)	Country	Main findings		Authors' interpretation
		Increased	Decreased	
Kowalczyk et al., 2021 (43)	Poland	Cereals, fruit, vegetable fats, dairy products, eggs, meat, animal fats, dietary supplements, sweets, water, alcohol	Potatoes, juice, fish, sugar, snacks, soft drinks	No overarching interpretation provided
Sidor et al., 2020 (39)	Poland	Alcohol (14.6%)	—	A significant percentage of individuals can experience modification of dietary habits, manifested by eating and snacking more
Giacalone et al., 2020 (59)	Denmark	Commercial and homemade pastries (21.1% and 38.1%), fish (15.8%), alcohol (30.3%), carbonated beverages (21.4%)	Fruit (24.9%), vegetables (19.5%), legumes (9.9%), fast food (25.4%), fried food (17.7%)	Dietary changes during the lockdown reflected pre-existing (un)healthy eating habits
Kriaucioniene et al., 2020 (63)	Lithuania	Vegetables (18.8%), fruits (22.1%), fried food (20.6%), homemade pastries (37.7%)	Fast food (41.3%), fish and seafood (14.3%), carbonated and sugary drinks (19.4%), commercial pastries (26%), red meat (17.9%), alcohol (15.9%)	Both positive and negative changes in nutrition
Poelman et al., 2020 (58)	The Netherlands	Sweets and snacks (22.1%)	—	Persistence of dietary routines
Buckland et al., 2020 (49)	United Kingdom	Fruit (48%), vegetables (49%), high-energy-dense sweet and savory foods (28%)	—	Eating behavior traits that increase susceptibility to increased intake of high-energy-dense sweet and savory foods were observed
Coulthard et al., 2021 (52)	United Kingdom	High-energy-dense snack foods, fruit and vegetables, alcohol	—	No overarching interpretation provided
Robinson et al., 2020 (51)	United Kingdom	—	Alcohol (30%)	No overarching interpretation provided
Ingram et al., 2020 (64)	Scotland	Alcohol (35.4%)	—	No overarching interpretation provided
North American studies				
Lamarque et al., 2021 (81)	Canada	Whole grains, greens and beans, refined grains, total vegetables, total dairy, seafood and plant proteins, added sugar, total proteins	Whole fruits, sodium, fatty acids	Improved overall diet quality
Bin Zarah et al., 2020 (77)	USA	Sweets (43.8%), salty snacks (37.4%), water (35.4%), coffee or tea (31.1%), white rice or pasta (26.8%), alcoholic beverages (23.9% and 15.6%), breakfast cereals (22.3%), potatoes (22.2%), starchy vegetables (21.6%), red and processed meat (20.4% and 20.0%), white bread (19.0%), margarine or butter (16.5%), fruit and vegetable juices (11.7% and 5.3%), sugary beverages (10.6%)	Fruit (33.4%), eggs, chicken, or turkey (31%), nonstarchy vegetables (28.2%), dairy (21.6%), fish and shellfish (16.6%), nut butter (26.0%), nuts or seeds (25.3%), brown rice or whole-grain pasta (15.1%), whole-grain bread (14.1%), oils (10.7%)	No major variation in dietary patterns aside from increases in the consumption of sweets and salty snacks

(Continued)

TABLE 2 (Continued)

First author, year (ref)	Country	Main findings			Authors' interpretation
		Increased	Decreased		
Chenariides et al., 2020 (78)	USA	Fresh products, dairy, grains, frozen and canned food, bottled water	Fast food (48%), meat		Food consumption patterns for major food groups seemed to stay the same for the majority of participants
Cummings et al., 2021 (79)	USA	Added sugar (14%)	—		Little evidence that US adults ate more added sugars as compared with before the pandemic
Zhang et al., 2021 (80)	USA	Alcohol (39.5%)	—		No overarching interpretation provided
South American studies					
Christofaro et al., 2021 (83)	Brazil	Vegetables (26.6%), fruits (25.9%) fried foods (18.8%), sweets (42.5%)	—		No overarching interpretation provided
Malta et al., 2020 (82)	Brazil	Sweets, savory snacks, frozen food, alcoholic beverages (17.6%)	Beans, greens, and vegetables		Worsening of lifestyles and increase in health risk behaviors
Tebar et al., 2021 (84)	Brazil	Sweetened food (42.6%)	—		No overarching interpretation provided
Martínez-Yáñez et al., 2021 (85)	Mexico	Water (36.2%), cereals, legumes, eggs, fats, coffee, sugar and sugar cane and its beverages	Alcoholic beverages (12.1%)		Positive changes in the quality of diet
Pertuz-Cruz et al., 2021 (86)	Colombia	—	Fish, nuts, fast food (33.8%), alcohol (18.1%), fruit and vegetables, snacks		Overall trend toward unhealthier diets
Ares et al., 2021 (89)	Uruguay	Fruit (16.0%), vegetables and pulses (10.0%), rice/flour-based dishes (2.0%), vitamins and minerals (5.0%), water (3.0%), natural juices (2.0%)	Ultra-processed food (3.0%)		Changes related to both an increase and a decrease in the consumption of healthy foods were observed
Huancahuire-Vega et al., 2020 (90)	Peru	Vegetables, fruit, legumes, dried fruits/nuts, eggs	Bakery products, meat, snacks, refreshment and fast-food		Increase in healthy eating habits
Reyes-Olavarría et al., 2020 (87)	Chile	Fruit and vegetables (30.9%)	—		No overarching interpretation provided
Asian studies					
Wang et al., 2020 (92)	China	Fruit, vegetables, milk products, snacks	—		Mixed effects
Yang et al., 2021 (94)	China	Staple food (18.8%), animal products (19.1%), vegetables (25.3%), fruits (27.3%), nuts (26.3%), water (27.1%), snacks (38.2%)	Mushroom (19.1%), dairy (21.4%), legumes (25%)		No overarching interpretation provided
Zhu et al., 2021 (95)	China	Snacks and drinks, fruits, vegetables, egg, livestock/poultry meat, dairy intake, staple food intake, aquatic products, legumes	—		There was an increase in total food intake by 39% of respondents, especially in snacks and drinks

(Continued)

TABLE 2 (Continued)

First author, year (ref)	Country	Main findings			Authors' interpretation
		Increased	Decreased		
Shrestha et al., 2020 (98)	Nepal	—	Alcohol drinking (53.6%)	No overrarching interpretation provided	
Chopra et al., 2020 (96)	India	Fruits and vegetables, pulses, egg or meat	Fast food, fried food, junk foods (snacks, sugar sweetened beverages), alcohol	COVID-19 marginally improved the eating behavior	
Singh et al., 2021 (97)	India	—	Junk food (73.8%), regular alcohol intake (46.3%)	Positive lifestyle changes	
Husain et al., 2020 (67)	Kuwait	—	Fast food, fish and seafood, Americano coffee, fruit juice	No overrarching interpretation provided	
Alfawaz et al., 2021 (73)	Saudi Arabia	Snacks	Fast food, fresh fruits, vegetables	Lockdown impacted on dietary behaviors in an unhealthy way	
Aljohani, 2020 (72)	Saudi Arabia	Coffee (44.8%)	—	No overrarching interpretation provided	
Mumena, 2020 (71)	Saudi Arabia	Fruits, savory snacks, sweets, candies	—	No overrarching interpretation provided	
Radwan et al., 2020 (69)	United Arab Emirates	Salty snacks (21.3%), sweet snacks (7.1%)	—	Unhealthy lifestyle changes including diet	
Cheikh Ismail et al., 2020 (68)	United Arab Emirates	Water	Fast food, frozen ready-to-eat meals	Unbalanced food choices	
Galali, 2021 (76)	Iraqi Kurdistan	Fruits, vegetables, homemade pizza and sweets, hot beverages, dairy products and yogurt, legumes, white meat	Processed meat, canned fish, alcoholic intake	Despite an increase in Mediterranean diet adherence, the consumption of "unhealthy" food also increased	
African studies	Zimbabwe	Dark-green leafy vegetables (33.72%), alcohol (46.7%)	Other vegetables (48.5%), other fruits (64.9%), nuts and seeds (45.0%), cereals breads and tubers (41.1%), dairy products (44.9%)	Decrease in dietary diversification, disrupted diet and consumption patterns	
Oceanian studies	New Zealand	Sweet snacks (41.1%), salty snacks (33.2%), white bread and pasta (26.6%), alcohol (32.8%) sugary drinks (19.8%)	Fruit (20.7%), vegetables (13.3%), legumes (25.9%), whole-meal bread and pasta (24.9%)	Overall shift toward an unhealthy dietary pattern	
Intercontinental studies	Middle East and North Africa (MENA) region	Vegetables, fruits, meat, poultry, carbohydrates, dairy products, eggs, snacks, sugars, water intake	Seafood, fast food, dietary supplements	30.9% reported an improvement in their eating habits compared with 24.8% reported worsening of their eating habits	

(Continued)

TABLE 2 (Continued)

First author, year (ref)	Country	Main findings		Authors' interpretation
		Increased	Decreased	
Ammar et al., 2020 (102)	Europe, North-Africa, Western Asia and the Americas	Unhealthy food	Alcohol binge drinking	An unhealthy pattern of food consumption was exhibited
Cavagnari et al., 2021 (107)	Spain and 11 Latin American countries ²	Vegetables, fried foods, and alcoholic beverages (Argentina, Chile, Costa Rica, Spain, and Uruguay); sweetened drinks, pastry products (Guatemala and Paraguay); baked goods (Paraguay, Argentina and Chile); chocolate (Argentina, and Chile); beer (Spain, Paraguay, Chile, Argentina, and Mexico); wine and distillates (Spain, Paraguay, Chile, Argentina, and Mexico)	—	All the Latin American countries showed a change in their consumption patterns toward less healthy diets
Cheikh Ismail et al., 2020 (104)	Middle East and North Africa	Water	Fast food	Unhealthy lifestyle changes
Janssen et al., 2021 (110)	(MENA) region Denmark (DK), Germany (DE), and Slovenia (SI)	Sweet snacks, alcoholic drinks (DE, DK) canned food (DE)	Fruit, vegetables, meat (all countries) Fish and bread (DE, SI) Dairy products (DE, DK)	Diverging trends in all food categories analyzed
Molina-Montes et al., 2021 (111)	16 European countries ³	Olive oil, fruits, vegetables, legumes	Fast food, fried food, red meat, soft beverages, alcohol, fish, pastry	Improvement in dietary habits among European population as reflected by an increased adherence to the Mediterranean diet
Murphy et al., 2020 (103)	New Zealand (NZ), USA, Great Britain (GB), and the Island of Ireland (IO)	Fruit (GB), vegetables (IO, GB, NZ), saturated fats (IO, GB, NZ)	—	No overarching interpretation provided
Pišot et al., 2020 (106)	Bosnia and Herzegovina, Croatia, Greece, Kosovo, Italy, Serbia, Slovakia, Slovenia, and Spain	—	Unhealthy food (35%), alcohol (36%)	No overarching interpretation provided
Papandreou et al., 2020 (112)	Spain, Greece	Pastries (69.4% Spain; 62.2% Greece), alcohol (81.2% Spain; 78.9% Greece)	—	No overarching interpretation provided

¹ Percentages indicate the proportion of subjects reporting increases/decreases in the consumption of a given food. COVID-19, coronavirus disease 2019; ref, reference; UPF, ultra-processed food.

