



## Effect of COVID-19 outbreak on the diet, body weight and food security status of students of higher education: a systematic review

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### Abstract

The COVID-19 pandemic has impacted college students' lifestyles and placed them at a greater risk of obesity and food insecurity. The purpose of the systematic review was to consolidate evidence for the effect of Covid-19 on students' dietary quality, dietary habits, body weight and food security status. A comprehensive literature search was conducted utilising various databases including Google Scholar, MEDLINE, ScienceDirect, Embase and Scopus to identify relevant studies. To be incorporated in this review, studies had to include higher education students, measure the prevalence of food insecurity and assess the dietary and body weight changes during the COVID-19 pandemic. The studies showed that the diet quality of college students was compromised during the pandemic in many nations due to the decrease in the intake of whole grains, dairy products, legumes, nuts, fruits and vegetables and the increase in consumption of alcohol, confectionery products and refined grains. There was an increase in the frequency of cooking, binge eating, breakfast skipping and unhealthy snacking. These modifications, in return, were associated with body weight changes, with no less than 20 to 30% of students gaining weight during the pandemic. The pandemic also impacted food security status of students, with over 30% being food insecure worldwide. The COVID-19 outbreak has exacerbated the students' diet quality and dietary habits and placed them under high risk of weight gain and food insecurity. Higher education institutions and governments should improve students' access to nutritious foods and incorporate nutrition education interventions in the curricula.

**Key words:** Body weight changes: Confinement: COVID-19: Diet: Food insecurity: Higher education: Students

Coronavirus disease of 2019 (COVID-19) is an acute respiratory syndrome that emerged in the Chinese city of Wuhan in December 2019, then rapidly spread weeks later to reach other countries of the world to become a global threat. The WHO<sup>(1)</sup>, as a result, declared Covid-19 to be a pandemic in March 2020. As of December 2021, there were over 279 million confirmed cases and over 5 million and three hundred and ninety thousand deaths<sup>(2)</sup>. Due to the increasing numbers of cases worldwide, health authorities undertook strict measures to control the virus's further spread, including social distancing, curfew, quarantines, closure of non-essential businesses and complete lockdowns<sup>(3)</sup>. These measures, albeit necessary, were associated with negative concomitants as they led to the drastic rise in unemployment rates<sup>(4)</sup> and to adverse modifications in the populations' lifestyles<sup>(5–8)</sup>. The lockdowns negatively impacted the dietary practices of individuals manifested in the elevated consumption rate of foods high in sugars, refined carbohydrates and saturated fats<sup>(5,6)</sup>. The lockdowns also limited physical activity due to the

closure of many fitness and recreational centers<sup>(7,8)</sup>. In return, these deleterious lifestyle changes rendered the world more susceptible to obesity<sup>(9)</sup> and various chronic diseases<sup>(10,11)</sup>.

College students were among the populations most vulnerable to the lockdowns due to the unprecedented modifications they had to acclimate to. The closure of campuses, suspension of standard in-person learning, transition to fully online instruction<sup>(12–15)</sup>, attenuation of social interaction<sup>(16–22)</sup>, financial challenges<sup>(23,24)</sup> and the uncertainty of the future have dramatically disrupted their psychosocial functioning<sup>(25)</sup> and altered their lifestyles<sup>(26)</sup>. Even preceding the pandemic, college students were highly vulnerable to inadequate diet and physical activity<sup>(27–29)</sup>. Studies in the USA<sup>(27)</sup> and Canada<sup>(28,29)</sup>, for example, have shown that, even prior to the pandemic, college students were not meeting the recommended intake for daily servings of fruits and vegetables. The pandemic unfavourably modified the college students' lifestyles further and thus rendered them more susceptible to weight gain especially during

**Abbreviations:** COVID-19, coronavirus disease of 2019.

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the lockdown periods<sup>(30–35)</sup>. Additionally, research suggests that college students were at high risk of becoming food insecure during the pandemic due to factors such as loss of employment, ineligibility to governmental economic relief efforts and alterations in living arrangements and housing status<sup>(36–43)</sup>.

The detrimental impact of the pandemic on the physical activity level among college students has been researched, and the major study findings were weighed and presented in a review by López-Valenciano *et al.*<sup>(44)</sup>. However, not much recent work has been done to assess the overall findings of studies investigating the association between the pandemic and the diet, body weight and food security status of college students. Thus, we conducted a systematic review to consolidate evidence for the effect of COVID-19 on college students' dietary quality, dietary habits, body weight and food security status.