² Argentina, Chile, Colombia, Costa Rica, Ecuador, Guatemala, Mexico, Peru, Paraguay, Panama, and Uruguay.

³ Bosnia and Herzegovina, Croatia, Denmark, Germany, Greece, Ireland, Italy, Lithuania, Montenegro, North Macedonia, Poland, Portugal, Serbia, Slovenia, Spain, and Turkey.

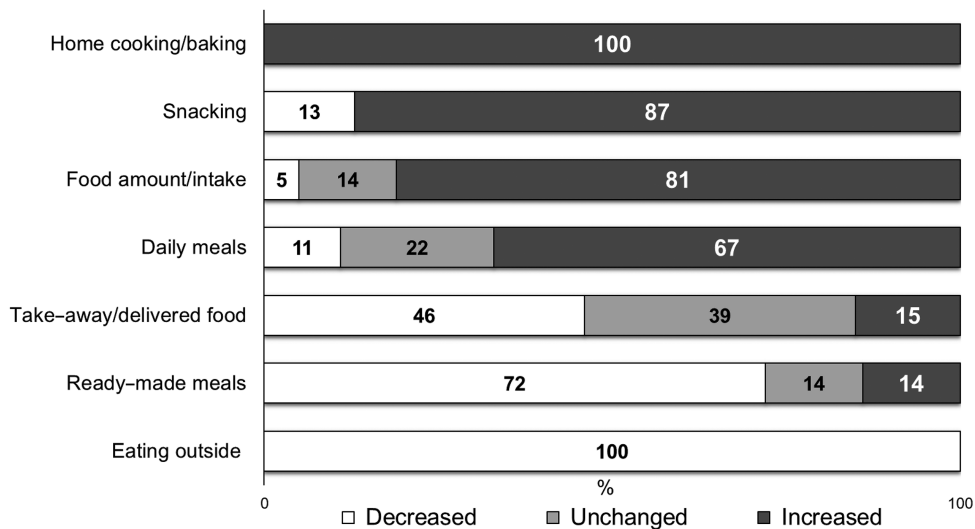


FIGURE 3 Percentages of high-quality and peer-reviewed observational studies from general adult populations reporting increased/decreased/unchanged eating behaviors during the lockdown following the first wave of the COVID-19 outbreak as compared to before (corresponding number on the related bars). COVID-19, coronavirus disease 2019.

Change in overall diet quality in adults

Fifteen studies analyzed changes in diet quality during lockdown as compared with before the lockdown by the use of validated dietary scores aimed to assess adherence to the Mediterranean diet (32, 33, 60, 65, 111) or to other eating patterns (23, 25, 70, 85, 86, 102), or to evaluate compliance with dietary recommendations (22, 44, 45, 81). Of note, only 3 (22, 44, 81) were cohort studies with a longitudinal design and were based on repeated dietary assessments, 10 were cross-sectional and relied on data collected retrospectively from convenience samples (23, 25, 32, 33, 45, 70, 102), whereas 2 articles (23, 25) reported cross-sectional analyses from the same population-based cohort (Table 4).

With regard to European studies, investigations from Spain and Cyprus revealed an increase in adherence to the Mediterranean diet, as reflected by an increase in the average PREvención con DIeta MEDiterránea (PREDIMED) Mediterranean Diet Adherence Screener (MEDAS) score, during the lockdown period as compared with before (32, 33, 65). An Italian study (25) found a slight improvement in diet quality as reflected by favorable changes toward a Mediterranean dietary pattern. Consistently, findings from the same cohorts revealed a mild decrease in consumption of ultra-processed food as compared with before the pandemic (23). On the contrary, another Italian cohort study found a worsening in overall diet quality as reflected by a reduction in the Dietary Quality Index (DQI) (22), while a study in Croatians reported a switch to a Mediterranean diet (60).

On the other side, a cross-sectional study (45) in French adults indicated a decrease in nutritional quality based on negative changes as measured by the Simplified Programme National Nutrition Santé-guidelines score 2 (sPNNS-GS2), a dietary index to assess compliance with the French dietary recommendations. Similarly, longitudinal data from the

NutriNet-Santé cohort (44) reported lower values of the Alternative Healthy Eating Index-2010 (AHEI-2010) score and an increase in the proportion of ultra-processed food in the diet.

Analysis from Canada (81) indicated an improvement in the overall diet quality, as reflected by an increase in the Healthy Eating Index-2015 (HEI-2015) dietary score, and a switch toward healthy eating was also found in Mexico (85), whereas in Saudi Arabia, a food-quality score was found to be lower during the lockdown as compared with before (70). Nevertheless, changes towards a westernized dietary pattern were also observed in Colombia (86). Finally, results from an international survey also indicated reduced diet quality overall (102), whereas another in 16 European countries pointed to an increased adherence to the Mediterranean diet (111).

To summarize, 9 out of 15 reviewed articles analyzing changes in overall diet quality indicated an improvement in diet quality at a population level, especially among Mediterranean populations.

Dietary changes in children/adolescents

Of the 10 studies conducted among children/adolescents (Table 5), 1 longitudinal analysis in a sample of 106 Spanish children with an average age of 12.0 ± 2.6 y indicated an improvement in diet quality as measured by the Mediterranean Diet Quality Index for children and teenagers (KIDMED) score (36). The same was reported by a longitudinal investigation among 1289 Italian children with a mean age of 12.5 y who experienced an increase in the KIDMED (28). At variance, Segre et al. (30) highlighted a higher amount of food eaten (57.3%) and an increased unhealthy food intake among 82 children aged 6–14 y who were web-interviewed. Androutsos et al. (57) found that

TABLE 3 Main findings of included observational studies from general adult populations evaluating changes in eating behaviors during the lockdown resulting from the first wave of the COVID-19 outbreak¹

First author, year (ref)	Country	Main findings		Authors' interpretation
		Increased	Decreased	
European studies				
López-Moreno et al., 2020 (34)	Spain	Home cooking (73.5%), daily meals (23%), more efficient preparation of food (64.2%)	Food intake (33.3%)	Mixed effects
Rodríguez-Pérez et al., 2020 (32)	Spain	Cooking (45.7%), snacking (37.6%)	—	Despite an increase in Mediterranean diet adherence, the consumption of "unhealthy" food also increased
Sánchez et al., 2021 (31)	Spain	Eating continuously (17.9%), ready-to-eat foods (22%)	—	No overarching interpretation provided
Sánchez-Sánchez et al., 2020 (33)	Spain	Homemade desserts and pastries	—	An improvement in dietary behaviors was observed
Bonaccio et al., 2021 (23)	Italy	Home cooking (48.6%), number of daily meals (17.6%)	Pre-prepared meals (11.6%)	About 40% of our population switched to unfavorable eating as reflected by increased UPF intake
Cancello et al., 2020 (21)	Italy	Food intake (42%), dietary supplements (2.3%)	—	No overarching interpretation provided
Di Renzo et al., 2020 (4)	Italy	Homemade food, eating (37.4%)	Delivery food	No overarching interpretation provided
Maffoni et al., 2021 (27)	Italy	Breakfast	Craving or eating between meals	Negative changes in eating behaviors were documented
Scacchi et al., 2021 (24)	Italy	Food consumption (43.4%), home cooking (55.1%)	—	The Italian lockdown highly affected food choice behaviors, leading to positive and sustainable habits towards food purchase and consumption
Scarmozzino et al., 2020 (20)	Italy	Eating more (52.9%)	Ready meals	No overarching interpretation provided
Ruggiero et al., 2021 (25)	Italy	Home cooking (49.3%), number of daily meals (17.8%)	Pre-prepared meals (12.0%), take-away (12.4%)	Higher intake of foods characterizing a Mediterranean dietary pattern, healthier lifestyle, and more sustainable food choices
Pfeifer et al., 2021 (60)	Croatia	Home cooking (53.8%), snacking (33.9%)	—	Increased diet quality among those cooking more
Mititelu et al., 2021 (61)	Romania	Amount of food eaten (25.6%), home cooking (77.5%)	—	Positive changes reflected by increases in homemade food, fruit, and vegetables

(Continued)

TABLE 3 (Continued)

First author, year (ref)	Country	Main findings		Authors' interpretation
		Increased	Decreased	
Kolokotroni et al., 2021 (65)	Cyprus	Number of daily meals, conviviality	—	Though participants reported eating more, their quality of diet did not seem to change
Deschateau-Tanguy et al., 2020 (44)	France	Cooking (40.4%), snacking (21.1%)	—	The lockdown created an opportunity to improve nutritional behaviors, such as cooking homemade meals, increasing consumption of fresh products, and buying food products from local shop and/or farmers
Marty et al., 2020 (45)	France	Cooking (83.2%), energy intake	—	Decrease in the nutritional quality of diet, on average, which could be partly explained by changes in food choice motives
Constant et al., 2020 (46)	France	Snacking (24%)	—	Less than 4 in 10 respondents reported healthy changes over the same period, mostly in relation to better eating habits
Driessens et al., 2021 (55)	Belgium	—	Food prepared out-of-home (39.7%)	No overarching interpretation provided
Błaszczuk-Bębenek et al., 2020 (38)	Poland	5 meals or more (31.1%), snacking (77.9%)	Eating outside or ordering take-away food (51.6%)	Nutrition behavior does not change during lockdown, nor does it increase the proportion of healthy products in the diet
Dobrowolski et al., 2021 (40)	Poland	Amount of food eaten (48.4%)	Home delivery and take-away (37.8%)	Increase in the consumption of total food and products with high energy density
Drywień et al., 2020 (41)	Poland	Eating more (35.7%) Homemade meals	Take-away meals	No overarching interpretation provided
Górnicka et al., 2020 (42)	Poland	Eating more (34.3%), homemade meals	—	Positive and negative on dietary-lifestyle changes
Kowalczyk et al., 2021 (43)	Poland	Eating more regularly	Diet diversity	No overarching interpretation provided
Sidor et al., 2020 (39)	Poland	Eating more (43.5%), snacking (51.8%), cooking (62.3%)	—	A significant percentage of individuals can experience modification of dietary habits, manifested by eating and snacking more
Giacalone et al., 2020 (59)	Denmark	Cooking (29.9%), eating (42.8%) snacking (41.7%)	—	Dietary changes during the lockdown reflected pre-existing (un)healthy eating habits

(Continued)

TABLE 3 (Continued)

First author, year (ref)	Country	Main findings		Authors' interpretation
		Increased	Decreased	
Kriaucioniene et al., 2020 (63)	Lithuania	Eating more (49.4%), snacking (45.1%), home cooking (62.1%)	—	Both positive and negative changes in nutrition
Poelman et al., 2020 (58)	The Netherlands	Eating more (8.9%), meal delivery services (29.5%)	—	Persistence of dietary routines
Buckland et al., 2020 (49)	United Kingdom	Food intake (48%), snacking (53%), number of meals (31%)	—	Eating behavior traits that increase susceptibility to increased intake of HED sweet and savory foods were observed
Coulthard et al., 2021 (52)	United Kingdom	Home-prepared food	—	No overarching interpretation provided
Herle et al., 2021 (53)	United Kingdom	Amount of food eaten (17.3%)	—	One-third of the sample report changes in quantities eaten throughout the first UK lockdown period
Robinson et al., 2020 (50)	United Kingdom	Large meals/snacks, snacking, drinking	Dieting/fasting, skipping meals	No overarching interpretation provided
Robinson et al., 2020 (51)	United Kingdom	Binged on food (49%)	—	No overarching interpretation provided
North American studies				
Lamarque et al., 2021 (81)	Canada	—	Meals consumed outside, lunch consumed outside, snacking	Improved overall diet quality
Chenarides et al., 2020 (78)	USA	Eating more (21%), snacking (41.9%)	Take-out meals (48%), prepped meals	An overwhelming shift away from consumption away from home (eg, fast food) to snack food consumption
South American studies				
Martínez-Vázquez et al., 2021 (85)	Mexico	Homemade foods (28.4%)	—	Positive changes in the quality of diet
Pertuz-Cruz et al., 2021 (86)	Colombia	Snacking (48%), amount of food eaten (45%), perishable food (50.2%), expenditure on food (71%), home cooking (59.3%)	—	Transition toward unhealthy diets
Reyes-Olavarría et al., 2020 (87)	Chile	Home cooking (59.6%), eating more (51.3%)	—	No overarching interpretation provided
Ares et al., 2021 (89)	Uruguay	Eating more homemade food (8.0%)	—	Changes related to both an increase and a decrease in the consumption of healthy foods were observed
Ramos-Padilla et al., 2021 (88)	Ecuador	Intake of any food (44%), supplement (41.4%), or beverage (31.6%)	—	No overarching interpretation provided
Asian studies				
Yang et al., 2021 (94)	China	—	Breakfast frequency (23.6%), midnight snacking (15.8%)	No overarching interpretation provided

(Continued)

TABLE 3 (Continued)

First author, year (ref)	Country	Main findings		Authors' interpretation
		Increased	Decreased	
Shrestha et al., 2020 (98)	Nepal	Quality of diet (67.6%)	Alcohol drinking (53.6%)	No overrarching interpretation provided
Husain et al., 2020 (67)	Kuwait	Late-night snack or meal, freshly made main meal, home cooking, skipping breakfast	Number of meals, main meal from a restaurant	Unhealthy meal patterns were detected
Al-Domi et al., 2021 (75)	Jordan	Food intake or supplements containing antioxidants (46.0%), breakfast (69.4%), lunch (89.8%), dinner (54.0%)	—	Significant negative changes in healthy nutritional behavior
Alhusseini et al., 2020 (70)	Saudi Arabia	Home-cooked meals	Take-away or delivered food	No overrarching interpretation provided
Aljohani, 2020 (72)	Saudi Arabia	Food intake (63%), after dinner snacking (47.9%)	—	No overrarching interpretation provided
Radwan et al., 2020 (69)	United Arab Emirates	Food intake (31.8%), cooked food (84.4%)	—	Unhealthy lifestyle changes including diet
Cheikh Ismail et al., 2020 (68)	United Arab Emirates	Homemade meals, daily meals, breakfast	Frozen ready-to-eat meals, skipping meals, eating outside	Unbalanced food choices
Galali, 2021 (76)	Iraqi Kurdistan	Home cooking	Delivered food products	An improvement in dietary behaviors was observed
Oceanian studies				
Curtis et al., 2021 (101)	Australia	Energy from alcohol	Energy from protein	Small dietary changes were observed
Phillipou et al., 2020 (100)	Australia	Binge eating (34.6%), food restriction (27.6%)	—	Potential adverse health consequences because of increased binge eating and restricting behaviors
Gerritsen et al., 2020 (99)	New Zealand	Cooking hot meals, baking	—	Overall shift toward an unhealthy dietary pattern
Intercontinental studies				
Ammar et al., 2020 (102)	Europe, North Africa, Western Asia, and the Americas	Snacking, number of meals	Alcohol binge drinking	An unhealthy pattern of food consumption was exhibited
Cheikh Ismail et al., 2020 (104)	Middle East and North Africa (MENA) region	Daily meals, homemade meals (97.2%), breakfast (71.2%)	Frozen ready-to-eat meals (7.5%), eating outside, skipping meals (45.1%)	Unhealthy lifestyle changes
Dou et al., 2021 (109)	China and USA	Home cooking, eating more	Ready-to-eat food, delivery food	Better nutrition from increased time spent on meal planning and preparing at home
Janssen et al., 2021 (110)	Denmark (DK), Germany (DE), and Slovenia (SI)	Ready-made meals (DE, DK)	Ready-made meals (SI)	Diverging trends in all food categories analyzed

(Continued)

TABLE 3 (Continued)

First author, year (ref)	Country	Main findings			Authors' interpretation
		Increased	Decreased		
Molina-Montes et al., 2021 (111)	16 European countries ²	Frequency of cooking and snacking, homemade pastry	—	—	An increase in overall dietary quality and more engagement in home cooking
Murphy et al., 2020 (103)	New Zealand, USA, Great Britain (GB), and the Island of Ireland (OI)	Fresh ingredients for dinner (OI and GB), baking	Ready-made dinner (not in the USA), take-away	—	No overarching interpretation provided
Pišot et al., 2020 (106)	Bosnia and Herzegovina, Croatia, Greece, Kosovo, Italy, Serbia, Slovakia, Slovenia, and Spain	Regular meals (44%), larger meal sizes (29%)	—	—	No overarching interpretation provided
Papandreou et al., 2020 (112)	Spain, Greece	Snacking (34.1% Spain; 40.8% Greece)	Amount of food eaten (74.3% Spain; 63.1% Greece)	—	No overarching interpretation provided

¹COVID-19, coronavirus disease 2019; HED, high-energy-dense; ref, reference; UPF, ultra-processed food.

²Bosnia and Herzegovina, Croatia, Denmark, Germany, Greece, Ireland, Italy, Lithuania, Montenegro, North Macedonia, Poland, Portugal, Serbia, Slovenia, Spain, and Turkey.

397 Greek children with a mean age of 7.8 y worsened their eating habits towards less healthy patterns, which was also in relation to their socioeconomic position, similarly to 303 Spanish adolescents from the DESK-cohort study, who increased consumption of sweets and snacks (37).

Analysis from France (48) showed a rise in the consumption of midafternoon snacks (15%) among 498 children—in particular, higher intakes of sweet foods, chips and salty biscuits, along with fruit juices and soda. As opposed to this unhealthy dietary behavior, there was an improvement in the consumption of fresh and dried fruits and nuts.

A retrospective analysis in a sample of 10,082 Chinese adolescents (93) revealed adolescents' dietary patterns had significantly changed during the COVID-19 lockdown, with both negative and positive changes that make it difficult to reach an overall conclusion.

Meanwhile, 447 Jordanian children and adolescents (74) increased consumption of main food groups (i.e., fruit, vegetables, cereals, and milk) compared with the pre-lockdown period, which led to an overall rise in food intake.

A survey carried out in Saudi Arabia, Britain, and Turkey (108) in 330 children aged between 4 and 7 y found a consistent increase in the consumption of sweets and unhealthy foods, along with an improvement in fruit intake, and showed that Turkish and British children followed a better nutritional style during lockdown than those from Saudi Arabia.

Last, in a sample of 820 adolescents from 5 countries (105), an increase in fruit, vegetables, and legumes was observed, and yet a concurrent increase in fried and sweet foods was documented, thus leading the authors to conclude that overall diet quality did not improve. Specifically, a qualitative analysis of dietary habits in each country underlined that adolescents from all countries increased consumption of unhealthy foods, those from Europe increased intakes of fruit and sweet food, and in South America, legume consumption increased significantly during lockdown.

Discussion

This systematic review synthesized results from observational studies in adults and children/adolescents analyzing the impact of nationwide lockdowns resulting from the first wave of the COVID-19 pandemic on food intake, eating behaviors, and diet quality.