## Methods

### Search strategy and inclusion criteria

The search was conducted based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA)<sup>(45)</sup>. To identify relevant studies, a comprehensive electronic search was conducted in Google Scholar, MEDLINE, ScienceDirect, Embase and Scopus. The reference lists of the identified investigations were also used to extract articles. The search was restricted from March 2020, which marks the start of the lockdown, to September 2021. The following key terms were searched: (1) (('weight' OR 'weight gain') AND ('students' OR 'college students') AND ('pandemic' OR 'covid-19' OR 'corona virus')); (2) (('diet' OR 'diet quality' OR 'dietary pattern' OR 'dietary habits' OR 'food intake') AND ('students' OR 'college students') AND ('pandemic' OR 'covid-19' OR 'corona virus')); and (3) (('food security' OR 'food insecurity') AND ('students' OR 'college students') AND ('pandemic' OR 'covid-19' OR 'corona virus')).

To be incorporated in this review, studies had to: (i) be published in peer-reviewed journals; (ii) be written in English; (iii) include students of higher education; (iv) measure the prevalence of obesity during the pandemic; (v) measure the prevalence of food insecurity during the pandemic; (vi) assess the changes in dietary habits and (vii) assess the changes in diet quality. We excluded investigations that did not include higher education students, did not measure the prevalence of obesity or food insecurity during the pandemic, did not assess the changes in diet quality or dietary habits and were review studies.

### Screening and data extraction

Two independent reviewers, T.J. and R.K. screened the retrieved abstracts and full texts and assessed them for inclusion using EndNote X7<sup>(46)</sup>. Disagreements between the two authors were resolved by discussion with the rest of the authors (R.A.H. and H.D.S.).

The electronic search identified 1529, 948 and 387 records related to the effect of the pandemic on diet quality/dietary habits (Fig. 1), body weight (Fig. 2) and food insecurity (Fig. 3), respectively. From these citations, 812, 486 and 241

duplicates were excluded, respectively. The remaining abstracts were then screened from which 429, 393 and 86, were excluded, respectively, for reasons such as conference abstracts, the lack of full texts, etc. Finally, the full-text articles were screened for eligibility based on the inclusion and exclusion criteria; articles were excluded for reasons such as published in a language other than English (13, 4 and 7 articles, respectively), did not target college students (189, 35 and 26 articles, respectively), did not provide assessment of changes in diet quality/dietary habits (38 articles), did not provide data on body weight changes (9 articles), did not provide data on prevalence of food insecurity (18 articles) and were preprints (24, 6 and 9 articles, respectively).

Data were extracted by two authors independently, T.J. and R.K., using Excel (version 15.37). Disagreements were discussed and resolved with the rest of the authors (R.A.H. and H.D.S.). The following data were extracted from the papers: author, year of publication, date of data collection, country, sample size, assessment tools for measuring diet quality, dietary habits, food insecurity, body weight and the key findings. The extracted results included the intake of various foods and food groups, the dietary habits such as cooking, shopping, snacking and ordering fast food, the prevalence of food insecurity, and the percentage of college students who gained weight during the pandemic.

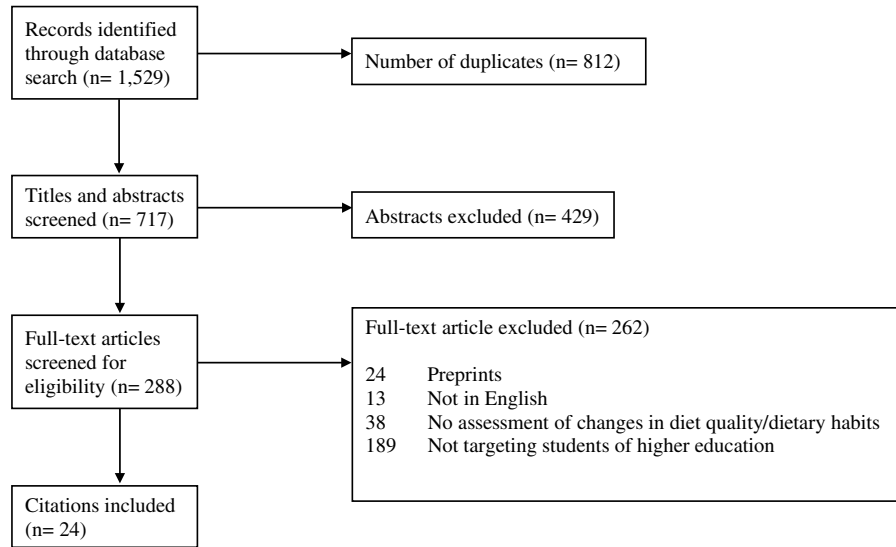
### Quality assessment and synthesis of findings

The methodological quality of all the included studies was evaluated independently by T.J. and R.K. using the Newcastle-Ottawa Scale (NOS) for non-randomised studies<sup>(47)</sup>. This scale utilises a 'star' system that ranges from 0 (minimum) to 9 (maximum) to assess the quality of studies in three subscales: comparability of subjects; selection of participants and the assessment of exposures/outcomes. Studies that scored seven to nine stars were deemed to be of high quality. Disagreements were discussed and resolved with the rest of the authors (R.A.H. and H.D.S.).

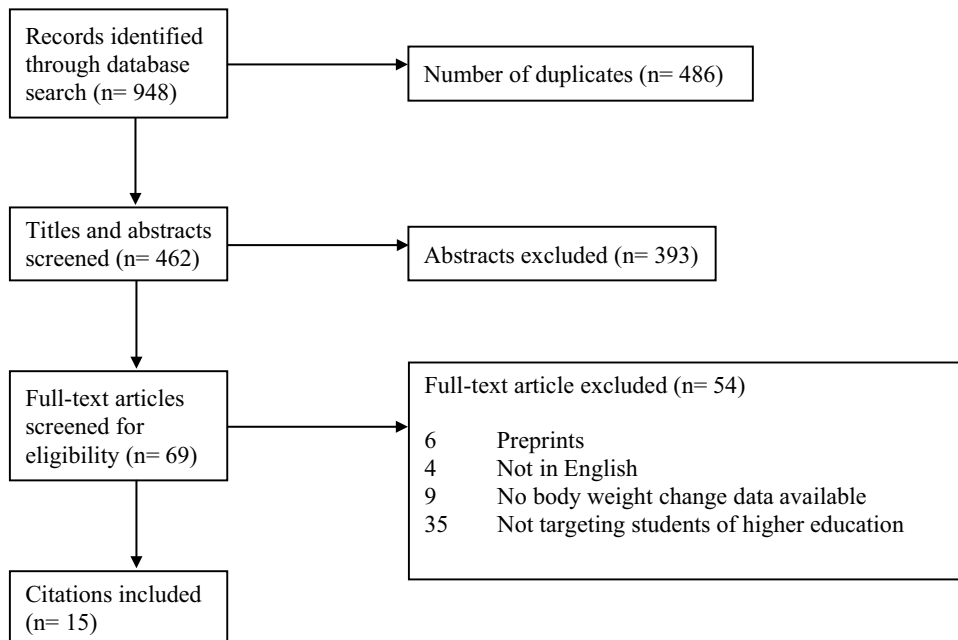
From the selected studies, diet-related findings were extracted and presented under two different themes, 'Diet Quality' and 'Dietary Habits'. Under 'Diet Quality', different food groups such as 'Fruits and Veggies', 'Dairy Products', etc as well as 'Alcohol' were presented separately. The percentage of the study population that changed their intake of specific foods under each food group, such as 'fruits' under 'Fruits and Veggies', was discussed and displayed on a table.

When it comes to dietary habits, findings were extracted and presented under different themes including 'Binge Eating', 'Breakfast Skipping and Meal Timing', 'Cooking', 'Shopping', 'Snacking' and 'Ordering Fast Food'. These were the most commonly prevalent habits among the college students during the pandemic. Under each theme, the percentage of the study population that changed their particular dietary habit was discussed textually and displayed in a table.

Findings related to the change in the prevalence of weight gain from before to during the pandemic were also extracted and presented in a table. The different factors that were associated with this weight gain were discussed under different themes. For instance, the foods and food patterns shown to have an association with weight gain during the pandemic were



**Fig. 1.** Screening process for the review of the impact of COVID-19 on diet.



**Fig. 2.** Screening process for the review of the impact of COVID-19 on body weight.

discussed under ‘Diet’. Factors such as reduction in physical activity and increase in screen time were discussed under ‘Lack of physical activity’.

The prevalence data of food insecurity among college students during the pandemic along with the different factors associated with it were extracted then presented textually and in a table.

## Results

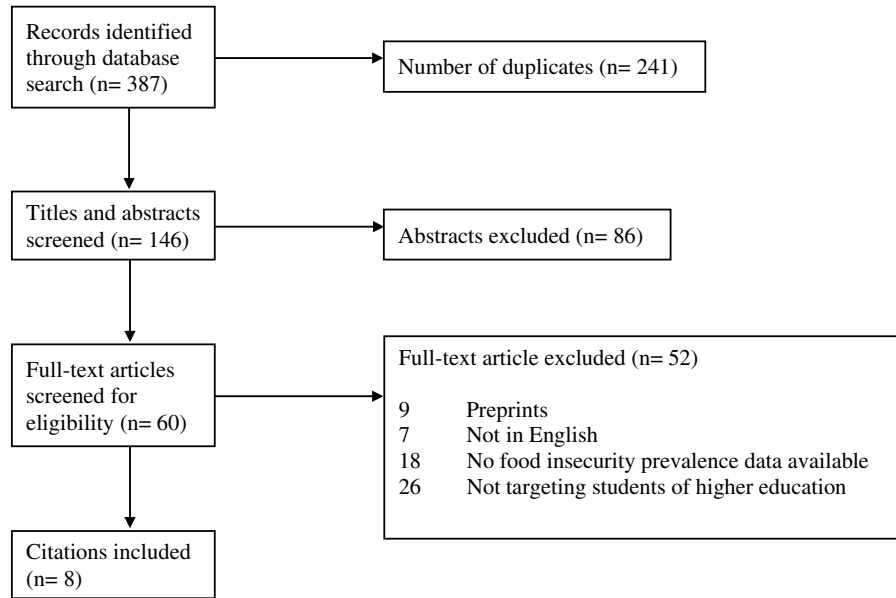
The findings of this systematic review were presented under three different themes: diet, body weight and food insecurity.