The majority of studies were conducted in Europe from March to September 2020 by retrospectively assessing dietary changes that occurred during lockdown as compared with before the lockdown, through the use of web-based surveys on convenience samples (4, 20, 21, 23–27, 29, 32–35, 38–43, 45–52, 54, 55, 57–80, 82, 83–100, 102–113), while only a few could rely on a longitudinal design, thus providing more robust findings (22, 28, 36, 44, 53, 55, 81, 101). In addition, more than half of the studies addressed dietary changes by asking participants to self-rate their food intake as increased, decreased, or remained stable during lockdown (4, 20, 21, 23–26, 29–31, 34, 35, 39–43, 46, 47, 49–56, 58, 59, 61–64, 66, 69, 72, 77, 78, 80, 82–84, 87–89, 91, 94, 95, 97, 98, 100, 106, 107, 109, 112), and mainly in the form of eating more/less/the

TABLE 4 Main findings of included observational studies from general adult populations evaluating changes in overall diet quality during the lockdown resulting from the first wave of the COVID-19 outbreak¹

First author, year (ref)	Country	Main findings	Authors' interpretation
Rodríguez-Pérez et al., 2020 (32)	Spain	MEDAS increased from 6.53 ± 2 (before lockdown) to 7.34 ± 1.93 (during lockdown)	Adherence to Mediterranean diet increased significantly during the lockdown
Sánchez-Sánchez et al., 2020 (33)	Spain	High adherence (MEDAS ≥9) increased from 4.7% (before lockdown) to 8% (during lockdown)	Mediterranean diet adherence slightly increases during lockdown, although consumption of "unhealthy" food also increases
Bonaccio et al., 2021 (23)	Italy	Average UPF score was -0.28 ± 4.07	Slight decrease in the consumption of UPF
Cicero et al., 2021 (22)	Italy	DQI reduced from 42.4 ± 4.1 to 37.8 ± 4.7	A trend towards decreasing diet quality
Ruggiero et al., 2021 (25)	Italy	Average MDP score was 0.5 ± 2.2	A slight improvement in diet quality at a population level during the lockdown
Pfeifer et al., 2021 (60)	Croatia	MEDAS increased from 5.02 ± 1.97 (before lockdown) to 5.85 ± 2.04 (during lockdown)	Increased diet quality among those cooking more
Kolokotroni et al., 2021 (65)	Cyprus	MEDAS increased by 1 unit (median 6, IQR 3) during lockdown	Increased adherence to Mediterranean diet (31.9%)
Deschasaux-Tanguy et al., 2020 (44)	France	AHEI-2010 decreased by 3% during lockdown UPF decreased by 1% during lockdown	The lockdown led, in a substantial part of the population, to unhealthy nutritional behaviours.
Marty et al., 2020 (45)	France	sPNNS-GS2 decreased from 1.2 ± 2.5 (before lockdown) to 0.8 ± 2.8 (during lockdown)	The lockdown period in France was related to a decrease in nutritional quality of diet, on average
Lamarche et al., 2021 (81)	Canada	HEI-2015 increased by 1.1 points (95% CI: 0.6, 1.5)	Diet quality has slightly improved during the COVID-19-related early lockdown
Pertuz-Cruz et al., 2021 (86)	Colombia	Change toward a westernized-like dietary pattern	Transition toward unhealthy diets
Martínez-Vázquez et al., 2021 (85)	Mexico	Median DQI increased from -1 (before lockdown) to 2 (during lockdown)	DQI was higher during lockdown in all groups
Alhusseini et al., 2020 (70)	Saudi Arabia	Food-quality score decreased from 16.46 ± 2.84 (before lockdown) to 16.39 ± 2.79 (during lockdown); food quantity score increased from 14.62 ± 2.71 (before lockdown) to 15.70 ± 2.66 (during lockdown)	The quality and the quantity of the food was compromised
Ammar et al., 2020 (102)	Europe, North Africa, Western Asia, and the Americas	Total diet score 4.4% higher during lockdown than before*	Isolation alters eating behaviors in a health-compromising direction
Molina-Montes et al., 2021 (111)	16 European countries ²	MEDAS score increased from 5.23 ± 2.06 (before lockdown) to 6.15 ± 2.06 (during lockdown)	A significantly higher adherence to the Mediterranean diet during the lockdown was observed across all countries

¹Values in the main findings' column are means ± SDs. *Measured through the Short Diet Behaviours Questionnaire for Lockdowns (higher values indicating a decrease in diet quality). AHEI-2010, Alternate Healthy Eating Index-2010 score; COVID-19, coronavirus disease 2019; DQI, Dietary Quality Index; HEI-2015, Healthy Eating Index-2015; MEDAS, PREDIMED (PREvención con Dieta MEDiterránea) Mediterranean Diet Adherence Screener; ref, reference; sPNNS-GS2, Simplified Programme National Nutrition Santé—guidelines score 2; UPF, ultra-processed food.

²Bosnia and Herzegovina, Croatia, Denmark, Germany, Greece, Ireland, Italy, Lithuania, Montenegro, North Macedonia, Poland, Portugal, Serbia, Slovenia, Spain, and Turkey.

same of a given food; others asked to report simultaneously for each food item their consumption before and during the lockdown (22, 32, 33, 38, 45, 48, 57, 60, 65, 67, 68, 70, 71, 73, 74, 85, 86, 90, 92, 93, 96, 99, 100, 102–105, 110, 111). Despite the fact that the latter approach allows to assess frequency of intake and, in some cases, the amount of food consumed, both methodologies have important limitations, including recall bias.

Studies analyzing changes in food and beverage intake

The majority of studies assessed variations in the consumption of specific food and beverages, and this renders it difficult to obtain a global evaluation of the changes in

diet quality that occurred during the lockdown period as compared with usual behaviors. According to these analyses, an increase in fruit and vegetables, legumes, cereals, olive oil, and dairy products was found. Studies were concordant in highlighting a sharp decrease in fish and seafood consumption, with only 6 studies pointing to an increasing intake (33, 45, 59, 65, 81, 95).

Most studies indicated an increase in the intake of unhealthy food and alcoholic beverages, while red and processed meat intake was lowered.

The intake of 5 out of 8 major food groups was in line with the definition of a healthful diet as reflected by the traditional Mediterranean diet (114) (i.e., increased intake

TABLE 5 Main findings of included observational studies from general populations of children and adolescents evaluating changes in diet during the lockdown resulting from the first wave of the COVID-19 outbreak¹

First author, year (ref)	Country	Main findings		Authors' interpretation
		Increased	Decreased	
Medrano et al., 2020 (36)	Spain	KIDMED increased from 5.9 ± 1.8 to 6.4 ± 1.5	—	KIDMED score increased, although the prevalence of children with a high adherence to the Mediterranean diet was not significantly improved
Aguilar-Martínez et al., 2021 (37)	Spain	Fruit, vegetables, cereals, dairy products, eggs, fresh food, number of meals (28.4%), snacking between meals (56.4%), amount of food eaten	Legumes, meat, fish, sweets and pastries (39.3%), convenience foods (49.2%), soft drinks (49.8%), convenience food, packaged food, regularity of meal hours	Changes towards less healthy eating were also related to students' socioeconomic position
Segre et al., 2021 (30)	Italy	Amount of food eaten (57.3%); junk food; snacks; sweets	—	Important changes in dietary habits
Mastorci et al., 2021 (28)	Italy	KIDMED increased from 6.1 ± 2.6 to 6.5 ± 2.5	—	Increased adherence to the Mediterranean diet
Androutsos et al., 2021 (57)	Greece	Fruits and fresh fruit; juices, vegetables, dairy products, pasta, sweets, total snacks	Fast food	Unfavorable changes in children's and adolescents' lifestyle behaviors during the first COVID-19 lockdown
Philippe et al., 2021 (48)	France	Mid-afternoon snack increased (15%), fruit juice and soda, chips, salty biscuits, candy, chocolate, ice cream, pastries, cake, sweet cookies, cream dessert, milks, yogurt, cheese, quark, fresh and dried fruits, nuts	Compote, fruits in syrup	No overarching interpretation provided
Jia et al., 2020 (93)	China	Wheat products, other staple foods, preserved vegetables, tea	Rice, meat, poultry, fresh vegetables, fresh fruit, soybean products, dairy products, sugar-sweetened beverages	Compensatory eating patterns deserve further investigation for a full evaluation of the effects of the lockdown on dietary patterns and quality
Al Hourani et al., 2021 (74)	Jordan	Milk and milk products, cooked and raw vegetables; fruit, bread and grains, carbonated beverages	—	Increased food consumption
Bahatheg, 2021 (108)	Saudi Arabia, Britain, and Turkey	Fruit, chocolate, sweets, cakes, biscuits, and cupcakes, frozen food (pizza, nuggets, and pies), soft drinks, sweetened juices, juice blends and fruit juice	—	Nutritional system of the Turkish and British children was better than that of Saudi children during the lockdown
Ruiz-Roso et al., 2020 (105)	Italy, Spain, Brazil, Chile, Colombia	Legumes; vegetables; fruit; fried food, sweet food	Fast food	Overall diet quality did not increase

¹Values in the main findings' column are means \pm SDs. COVID-19, coronavirus disease 2019; KIDMED, Mediterranean Diet Quality Index for children and teenagers; ref, reference.

of fruits and vegetables, legumes, cereals, olive oil; lower intake of red and processed meat), indicating a moderate but consistent improvement in dietary habits worldwide. On the other side, the consumption of foods that should be consumed at low to moderate amounts, such as dairy products (115), increased while fish consumption was found to be substantially decreased in most surveys.

Analyses of changes in alcohol consumption yielded mixed results, but a tendency toward increased intakes was observed. Analyses by geographic area suggest a healthier trend in nutritional patterns in European populations, showing increased consumption of fruit and vegetables, legumes, and cereals, as well as in Asian and South American countries. An unhealthful change in dietary patterns was otherwise observed in North America, where alcoholic beverage consumption increased concurrently with a lowering in fruit and vegetable intake reported by half of the surveys (Supplemental Figures 1–4).

Studies analyzing changes in overall diet quality

In addition to studies analyzing changes in major food group intakes, our systematic review identified a few investigations that used validated dietary indices to assess modification in adherence to a Mediterranean diet (32, 33, 60, 65, 111), eating patterns (23, 25, 70, 85, 86, 102), changes in compliance to national dietary recommendations, or relied on scores that are not widely used (22, 44, 45, 81).