### Diet

We found that twenty-four studies met the inclusion criteria and assessed the dietary changes of college students during the pandemic<sup>(30–32,34–37,48–64)</sup>. Most of these investigations were cross-sectional and measured the college students’ diets via online questionnaires (online supplementary table). Findings related to diet were further grouped into two different sections, dietary intake and dietary habits.

### Diet quality

Overall, in studies conducted in various nations, the diet quality of college students was reduced<sup>(36,55,57,62)</sup> during the pandemic due to



**Fig. 3.** Screening process for the review of the impact of COVID-19 on food insecurity.

the decrease in the intake of whole grains<sup>(62)</sup>, dairy products<sup>(34,49,55,62,64)</sup>, legumes<sup>(55)</sup>, nuts<sup>(62)</sup>, fruits and vegetables<sup>(37,55,62,64)</sup> and the increase in the intake of confectionery products<sup>(32,34,52,64)</sup> and refined grains<sup>(32,52)</sup>. Nevertheless, research strongly indicates that the diet quality improved during the lockdown in the study populations in certain nations, especially Spain, which enhanced their adherence to the Mediterranean dietary pattern<sup>(31,34,53)</sup>.

**Fruits and veggies.** The impact of the Covid-19 pandemic on the intake of fruits and vegetables varied based on the country. Studies conducted in nations that follow the Mediterranean diet indicated an increase in the intake of fruits<sup>(31,34)</sup> and vegetables<sup>(31,53)</sup> among college students during lockdown. Celorio-Sardà *et al.*<sup>(31)</sup>, for instance, carried out a cross-sectional study to assess the dietary changes of Food Science students in Spain and showed that 24% and 20% of the study population increased their fruit and vegetable intake, respectively, during the pandemic. Imaz-Aramburu *et al.*<sup>(53)</sup>, in a longitudinal study conducted to assess the lifestyle changes of Health Sciences students from before to during the pandemic in Spain, showed that the percentage of the study population consuming vegetables increased from 59.8% to 65.8%, respectively.

Studies conducted on populations who were not following the Mediterranean dietary pattern, such as Canada<sup>(62)</sup>, China<sup>(55)</sup>, Malaysia<sup>(64)</sup> and the USA<sup>(37)</sup>, indicated that the intake of fruits and vegetables among college students was reduced during the pandemic. Jia *et al.*<sup>(55)</sup>, for instance, administered the Lifestyle Change Survey (COINLICS), a nationwide retrospective survey distributed via social media platforms, on 10 082 youth participants in China, before and after the lockdown and showed that there was a significant decrease in the percentage of students consuming fresh vegetables (from 56.9% to 55.9%) and fruits (from 24.7% to 24%).

**Alcohol.** Emerging but limited evidence suggests that alcohol intake increased during the pandemic in certain study populations<sup>(37,50,62)</sup>. Bertrand *et al.*<sup>(62)</sup> administered an online questionnaire before and during the pandemic on 125 students from the Universities of Saskatchewan and Regina in Canada to assess alcohol intake and showed a significant increase. An escalation in alcohol intake was also observed in a college population in Southwestern USA<sup>(37)</sup> and was more pronounced among males than females<sup>(50)</sup>.

Alcohol intake has been shown to decrease during the pandemic in other populations such as Spain<sup>(30,31)</sup> and Korea<sup>(56)</sup>. Millán-Jiménez *et al.*<sup>(30)</sup>, for instance, administered an online survey on medicine and architecture undergraduate students at the University of Seville, Spain. The study showed that 59% reported alcohol consumption; however, data from pre-confinement attained from a national survey conducted by the Spanish Drugs and Addictions Observatory (OEDA) showed that 72% of the Spanish population consumed alcohol.

**Dairy products.** The majority of the existing studies have shown that the intake of dairy products was below recommendations during confinement<sup>(34,49,55,62,64)</sup>. Boukrim *et al.*<sup>(49)</sup>, using a reference score of the National Nutrition and Health Program (PNNS-GS) to measure the effect of confinement on the dietary habits of students of higher education in Southern Morocco, showed that only 18.47% of participants met the recommendations for dairy products. The majority (76.11%) consumed dairy products less than 2.5 times a day during the confinement. Gender differences were observed<sup>(49,55)</sup>. Jia *et al.*<sup>(55)</sup> denoted that females consumed less dairy products than males during the lockdown.

**Protein foods.** Research has shown that study populations adhering to the Mediterranean diet increased their fish intake

during the pandemic<sup>(31,34)</sup>. In a cross-sectional study carried out to assess the dietary habits of medical students in Split, Croatia, Dragun *et al.*<sup>(34)</sup> showed an increase in the adherence to the Mediterranean diet when it came to fish during the pandemic compared with the pre-COVID-19 period. Research conducted on other study populations indicated there was little to no effect of the pandemic on fish intake<sup>(49)</sup>.

The lockdown also had little to no impact on the intake of legumes<sup>(31,34,53,55)</sup>. Dragun *et al.*<sup>(34)</sup> denoted in their study that college students slightly increased the intake of legumes in Spain during lockdown. On the other hand, Jia *et al.*<sup>(55)</sup> indicated a decrease in the percentage of students (from 7.3 % to 6.3 %, respectively) consuming soya bean products from before to during the lockdown.

Regarding the intake of nuts<sup>(34,53,62)</sup> and meat<sup>(32,49,53,55,56,62)</sup>, research findings were less consistent. Imaz-Aramburu *et al.*<sup>(53)</sup>, for instance, observed in their study population that the percentage of the study population consuming fatty meats increased from before to during the pandemic (68.8 % to 75.9 %, respectively). Bertrand *et al.*<sup>(62)</sup>, Palmer *et al.*<sup>(32)</sup>, Kang *et al.*<sup>(56)</sup>, and Jia *et al.*<sup>(55)</sup>, on the contrary, showed that meat intake decreased.

**Grain and confectionery products.** The change in the intake of grain products before and after the pandemic varied based on the type of food. Bertrand *et al.*<sup>(62)</sup> indicated that the consumption of whole grains was attenuated during the pandemic in a group of University students in Canada. Huber *et al.*<sup>(52)</sup>, in a cross-sectional study conducted to assess the impact of lockdown measures on nutrition behaviour of 1980 college students in Germany, showed that the intake of white bread increased primarily in those who increased their overall food intake level.

The intake of confectionery products increased during the pandemic<sup>(32,34,52,64)</sup>. Palmer *et al.*<sup>(32)</sup> conducted an investigation to assess the lifestyle modifications in a group of university students in Germany during the first COVID-19 lockdown period and showed that 49 % of the participants reported an increase in the consumption of sweets and cakes. Huber *et al.*<sup>(52)</sup> denoted that the increased intake of confectionery products was more pronounced among those who increased their overall food intake during the lockdown. Cheng and Wong<sup>(64)</sup> suggested that this increase could be related to the COVID-19 perceived stress and observed a more pronounced increase in females than males.

### Dietary habits

There was an increase in the prevalence of binge eating<sup>(35,63)</sup>, breakfast skipping<sup>(31,61,65)</sup>, cooking<sup>(31,32,35–37,56)</sup> and snacking<sup>(31,32,35,51,54,58,59,64,66)</sup> in various student populations during the pandemic.

**Binge eating.** The lockdown measures were associated with eating disorders such as binge eating<sup>(35,63)</sup>. Flaudias *et al.*<sup>(63)</sup> carried out a cross-sectional study on a group of 5738 French students and found an association between stress related to the lockdown and a greater likelihood of binge eating and dietary restriction. The study also found that aside from stress, exposure

to Covid-19 related media was associated with eating restriction. Other factors related to binge eating included having an existing eating disorder, being a female, and having high body dissatisfaction. Tavorolacci *et al.*<sup>(35)</sup>, in a repeated cross-sectional study, examined the changes in eating disorders among 8981 university students in France and showed that it was stable between 2009 and 2018 but significantly rose from 31.8 % in 2018 to 51.8 % in 2021 and from 13.0 % in 2009 to 31.3 % in 2021 for women and men, respectively. All types of eating disorders, including binge eating, increased except for restrictive eating disorders among men.

**Breakfast skipping and meal timing.** College students were skipping breakfast and delaying meal time during the pandemic<sup>(31,61,65)</sup>. Yokoro *et al.*<sup>(61)</sup> indicated in their study conducted in Japan that the percentage of the study population skipping breakfast during the emergency was significantly higher than the pre-emergency period (26.8 % *v.* 11 %, respectively); frequencies of skipping lunch and dinner, however, did not change<sup>(61)</sup>. Similar findings were observed by Celorio-Sardà *et al.*<sup>(31)</sup> who indicated that 7.2 % of the subjects skipped breakfast while maintaining lunch and dinner in Spain. In addition, Baquerizo-Sedano *et al.*<sup>(65)</sup> denoted that students were delaying the consumption of many of their main meals.

**Cooking.** Research strongly indicates an increase in cooking frequency among college students during the pandemic<sup>(31,32,35–37,56)</sup>. Celorio-Sardà *et al.*<sup>(31)</sup> showed that 57 % of the students increased their home cooking practices, and 67 % reported trying new recipes yet most did not change the type of fat used in cooking before and during the pandemic. Silva *et al.*<sup>(36)</sup> denoted that most students in their study increased the frequency of cooking meals at home and reduced that of eating out or getting takeout. Kang *et al.*<sup>(56)</sup> reported an increase in the percentage of students who cooked at least 1 meal/d from 17.6 % in 2019 to 32.9 % in 2020. Palmer *et al.*<sup>(32)</sup> indicated that 56.7 % of students in their study reported cooking with fresh ingredients during the pandemic.