Analyses in the Spanish adult population revealed an improvement in diet quality as reflected by increased adherence to the Mediterranean diet (32, 33), as did a longitudinal analysis conducted in a subsample of the larger NutriQuébec cohort study in Canada (81). A slight improvement in diet quality was also detected in an Italian sample (25) that consistently documented a decrease in the intake of ultra-processed foods (23). On the contrary, 1 longitudinal investigation in France highlighted a mild decrease in diet quality, in line with a web-based survey showing lower compliance with national dietary guidelines (44, 45) and a cohort study from northern Italy (22) showed a decreasing trend in diet quality. Similarly, a study in Saudi Arabia (70) and an international study surveying people from Europe, North Africa, Western Asia, and the Americas indicated poorer diet quality during lockdown as compared with before lockdown (102).

Based on such findings, a trend of improved diet quality, as reflected by an increased adherence to the Mediterranean diet, emerges in European populations, especially among Mediterranean countries (32, 33, 60, 65, 111), with the exception of France where 2 surveys indicated poor nutritional patterns possibly established during lockdown (44, 45). Outside Europe, favorable dietary changes were documented in Canada (81) and Mexico (85), while a switch to unhealthy diets was found in Saudi Arabia (70) and Colombia (86).

However, a definitive conclusion on the impact of lockdown on diet quality cannot be drawn due to the relatively small number of studies.

Moreover, evaluations restricted to data from the only 3 longitudinal cohorts available are discordant since one highlighted an improvement in diet quality (81) while the other 2 observed a decrease in nutritional quality of diet, on average (22, 44).

The same applies to analyses conducted among children/adolescents that highlighted either improvements (28, 36), worsening (30, 37, 57, 74), or negligible changes in diet quality (105), or even were unable to provide conclusive evidence (48, 93, 108).

Studies analyzing changes in eating behaviors

The majority of high-quality studies are concordant in showing an increase in healthful food practices, such as homemade foods and reduced take-away/delivered food (4, 23, 33, 41, 44, 67–70, 76, 78, 81, 99, 103, 109), but at the same time, many indicated an increase in snacking and number of daily meals (21, 32, 34, 39, 44, 46, 49, 50, 59, 63, 68, 78), along with an increased amount of food eaten daily (23, 25, 34, 49, 68).

Although cooking more and consuming more fruit and vegetables, people experiencing lockdown were generally more likely to increase snacking and tended to eat more. This is potentially counterbalanced by consuming more vegetables and fruits and reduced fast food or take-away foods. However, the long-term effect of diet on health is the result of a complex interplay between a number of diet-related aspects that include foods, nutrients, and the way they are combined and consumed (116, 117).

More recently, other aspects of foods, such as the degree of food processing, have been shown to be risk factors themselves, beyond nutritional content (118).

Also, high consumption of ultra-processed food, such as sweet and salty snacks and carbonated soft drinks, leads to an increased risk of death independently of the overall diet quality (119), whereas a high intake of unhealthy foods possibly attenuates the benefits of the Mediterranean diet (120).

Although moderate alcohol intake during main meals has been positively considered within the framework of a traditional Mediterranean diet (121), the observed tendency toward an increase in the consumption of alcoholic beverages during the lockdown is worthy of attention from public health experts, in light of the detrimental effects of excessive alcohol consumption on health outcomes (122).

Strengths and limitations of this study

This is the first broad systematic synthesis of published studies evaluating changes in diet quality and eating behaviors that occurred during the nationwide lockdowns resulting from the COVID-19 pandemic.

Limitations include the possibility of our eligibility criteria to exclude important data sources and the heterogeneity of extracted data that precluded any meta-analysis. We also acknowledge that the studies considered here mainly relied on poorly accurate dietary assessments, were mostly cross-sectional, and mostly based on convenience samples; thus,

generalizability of the findings should be made with caution. Also, the majority relied on retrospective recall and this resulted in 2 major limitations—that is, recall bias and reliance on self-reported measurements.

It is worth noting that, although a small proportion of surveys used validated questionnaires/indices (e.g., MEDAS, AHEI-2010, etc.), the majority of studies (>60% of those analyzed) examined diet variations by asking participants to indicate whether they ate more/less/the same during lockdown as compared with before. Others, including cross-sectional studies using validated tools, relied on a simultaneous administration of dietary questionnaires aiming to assess food intakes (or eating behaviors) before and during lockdown. Both of these latter approaches represent a pragmatic solution to conducting research on a large sample in relation to an unexpected event (52, 100) but might lack specificity to the current pandemic state. Last, web-based surveys are equivalent to conventional face-to-face interviews in terms of data quality (123, 124).

Conclusions

Maintaining a healthy and balanced diet has become increasingly relevant during the current COVID-19 pandemic to support the immune system, which is a key determinant of COVID-19 prognosis for infected individuals (125). Results available to date are quite heterogeneous in dietary assessment and sampling. An analysis of food groups in isolation but lacking a global assessment of diet quality is in contrast with the most used approach in nutritional epidemiology, which is based on the assumption that the role of diet in health has to be examined as a composite of multiple nutrients and foods; indeed, people eat foods, not nutrients, and the combination of foods may be more synergistically powerful for health than any specific food or nutrient (117, 126).

For this reason, our original research question on whether the lockdown due to the COVID-19 pandemic has had an impact on diet quality at a population level could only be satisfied by studies considering diet as a whole rather than relying on single-food intake without providing a global assessment of diet quality. In light of this, the main findings of our systematic review indicate a modest improvement in diet quality in Mediterranean populations and a few other countries such as Canada and Mexico, while showing a decreased diet quality in other countries.

However, based on studies analyzing changes in major food groups, a slight improvement in dietary habits could be observed, since the healthful dietary choices seemed to counterbalance the unhealthful choices.

Future studies are warranted to evaluate to what extent dietary modifications that occurred during lockdown would possibly persist over time and what consequences this may produce in terms of newly established dietary patterns.

Future investigations should possibly overcome some major limitations of the majority of studies published so far, either by using quota-sampling or more accurate dietary

assessment methods that possibly rely on the evaluation of overall diet quality.

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References

1. WHO. Coronavirus disease 2019 situation report 51-11th March 2020 [Internet]. WHO Bull 2020;2019(March):2633. Available from: <https://www.who.int/emergencies/diseases/novel-coronavirus-2019>.
2. Haug N, Geyrhofer L, Londei A, Dervic E, Desvars-Larrive A, Loreto V, Piniór B, Thurner S, Klimek P. Ranking the effectiveness of worldwide COVID-19 government interventions. *Nat Hum Behav* 2020;4(12):1303–12.
3. Hartley DM, Perencevich EN. Public health interventions for COVID-19: emerging evidence and implications for an evolving public health crisis. *JAMA* 2020;323(19):1908–9.
4. Di Renzo L, Gualtieri P, Pivari F, Soldati L, Attinà A, Cinelli G, Leggeri C, Capareello G, Barrea L, Scerbo F, et al. Eating habits and lifestyle changes during COVID-19 lockdown: an Italian survey. *J Transl Med* 2020;18(1):229.
5. Mattioli AV, Ballerini Puviani M, Nasi M, Farinetti A. COVID-19 pandemic: the effects of quarantine on cardiovascular risk. *Eur J Clin Nutr* 2020;74(6):852–5.
6. Anton SD, Miller PM. Do negative emotions predict alcohol consumption, saturated fat intake, and physical activity in older adults? *Behav Modif* 2005;29(4):677–88.
7. Macht M. How emotions affect eating: a five-way model. *Appetite* 2008;50(1):1–11.
8. Mattioli AV, Sciomer S, Cocchi C, Maffei S, Gallina S. Quarantine during COVID-19 outbreak: changes in diet and physical activity increase the risk of cardiovascular disease. *Nutr Metab Cardiovasc Dis* 2020;30(9):1409–17.
9. Sanyaolu A, Okorie C, Marinkovic A, Patidar R, Younis K, Desai P, Hosen Z, Padda I, Mangat J, Altam M. Comorbidity and its impact on patients with COVID-19. *SN Compr Clin Med* 2020:1–8. doi: 10.1007/s42399-020-00363-4.
10. Naja F, Hamadeh R. Nutrition amid the COVID-19 pandemic: a multi-level framework for action. *Eur J Clin Nutr* 2020;74(8):1117–21.
11. Muscogiuri G, Barrea L, Savastano S, Colao A. Nutritional recommendations for Covid-19 quarantine. *Eur J Clin Nutr* 2020;74(6):850–51.
12. Iddir M, Brito A, Dingo G, Fernandez Del Campo SS, Samouda H, La Frano MR, Bohn T. Strengthening the immune system and reducing inflammation and oxidative stress through diet and nutrition: considerations during the COVID-19 crisis. *Nutrients* 2020;12(6):1562.
13. Bakaloudi DR, Jeyakumar DT, Jayawardena R, Chourdakis M. The impact of COVID-19 lockdown on snacking habits, fast-food and alcohol consumption: a systematic review of the evidence. *Clin Nutr* Published online April 17, 2021. doi: 10.1016/j.clnu.2021.04.020.
14. 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.
15. Neira C, Godinho R, Rincón F, Mardones R, Pedroso J. Consequences of the covid-19 pandemic for nutritional health: a systematic review. *Nutrients* 2021;13(4):1168.

16. Zupo R, Castellana F, Sardone R, Sila A, Giagulli VA, Triggiani V, Cincione RI, Giannelli G, De Pergola G. Preliminary trajectories in dietary behaviors during the COVID-19 pandemic: a public health call to action to face obesity. *Int J Environ Res Public Health* 2020;17(19):7073.
17. Higgins JPT, Thomas J, Chandler J, Cumpston M, Li T, Page MJ, Welch VA. *Cochrane Handbook for Systematic Reviews of Interventions* version 6.2 (updated February 2021). Cochrane, 2021. [Internet]. Available from: www.training.cochrane.org/handbook.
18. Moher D, Liberati A, Tetzlaff J, Altman DG; PRISMA Group. Preferred Reporting Items for Systematic Reviews and Meta-Analyses: the PRISMA statement. *PLoS Med* 2009;6(7):e1000097.
19. Moola S, Munn Z, Tufanaru C, Aromataris E, Sears K, Sfetcu R, Currie M, Qureshi R, Mattis P, Lisy K MP-F. Chapter 7: systematic reviews of etiology and risk—Joanna Briggs institute reviewers' manual. Published online 2017 [Internet]. Available from: <https://reviewersmanual.joannabriggs.org/>.
20. Scarmozzino F, Visioli F. Covid-19 and the subsequent lockdown modified dietary habits of almost half the population in an Italian sample. *Foods* 2020;9(5):675.
21. Canello R, Soranna D, Zambra G, Zambon A, Invitti C. Determinants of the lifestyle changes during covid-19 pandemic in the residents of northern Italy. *Int J Environ Res Public Health* 2020;17(17):1–14.
22. Cicero AFG, Fogacci F, Giovannini M, Mezzadri M, Grandi E, Borghi C; Brisighella Heart Study Group. COVID-19-related quarantine effect on dietary habits in a northern Italian rural population: data from the Brisighella Heart Study. *Nutrients* 2021;13(2):1–10.
23. Bonaccio M, Costanzo S, Ruggiero E, Persichillo M, Esposito S, Olivieri M, Di Castelnuovo A, Cerletti C, Donati MB, de Gaetano G, et al. Changes in ultra-processed food consumption during the first Italian lockdown following the COVID-19 pandemic and major correlates: results from two population-based cohorts. *Public Health Nutr* 2021;24(12):3905–15.
24. Scacchi A, Catozzi D, Boietti E, Bert F, Siliquini R. COVID-19 lockdown and self-perceived changes of food choice, waste, impulse buying and their determinants in Italy: QuarantEat, a cross-sectional study. *Foods* 2021;10(2):306.
25. Ruggiero E, Mignogna C, Costanzo S, Persichillo M, Di Castelnuovo A, Esposito S, Cerletti C, Donati MB, de Gaetano G, Iacoviello L, et al. Changes in the consumption of foods characterising the Mediterranean dietary pattern and major correlates during the COVID-19 confinement in Italy: results from two cohort studies. *Int J Food Sci Nutr* 2021;72(8):1105–17.
26. Ferrante G, Camussi E, Piccinelli C, Senore C, Armaroli P, Ortale A, Garena F, Giordano L. Did social isolation during the SARS-CoV-2 epidemic have an impact on the lifestyles of citizens? *Epidemiol Prev* 2020;44(5-6, 2):353–62.
27. Maffoni S, Brazzo S, De Giuseppe R, Biino G, Vietti I, Pallavicini C, Cena H. Lifestyle changes and body mass index during COVID-19 pandemic lockdown: an Italian online-survey. *Nutrients* 2021;13(4):1117.
28. Mastorci F, Piaggi P, Doveri C, Trivellini G, Casu A, Pozzi M, Vassalle C, Pingitore A. Health-related quality of life in Italian adolescents during covid-19 outbreak. *Front Pediatr* 2021;9:611136.
29. Prete M, Luzzetti A, Augustin LSA, Porciello G, Montagnese C, Calabrese I, Ballarin G, Coluccia S, Patel L, Vitale S, et al. Changes in lifestyle and dietary habits during COVID-19 lockdown in Italy: results of an online survey. *Nutrients* 2021;13(6):1923.
30. Segre G, Campi R, Scarpellini F, Clavenna A, Zanetti M, Cartabia M, Bonati M. Interviewing children: the impact of the COVID-19 quarantine on children's perceived psychological distress and changes in routine. *BMC Pediatr* 2021;21(1):231.
31. Sánchez E, Lecube A, Bellido D, Monereo S, Malagón MM, Tinahones FJ. Leading factors for weight gain during covid-19 lockdown in a Spanish population: a cross-sectional study. *Nutrients* 2021;13(3):1–12.
32. Rodríguez-Pérez C, Molina-Montes E, Verardo V, Artacho R, García-Villanova B, Guerra-Hernández EJ, Ruíz-López MD. Changes in dietary behaviours during the COVID-19 outbreak confinement in the Spanish COVIDiet study. *Nutrients* 2020;12(6):1–19.
33. Sánchez-Sánchez E, Ramírez-Vargas G, Avellaneda-López Y, Orellana-Pecino JI, García-Marín E, Díaz-Jimenez J. Eating habits and physical activity of the Spanish population during the Covid-19 pandemic period. *Nutrients* 2020;12(9):1–12.
34. López-Moreno M, López MTL, Miguel M, Garcés-Rimón M. Physical and psychological effects related to food habits and lifestyle changes derived from covid-19 home confinement in the Spanish population. *Nutrients* 2020;12(11):1–17.
35. Romeo-Arroyo E, Mora M, Vázquez-Araújo L. Consumer behavior in confinement times: food choice and cooking attitudes in Spain. *Int J Gastron Food Sci* 2020;21:100226.
36. Medrano M, Cadenas-Sanchez C, Osés M, Arenaza L, Amasene M, Labayen I. Changes in lifestyle behaviours during the COVID-19 confinement in Spanish children: a longitudinal analysis from the MUGI project. *Pediatr Obes* 2020;16(4):12731.
37. Aguilar-Martínez A, Bosque-Prous M, González-Casals H, Colillas-Malet E, Puigcorbó S, Esquiú L, Espelt A. Social inequalities in changes in diet in adolescents during confinement due to COVID-19 in Spain: the DESKcohort project. *Nutrients* 2021;13(5):1577.
38. Błaszczyk-Bębenek E, Jagielski P, Bolesławska I, Jagielska A, Nitsch-Osuch A, Kawalec P. Nutrition behaviors in Polish adults before and during COVID-19 lockdown. *Nutrients* 2020;12(10):1–16.
39. Sidor A, Rzymiski P. Dietary choices and habits during COVID-19 lockdown: experience from Poland. *Nutrients* 2020;12(6):1657.
40. Dobrowolski H, Włodarek D. Body mass, physical activity and eating habits changes during the first COVID-19 pandemic lockdown in Poland. *Int J Environ Res Public Health* 2021;18(11):5682.
41. Drywień ME, Hamulka J, Zielinska-Pukos MA, Jeruzska-Bielak M, Górnicka M. The COVID-19 pandemic lockdowns and changes in body weight among Polish women. A cross-sectional online survey. *PLifeCOVID-19 study. Sustainability* 2020;12(18):7768.
42. Górnicka M, Drywień ME, Zielinska MA, Hamulka J. Dietary and lifestyle changes during covid-19 and the subsequent lockdowns among Polish adults: a cross-sectional online survey *PLifecovid-19 study. Nutrients* 2020;12(8):1–23.
43. Kowalczyk I, Gębski J. Impact of fear of contracting covid-19 and complying with the rules of isolation on nutritional behaviors of Polish adults. *Int J Environ Res Public Health* 2021;18(4):1–12.
44. Deschasaux-Tanguy M, Druenes-Pecollo N, Esseddik Y, de Edelenyi FS, Allès B, Andreeva VA, Baudry J, Charreire H, Deschamps V, Egnell M, et al. Diet and physical activity during the coronavirus disease 2019 (COVID-19) lockdown (March-May 2020): results from the French Nutrinet-Santé cohort study. *Am J Clin Nutr* 2021;113(4):924–38.
45. Marty L, de Lauzon-Guillain B, Labesse M, Nicklaus S. Food choice motives and the nutritional quality of diet during the COVID-19 lockdown in France. *Appetite* 2021;157:105005.
46. Constant A, Conserve DF, Gallopel-Morvan K, Raude J. Socio-Cognitive factors associated with lifestyle changes in response to the COVID-19 epidemic in the general population: results from a cross-sectional study in France. *Front Psychol* 2020;11:579460.
47. Rolland B, Haesebaert F, Zante E, Benyamina A, Haesebaert J, Franck N. Global changes and factors of increase in caloric/salty food intake, screen use, and substance use during the early COVID-19 containment phase in the general population in France: survey study. *JMIR Public Heal Surveill* 2020;6(3):e19630.
48. Philippe K, Chabanet C, Issanchou S, Monnery-Patris S. Child eating behaviors, parental feeding practices and food shopping motivations during the COVID-19 lockdown in France: (how) did they change? *Appetite* 2021;161:105132.
49. Buckland NJ, Swinnerton LF, Ng K, Price M, Wilkinson LL, Myers A, Dalton M. Susceptibility to increased high energy dense sweet and savoury food intake in response to the COVID-19 lockdown: the role of craving control and acceptance coping strategies. *Appetite* 2021;158:105017.
50. Robinson E, Boyland E, Chisholm A, Harrold J, Maloney NG, Marty L, Mead BR, Noonan R, Hardman CA. Obesity, eating behavior and