**Shopping.** The pandemic led to modifications in the shopping habits of college students; while many were buying in large quantities due to worry of future food shortages, others reduced their shopping due to financial issues<sup>(31,36,53)</sup>. Silva *et al.*<sup>(36)</sup>, in a cross-sectional internet-based study, showed that COVID-19 restriction led to changes in shopping habits of a group of college students in Texas, USA; African American students, in particular, struggled to buy food due to the alterations in their employment status. Studies conducted in Spain, however, showed that the pandemic had a different impact on shopping habits of students<sup>(31,53)</sup>. Imaz-Aramburu *et al.*<sup>(53)</sup> observed, in their study, a higher frequency of food purchases especially vegetables. Furthermore, Celorio-Sardà *et al.*<sup>(31)</sup> indicated that 39 % of students in their study reported a greater purchase of local products compared with pre-pandemic.

**Snacking.** College students increased the frequency of unhealthy snacking during the pandemic<sup>(31,32,35,51,54,58,59,64,66)</sup>. Gallo *et al.*<sup>(51)</sup> showed that the frequency of intake of energy-dense



snacks increased in a population of Australian university female students; no significant change was observed in males. Celorio-Sardà *et al.*<sup>(31)</sup> denoted in their study an increase in the intake of foods such as salty snacks, homemade pastries and chocolate, and a change in timing of snacks; almost 50 % of the study population ceased the intake of a midmorning snack while over 53 % started consuming a late-night snack before bedtime. Cheng and Wong<sup>(64)</sup> reported that students who were more stressed engaged in emotional eating and consumed high palatability and energy-dense snacks.

**Ordering fast food.** The evidence, albeit meagre, has displayed a decrease in the frequency of ordering and consuming fast food meals among college students during the pandemic<sup>(32,48,54)</sup>. Al-Musharaf *et al.*<sup>(48)</sup> conducted a prospective study to evaluate the lifestyle changes of students before and during lockdown in Saudi Arabia and showed that 81 % of participants decreased their fast-food intake during the pandemic.

### Weight gain prevalence

As displayed in Table 1, we found that fifteen studies have met the inclusion criteria and assessed weight change among college students during the early phase of the pandemic. Most of these investigations were cross-sectional and assessed self-reported weight change via online surveys. Students had to report their current weight and recall their pre-pandemic weight status<sup>(30–35,58,65,67–69)</sup>.

In studies conducted in Spain, no less than 30 % of students gained weight during confinement<sup>(30,31)</sup>. Weight gain was also observed in other European countries such as Germany<sup>(32)</sup>, Romania<sup>(33)</sup>, Croatia<sup>(34)</sup> and France<sup>(35)</sup>. Tavorlacci *et al.*<sup>(35)</sup> conducted repeated cross-sectional studies in France and showed that between 2009 and 2021, the prevalence of overweight and obesity significantly increased from 8.8 to 13.3 % in women and from 4.0 to 9.5 % in men, respectively. In China, two retrospective studies were carried out to measure body weight change between the period preceding the lockdown (December 2019 – January 2020) to after the end of the lockdown (May 2020)<sup>(66,70)</sup>. Jia *et al.*<sup>(70)</sup>, for instance, indicated that the prevalence of overweight and obesity in their study population increased from 21.4 % to 24.6 % and from 10.5 % to 12.6 %, respectively. The percentage of weight gain was even more pronounced in the study populations in other Asian countries such as India<sup>(69)</sup>, Korea<sup>(58)</sup>, Malaysia and Indonesia<sup>(67)</sup>, with no less than 35 % of students gaining weight during the pandemic. Countries in South America such as Peru<sup>(65)</sup> and Brazil<sup>(68)</sup> showed that no less than half of the student populations gained weight during the pandemic. Other investigations did not display the prevalence of weight gain but did indicate an increase the students' body weight<sup>(50,71)</sup>. Brancaccio *et al.*<sup>(50)</sup> showed that, in Italy, there was a modest increase in mean body weight from 67.4 ± 14.9 kg to 68.0 ± 15.2 kg before and after the beginning of the quarantine, respectively.

### Factors associated with weight gain

**Gender.** Studies have shown that male college students were more likely to gain weight than female college students during

the pandemic<sup>(33,35,50,68)</sup>. In a cross-sectional study involving a group of participants from the University of Naples Federico II (Italy), Brancaccio *et al.*<sup>(50)</sup> showed that body weight increased more significantly among males than females which was related to the higher consumption of take-away food and alcohol. Stanila *et al.*<sup>(33)</sup> also denoted an association between high alcohol intake among males and an increase in body weight during the pandemic.

**Diet.** The unfavourable changes in diet quality and dietary habits were directly associated with weight gain<sup>(32,49,50,54,68)</sup>. Foods that were strong predictors of weight gain included take-away foods, alcohol<sup>(50)</sup>, refined carbohydrates such as pasta, sweets including cake, savoury snacks<sup>(32)</sup> and fast and fried foods<sup>(54)</sup>. When it comes to dietary patterns, da Mota Santana *et al.*<sup>(68)</sup> indicated, in a cross-sectional study involving students from four universities in Brazil, that processed and ultra-processed dietary patterns (based mainly on processed and ultra-processed foods, respectively) were a major risk factor for obesity during the pandemic.

**Lack of physical activity.** Sedentary behaviour exacerbated the risk of weight gain during the pandemic, especially when the lockdown was first set forth. Baquerizo-Sedano *et al.*<sup>(65)</sup> carried out a study to assess the effect of 12-week confinement on body weight of 521 university students and showed that for every 1 h-increase in sedentarism, there was a 0.3 % increase in body weight. Screen exposure time was another factor associated with weight gain during the confinement<sup>(67)</sup>. Tan *et al.*<sup>(67)</sup> showed in their study population that Malaysian and Indonesian students spent 9.16 h/d and 7.85 h/d, respectively, in sedentary behaviour during home confinement. López-Valenciano *et al.*<sup>(44)</sup> indicated that college students from different countries in their study reduced their level of walking, along with moderate, vigorous, and total physical activity levels during the COVID-19 pandemic confinements. Nevertheless, students who met the current minimum physical activity recommendations preceding lockdown continued to meet them during the confinements. Physical inactivity could also be related to the increased sitting time associated with remote learning and working from home which in-return increased the risk of weight gain<sup>(66,67)</sup>.

**Weight status pre-pandemic.** Weight status preceding the pandemic was a risk factor for obesity during the pandemic; those who were obese/overweight before the confinement were at higher risk of increasing their food intake considerably during the lockdown and thus gained more weight<sup>(52)</sup>.

**Sleep quality.** The pandemic has been associated with reduced sleep quality and duration among the college student population which in return increased the risk of obesity<sup>(72)</sup>. Baquerizo-Sedano *et al.*<sup>(65)</sup> indicated that for every hour of increase in sleep duration, there was a 0.2 % decrease in body weight.

**Meal timing.** Research suggests that the pandemic led to delays in meal timing<sup>(73)</sup>. This delay, according to a study by Baquerizo-Sedano *et al.*<sup>(65)</sup>, was associated with a twofold increase in obesity among college students.

**Table 1.** Findings of studies related to impact of COVID-19 pandemic on students' body weight

Author (year)	Study design	Date of data collection	Country	Sample size	Body weight assessment	Results
Al-Musharaf <i>et al.</i> <sup>(48)</sup>	Prospective study	Before (February to May 2019) and after pandemic (April to May 2020)	Saudi Arabia	297	Self-reported; online survey	18 % of participants gained weight
Baquerizo-Sedano <i>et al.</i> <sup>(65)</sup>	Cross-sectional	June 2020	Peru	521	Self-Reported; online survey	64 % of the total population gained weight
Celorio-Sardà <i>et al.</i> <sup>(31)</sup>	Cross-sectional	From May to July 2020	Spain	321	Self-Reported; online survey	32 % of the participants gained weight
Chaturvedi <i>et al.</i> <sup>(69)</sup>	Cross-sectional	July 2020	India	1182	Self-Reported; online survey	37.1 % of students gained weight
da Mota Santana <i>et al.</i> <sup>(68)</sup>	Cross-sectional	April to May 2020	Brazil	955	Self-Reported; online survey	53 % of the students gained weight
Dragun <i>et al.</i> <sup>(34)</sup>	Cross-sectional	Pre-Covid 19 (April–May 2018 and 2019); during Covid-19 (May 2020)	Croatia	1326 students (pre-COVID 19) and 531 students (during COVID-19 lockdown)	Self-Reported; online survey	19 % of students gained weight
Dun <i>et al.</i> <sup>(66)</sup>	Retrospective study	Before lockdown (December 2019 – January 2020) and after the end of the lockdown (May 2020)	China	12 889	Weight scale before lockdown and self-reporting after lockdown	Increase in % of overweight and obese men by 4.5 % and 2.7 %, and women by 4.8 % and 3.4 %, respectively
Jalal <i>et al.</i> <sup>(54)</sup>	Prospective-cohort study	Before (March 2020) and during (June 2020) lockdown	Saudi Arabia	628	Weight scale	32 % of the students increased their weight
Jia <i>et al.</i> <sup>(70)</sup>	Retrospective study	Before (January 2020) and after lockdown (April–May 2020)	China	10 082	Self-Reported; online survey	Prevalence of overweight and obesity increased from 21.4 % to 24.6 % and from 10.5 % to 12.6 %, respectively, before and after lockdown
Kim and Yeon <sup>(58)</sup>	Cross-sectional	December 2020	Korea	460	Self-Reported; online survey	36 % of the students gained weight
Millán-Jiménez <i>et al.</i> <sup>(30)</sup>	Cross-sectional	Not listed	Spain	188	Self-Reported; online survey	38 % gained weight
Palmer <i>et al.</i> <sup>(32)</sup>	Cross-sectional	March–May 2020	Germany	827	Self-Reported; online survey	27 % of students gained weight
Stanila <i>et al.</i> <sup>(33)</sup>	Cross-sectional	April–May 2020	Romania	433	Self-Reported; online survey	27 % of students gained weight
Tan <i>et al.</i> <sup>(67)</sup>	Cross-sectional	December 2020	Malaysia and Indonesia	147 Malaysian students and 107 Indonesian students	Self-Reported; online survey	57.8 % and 47.7 % of the Malaysian and Indonesian students gained weight, respectively
Tavolacci <i>et al.</i> <sup>(35)</sup>	Repeated cross-sectional studies	2009 and 2021	France	1872 in 2009, and 3357 in 2021	Self-Reported; online survey	Between 2009 and 2021, overweightness and obesity significantly increased from 8.8 to 13.3 % and from 4.0 to 9.5 % in women and men, respectively