- physical activity during COVID-19 lockdown: a study of UK adults. *Appetite* 2021;156:104853.
51. Robinson E, Gillespie S, Jones A. Weight-related lifestyle behaviours and the COVID-19 crisis: an online survey study of UK adults during social lockdown. *Obes Sci Pract* 2020;6(6):735–40.
 52. Coulthard H, Sharps M, Cunliffe L, van den Tol A. Eating in the lockdown during the Covid 19 pandemic; self-reported changes in eating behaviour, and associations with BMI, eating style, coping and health anxiety. *Appetite* 2021;161:105082.
 53. Herle M, Smith AD, Bu F, Steptoe A, Fancourt D. Trajectories of eating behavior during COVID-19 lockdown: longitudinal analyses of 22,374 adults. *Clin Nutr ESPEN* 2021;42:158–65.
 54. Vandevijvere S, De Ridder K, Drieskens S, Charafeddine R, Berete F, Demarest S. Food insecurity and its association with changes in nutritional habits among adults during the COVID-19 confinement measures in Belgium. *Public Health Nutr* 2021;24(5):950–6.
 55. Drieskens S, Berger N, Vandevijvere S, Gisle L, Braekman E, Charafeddine R, De Ridder K, Demarest S. Short-term impact of the COVID-19 confinement measures on health behaviours and weight gain among adults in Belgium. *Arch Public Heal* 2021;79(1):22.
 56. Tsigkas G, Koufou EE, Katsanos K, Patrinos P, Moulia A, Miliordos I, Almpanis G, Christodoulou I, Papanikolaou F, Dimitroula T, et al. Potential relationship between lifestyle changes and incidence of hospital admissions for acute coronary syndrome during the COVID-19 lockdown. *Front Cardiovasc Med* 2021;8:604374.
 57. Androustos O, Perperidi M, Georgiou C, Chouliaras G. Lifestyle changes and determinants of children's and adolescents' body weight increase during the first COVID-19 lockdown in Greece: the COVEAT study. *Nutrients* 2021;13(3):1–11.
 58. Poelman MP, Gillebaart M, Schlinkert C, Dijkstra SC, Derksen E, Mensink F, Hermans RCJ, Aardening P, de Ridder D, de Vet E. Eating behavior and food purchases during the COVID-19 lockdown: a cross-sectional study among adults in the Netherlands. *Appetite* 2021;157:105002.
 59. Giacalone D, Fröst MB, Rodríguez-Pérez C. Reported changes in dietary habits during the COVID-19 lockdown in the Danish population: the Danish COVIDiet Study. *Front Nutr* 2020;7:592112.
 60. Pfeifer D, Rešetar J, Gajdoš Kljusurić J, Panjkota Krbavčić I, Vranešić Bender D, Rodríguez-Pérez C, Ruíz-López MD, Štalić Z. Cooking at home and adherence to the Mediterranean diet during the COVID-19 confinement: the experience from the Croatian COVIDiet study. *Front Nutr* 2021;8:617721.
 61. Mititelu M, Stanciu TI, Udeanu DI, Popa DE, Drăgănescu D, Cobelschi C, Grigore ND, Pop AL, Ghica M. The impact of covid-19 lockdown on the lifestyle and dietary patterns among Romanian population. *Farmacia* 2021;69(1):1–11.
 62. Troka P, Kapaj I, Satka E. The short-term effects of COVID-19 pandemic lockdown on eating habits and dietary changes case of Tirana, Albania. *Eur Sci J* 2021;17(17):30–8.
 63. Kriaucioniene V, Bagdonaviciene L, Rodríguez-Pérez C, Petkeviciene J. Associations between changes in health behaviours and body weight during the covid-19 quarantine in Lithuania: the Lithuanian Covidiet Study. *Nutrients* 2020;12(10):1–9.
 64. Ingram J, Maciejewski G, Hand CJ. Changes in diet, sleep, and physical activity are associated with differences in negative mood during COVID-19 lockdown [published correction appears in *Front Psychol* 2020;11:605118]. *Front Psychol* 2020;11:588604.
 65. Kolokotroni O, Mosquera MC, Quattrocchi A, Heraclides A, Demetriou C, Philippou E. Lifestyle habits of adults during the COVID-19 pandemic lockdown in Cyprus: evidence from a cross-sectional study. *BMC Public Health* 2021;21(1):786.
 66. Steffen J, Schlichtiger J, Huber BC, Brunner S. Altered alcohol consumption during COVID-19 pandemic lockdown. *Nutr J* 2021;20(1):44.
 67. Husain W, Ashkanani F. Does COVID-19 change dietary habits and lifestyle behaviours in Kuwait: a community-based cross-sectional study. *Environ Health Prev Med* 2020;25(1):61.
 68. Cheikh Ismail L, Osaili TM, Mohamad MN, AlMarzouqi A, Jarrar AH, Abu Jamous DO, Magriplis E, Ali HI, Al Sabbah H, Hasan H, et al. Eating habits and lifestyle during COVID-19 lockdown in the United Arab Emirates: a cross-sectional study. *Nutrients* 2020;12(11):3314.
 69. Radwan H, Al Kitbi M, Al Hilali M, Hasan H, Abbas N, Hamadeh R, Saif ER, Naja F. Diet and lifestyle changes during COVID-19 lockdown in the United Arab Emirates: results of a cross-sectional study. Preprint. Published online 2020. [Internet]. Available from: <https://www.researchsquare.com/article/rs-76807/v1> (Accessed in January 2021).
 70. Alhuseini N, Alqahtani A. COVID-19 pandemic's impact on eating habits in Saudi Arabia. *J Public Health Res* 2020;9(3):1868.
 71. Mumena WA. Impact of COVID-19 curfew on eating habits, food intake, and weight according to food security status in Saudi Arabia: a retrospective study. *Prog Nutr* 2020;22(1):1–9.
 72. Aljohani NE, Al-Munawarah M. The effect of the lockdown for the coronavirus (COVID-19) pandemic on body weight changes and eating habits in Saudi Arabia. *JSSFN* 2020;13(1):103–13.
 73. Alfawaz H, Amer OE, Aljumah AA, Aldisi DA, Enani MA, Aljohani NJ, Alotaibi NH, Alshingetti N, Alomar SY, Khattak MNK, et al. Effects of home quarantine during COVID-19 lockdown on physical activity and dietary habits of adults in Saudi Arabia. *Sci Rep* 2021;11(1):5904.
 74. Al Hourani H, Alkhatib B, Abdullah M. Impact of COVID-19 lockdown on body weight, eating habits, and physical activity of Jordanian children and adolescents. *Disaster Med Public Health Prep* 2021;1–9.
 75. Al-Domi H, Al-Dalaeen A, Al-Rosan S, Batarseh N, Nawaiseh H. Healthy nutritional behavior during COVID-19 lockdown: a cross-sectional study. *Clin Nutr ESPEN* 2021;42:132–7.
 76. Galali Y. The impact of COVID-19 confinement on the eating habits and lifestyle changes: a cross sectional study. *Food Sci Nutr* 2021;9(4):2105–13.
 77. Bin Zarah A, Enriquez-Marulanda J, Andrade JM. Relationship between dietary habits, food attitudes and food security status among adults living within the United States three months post-mandated quarantine: a cross-sectional study. *Nutrients* 2020;12(11):1–14.
 78. Chenarides L, Grebitus C, Lusk JL, Printezis I. Food consumption behavior during the COVID-19 pandemic. *Agribusiness* 2021;37(1):44–81.
 79. Cummings JR, Ackerman JM, Wolfson JA, Gearhardt AN. COVID-19 stress and eating and drinking behaviors in the United States during the early stages of the pandemic. *Appetite* 2021;162:105163.
 80. Zhang X, Oluyomi A, Woodard L, Raza SA, Adel Fahmideh M, El-Mubasher O, Byun J, Han Y, Amos CI, Badr H. Individual-level determinants of lifestyle behavioral changes during covid-19 lockdown in the united states: results of an online survey. *Int J Environ Res Public Health* 2021;18(8):4364.
 81. Lamarche B, Brassard D, Lapointe A, Laramée C, Kearney M, Côté M, Bélanger-Gravel A, Desroches S, Lemieux S, Plante C. Changes in diet quality and food security among adults during the COVID-19-related early lockdown: results from NutriQuébec. *Am J Clin Nutr* 2021;113(4):984–92.
 82. Malta DC, Szwarcwald CL, Barros MBA, Gomes CS, Machado ÍE, Souza Júnior PRB, Romero DE, Lima MG, Damacena GN, Pina MF, et al. The COVID-19 pandemic and changes in adult Brazilian lifestyles: a cross-sectional study, 2020. A pandemia da COVID-19 e as mudanças no estilo de vida dos brasileiros adultos: um estudo transversal, 2020. *Epidemiol Serv Saude* 2020;29(4):e2020407.
 83. Christofaro DGD, Werneck AO, Tebar WR, Lofrano-Prado MC, Botero JP, Cucato GG, Malik N, Correia MA, Ritti-Dias RM, Prado WL. Physical activity is associated with improved eating habits during the COVID-19 pandemic. *Front Psychol* 2021;12:664568.
 84. Tebar WR, Christofaro DGD, Diniz TA, Lofrano-Prado MC, Botero JP, Correia MA, Cucato GG, Ritti-Dias RM, do Prado WL. Increased screen time is associated with alcohol desire and sweetened foods consumption during the COVID-19 pandemic. *Front Nutr* 2021;8:630586.

85. Martínez-Vázquez SE, Ceballos-Rasgado M, Posada-Velázquez R, Hunot-Alexander C, Nava-González EJ, Ramírez-Silva CI, Aguilar-López DK, Quiroz-Olguín G, López-Jara B, Cruz ACD, et al. Perceived diet and lifestyle changes during confinement for Covid-19 pandemic in Mexico: ESCAN-COVID19Mx survey. *J Nutr Preprint* 2021 [Internet]. Available from: <https://www.researchsquare.com/article/rs-419414/v1> (Accessed in April 2021).
86. Pertuz-Cruz SL, Molina-Montes E, Rodríguez-Pérez C, Guerra-Hernández EJ, Cobos de Rangel OP, Artacho R, Verardo V, Ruiz-López MD, García-Villanova B. Exploring dietary behavior changes due to the COVID-19 confinement in Colombia: a national and regional survey study. *Front Nutr* 2021;8:644800.
87. Reyes-Olavarria D, Latorre-Román PÁ, Guzmán-Guzmán IP, Jerez-Mayorga D, Caamaño-Navarrete F, Delgado-Floody P. Positive and negative changes in food habits, physical activity patterns, and weight status during covid-19 confinement: associated factors in the Chilean population. *Int J Environ Res Public Health* 2020;17(15):1–14.
88. Ramos-Padilla P, Villavicencio-Barriga VD, Cárdenas-Quintana H, Abril-Merizalde L, Solís-Manzano A, Carpio-Arias TV. Eating habits and sleep quality during the covid-19 pandemic in adult population of Ecuador. *Int J Environ Res Public Health* 2021;18(7):3606.
89. Ares G, Bove I, Vidal L, Brunet G, Fuletti D, Arroyo Á, Blanc MV. The experience of social distancing for families with children and adolescents during the coronavirus (COVID-19) pandemic in Uruguay: difficulties and opportunities. *Child Youth Serv Rev* 2021;121:105906.
90. Huancahuire-Vega S, Newball-Noriega EE, Rojas-Humpire R, Saintila J, Rodriguez Vásquez M, Ruiz-Mamani PG, Morales-García WC, White M. Changes in eating habits and lifestyles in Peruvian population during social isolation by the COVID-19 pandemic. *medRxiv[Preprint]* 2020;(165):1–13. Available from: <https://www.medrxiv.org/content/10.1101/2021.03.08.21252979v1> (Publication date March 12, 2021).
91. Matsungo TM, Chopera P. Effect of the COVID-19-induced lockdown on nutrition, health and lifestyle patterns among adults in Zimbabwe. *BMJ Nutr Prev Heal* 2020;3(2):205–12.
92. Wang X, Lei SM, Le S, Yang Y, Zhang B, Yao W, Gao Z, Cheng S. Bidirectional influence of the COVID-19 pandemic lockdowns on health behaviors and quality of life among Chinese adults. *Int J Environ Res Public Health* 2020;17(15):1–17.
93. Jia P, Liu L, Xie X, Yuan C, Chen H, Guo B, Zhou J, Yang S. Changes in dietary patterns among youths in China during COVID-19 epidemic: the COVID-19 impact on lifestyle change survey (COINLICS). *Appetite* 2021;158:105015.
94. Yang GY, Lin XL, Fang AP, Zhu HL. Eating habits and lifestyles during the initial stage of the covid-19 lockdown in China: a cross-sectional study. *Nutrients* 2021;13(3):1–13.
95. Zhu Q, Li M, Ji Y, Shi Y, Zhou J, Li Q, Qin R, Zhuang X. “Stay-at-home” lifestyle effect on weight gain during the COVID-19 outbreak confinement in China. *Int J Environ Res Public Health* 2021;18(4):1–13.
96. Chopra S, Ranjan P, Singh V, Kumar S, Arora M, Hasan MS, Kasiraj R, Suryansh KD, Kaur D, Vikram NK, et al. Impact of COVID-19 on lifestyle-related behaviours—a cross-sectional audit of responses from nine hundred and ninety-five participants from India. *Diabetes Metab Syndr* 2020;14(6):2021–30.
97. Singh B, Jain S, Rastogi A. Effects of nationwide COVID-19 lockdown on lifestyle and diet: an Indian survey. *J Fam Med Prim Care* 2021;10(3):1246.
98. Shrestha C, Acharya S, Sharma R, Khanal R, Joshi J, Ghimire C, Bhandari P, Agrawal A. Changes and compromises in health choices during COVID-19 lockdown in Kathmandu Valley: a descriptive cross-sectional study. *J Nepal Med Assoc* 2020;58(232):1046–51.
99. Gerritsen S, Egli V, Roy R, Haszard J, De Backer C, Teunissen L, Cuykx I, Decorte P, Pabian Pabian S, Van Royen K, et al. Seven weeks of home-cooked meals: changes to New Zealanders’ grocery shopping, cooking and eating during the COVID-19 lockdown. *J R Soc New Zeal* 2020;51(Suppl 1):S4–S22.
100. Phillipou A, Meyer D, Neill E, Tan EJ, Toh WL, Van Rheenen TE, Rossell SL. Eating and exercise behaviors in eating disorders and the general population during the COVID-19 pandemic in Australia: initial results from the COLLATE project. *Int J Eat Disord* 2020;53(7):1158–65.
101. Curtis RG, Olds T, Ferguson T, Frayssé F, Dumuid D, Esterman A, Hendrie GA, Brown WJ, Lagiseti R, Maher CA. Changes in diet, activity, weight, and wellbeing of parents during COVID-19 lockdown. *PLoS One* 2021;16(3):e0248008.
102. Ammar A, Brach M, Trabelsi K, Chtourou H, Boukhris O, Masmoudi L, Bouaziz B, Bentlage E, How D, Ahmed M, et al. Effects of COVID-19 home confinement on eating behaviour and physical activity: results of the ECLB-COVID19 international online survey. *Nutrients* 2020;12(6):1583.
103. Murphy B, Benson T, McCloath A, Mooney E, Elliott C, Dean M, Lavelle F. Changes in consumers’ food practices during the covid-19 lockdown, implications for diet quality and the food system: a cross-continental comparison. *Nutrients* 2020;13(1):1–14.
104. Cheikh Ismail L, Osaili TM, Mohamad MN, Al Marzouqi A, Jarrar AH, Zampelas A, Habib-Mourad C, Omar Abu Jamous D, Ali HI, Al Sabbah H, et al. Assessment of eating habits and lifestyle during the coronavirus 2019 pandemic in the Middle East and North Africa region: a cross-sectional study *Br J Nutr* 2020;126(5):757–66.
105. Ruiz-Roso MB, de Carvalho Padilha P, Mantilla-Escalante DC, Ulloa N, Brun P, Acevedo-Correa D, Arantes Ferreira Peres W, Martorell M, Aires MT, de Oliveira Cardoso L, et al. Covid-19 confinement and changes of adolescent’s dietary trends in Italy, Spain, Chile, Colombia and Brazil. *Nutrients* 2020;12(6):1–18.
106. Pišot S, Milovanović I, Šimunić B, Gentile A, Bosnar K, Prot F, Bianco A, Lo Coco G, Bartoluci S, Katović D, et al. Maintaining everyday life praxis in the time of COVID-19 pandemic measures (ELP-COVID-19 survey). *Eur J Public Health* 2020;30(6):1181–6.
107. Cavagnari BM, Fernanda Vinuesa-Veloz M, Carpio-Arias V, Durán-Agüero S, Ríos-Castillo I, Nava-González EJ, Pérez-Armijo P, Camacho-López S, Jairo Bejarano-Roncancio J, Núñez-Martínez B, et al. Body weight change and its association with food and beverage consumption during COVID-19 confinement: a study in 12 Ibero-American countries. Isabel Ríos-Castillo Organización de las Naciones Unidas para la Alimentación y la Agricultura. Preprint from researchsquare.com. [Internet]. Available from: <https://www.researchsquare.com/article/rs-548724/v1> (Published online May 21, 2021).
108. Bahattheg RO. Young children’s nutrition during the COVID-19 pandemic lockdown: a comparative study. *Early Child Educ J* 2021;49:915–23.
109. Dou Z, Stefanovski D, Galligan D, Lindem M, Rozin P, Chen T, Chao AM. Household food dynamics and food system resilience amid the COVID-19 pandemic: a cross-national comparison of China and the United States. *Front Sustain Food Syst* 2021;4:577153.
110. Janssen M, Chang BPI, Hristov H, Pravst I, Profeta A, Millard J. Changes in food consumption during the COVID-19 pandemic: analysis of consumer survey data from the first lockdown period in Denmark, Germany, and Slovenia. *Front Nutr* 2021;8:635859.
111. Molina-Montes E, Uzhova I, Verardo V, Artacho R, García-Villanova B, Guerra-Hernández EJ, Kapsokefalou M, Malisova O, Vlassopoulos A, Katidi A, et al. Impact of COVID-19 confinement on eating behaviours across 16 European countries: the COVIDiet cross-national study. *Food Qual Preference* 2021;93:104231.
112. Papandreou C, Arijia V, Aretouli E, Tsilidis KK, Bullo M, Bulló M. Comparing eating behaviours, and symptoms of depression and anxiety between Spain and Greece during the COVID-19 outbreak: cross-sectional analysis of two different confinement strategies. *Eur Eat Disord Rev* 2020;28(6):836–46.
113. Abouzid M, El-Sherif DM, Eltwacy NK, Dahman NBH, Okasha SA, Ghozy S, Islam SMS; EARG Collaborators. Influence of COVID-19

- on lifestyle behaviors in the Middle East and North Africa Region: a survey of 5896 individuals. *J Transl Med* 2021;19(1):129.
114. Trichopoulou A, Costacou T, Bamia C, Trichopoulos D. Adherence to a Mediterranean diet and survival in a Greek population. *N Engl J Med* 2003;348(26):2599–608.
115. Willett WC, Sacks F, Trichopoulou A, Drescher G, Ferro-Luzzi A, Helsing E, Trichopoulos D. Mediterranean diet pyramid: a cultural model for healthy eating. *Am J Clin Nutr* 1995;61(6):1402S–6S.
116. Tapsell LC, Neale EP, Satija A, Hu FB. Foods, nutrients, and dietary patterns: interconnections and implications for dietary guidelines. *Adv Nutr* 2016;7(3):445–54.
117. Hu FB. Dietary pattern analysis: a new direction in nutritional epidemiology. *Curr Opin Lipidol* 2002;13(1):3–9.
118. Bonaccio M, Di Castelnuovo A, Costanzo S, De Curtis A, Persichillo M, Sofi F, Cerletti C, Donati MB, de Gaetano G, Iacoviello L. Ultra-processed food consumption is associated with increased risk of all-cause and cardiovascular mortality in the Moli-sani study. *Am J Clin Nutr* 2021;113(2):446–55.
119. Schnabel L, Kesse-Guyot E, Allès B, Touvier M, Srour B, Hercberg S, Buscail C, Julia C. Association between ultraprocessed food consumption and risk of mortality among middle-aged adults in France. *JAMA Intern Med* 2019;179(4):490–98.
120. Agarwal P, Dhana K, Barnes LL, Holland TM, Zhang Y, Evans DA, Morris MC. Unhealthy foods may attenuate the beneficial relation of a Mediterranean diet to cognitive decline. *Alzheimers Dement* 2021;17(7):1157–65.
121. Bonaccio M, Di Castelnuovo A, Costanzo S, Persichillo M, De Curtis A, Donati MB, de Gaetano G, Iacoviello L; MOLI-SANI Study Investigators. Adherence to the traditional Mediterranean diet and mortality in subjects with diabetes. Prospective results from the MOLI-SANI study. *Eur J Prev Cardiol* 2016;23(4):400–7.
122. World Cancer Research Fund/American Institute for Cancer Research. Recommendations and public health and policy implications. Continuous Update Project. Published online 2018 [Internet]. Available from: <https://www.wcrf.org/sites/default/files/Recommendations.pdf>.
123. Ekman A, Dickman PW, Klint A, Weiderpass E, Litton JE. Feasibility of using web-based questionnaires in large population-based epidemiological studies. *Eur J Epidemiol* 2006;21(2):103–11.
124. Van Gelder M, Bretveld RW, Roeleveld N. Web-based questionnaires: the future in epidemiology? *Am J Epidemiol* 2010;172(11):1292–8.
125. Calder PC. Nutrition, immunity and COVID-19. *BMJ Nutr Prev Heal* 2020;3(1):74–92.
126. Jacobs DR, Tapsell LC. Food, not nutrients, is the fundamental unit in nutrition. *Nutr Rev* 2007;65(10):439–50.