Food insecurity

Research suggests that the COVID-19 pandemic affected the students' abilities to attain food and increased the prevalence of food insecurity<sup>(36-43)</sup>. Table 2 displays the prevalence of food insecurity during the early phase of the pandemic. In studies conducted in the USA<sup>(38,39,41,43)</sup>, Brazil<sup>(42)</sup>, Thailand<sup>(74)</sup> and Australia<sup>(75)</sup>, over 30 % of students were food insecure. Mialki *et al.*<sup>(39)</sup> denoted that 59.6 % of students became less food secure due to the pandemic in the USA. Sidebottom *et al.*<sup>(37)</sup> indicated that there was an increase of 54 % in the number of students not able to afford healthy food or balanced meals and an increase of 68 % in the number of those who started skipping meals or consuming less food due to lack of resources during the pandemic. Food insecurity was even more pronounced among minorities than non-minorities<sup>(36,39,74)</sup>. Silva *et al.*<sup>(36)</sup> indicated that Black students were more likely to report changes in their ability to access sufficient healthy food. Davitt *et al.*<sup>(40)</sup> reported that 17 % of students were food insecure during the pandemic. This lower level of food insecurity prevalence compared with other studies could be partly related to the high number of students who moved back with their parents during the pandemic and thus had access to additional family resources. Factors that predicted food insecurity among college students during the pandemic included loss or reduction of employment, receipt of financial aid, furlough, alterations in living arrangements and housing status, lower cooking self-efficacy, consumption of more take-out or fast food, low diet quality, pre-COVID-19 financial status, the non-White ethnicity and closure of college campuses<sup>(38-43,74)</sup>.

Discussion

The diet quality of college students was compromised<sup>(36,55,57,62)</sup> during the pandemic in many nations due to the decrease in the intake of whole grains<sup>(62)</sup>, dairy products<sup>(34,49,55,62,64)</sup>, legumes<sup>(55)</sup>, nuts<sup>(62)</sup>, fruits and vegetables<sup>(37,55,62,64)</sup> and the increase in consumption of alcohol<sup>(37,50,62)</sup>, confectionery products<sup>(32,34,52,64)</sup> and refined grains<sup>(52)</sup>. Nevertheless, the lockdown had the opposite effect on the diet quality in countries that adopted the Mediterranean dietary pattern<sup>(31,34,53)</sup>. The increased intake of fruits and vegetables in Spain, for instance, could be partially explained by their low prices, the growth in their production and accessibility<sup>(76)</sup>, the higher frequency of food purchases<sup>(60,77)</sup>, the increased health perception and the emphasis on eating healthy during the pandemic to boost the immunity and prevent severe disease effects<sup>(60,78)</sup>. The reduction in alcohol intake<sup>(30,31)</sup> could also be explained by the increase in health awareness and by its association with leisure activities. The restriction of leisure activities during the pandemic led to a decrease in alcohol intake since students had less opportunities to meet for drinks<sup>(56)</sup>.

The reduction in diet quality observed in many nations, however, could be a concomitant of unfavourable changes in dietary habits of college students such as binge eating<sup>(35,63)</sup>, breakfast skipping<sup>(31,61)</sup> and increased snacking frequency of unhealthy food items<sup>(31,32,35,51,54,58,59,64,66)</sup>. These changes could be partially explained by the rise in the prevalence of pandemic-related

Table 2. Findings of studies related to impact of COVID-19 pandemic on students' food insecurity status

Author (year)	Study design	Date of data collection	Country	Sample size	Assessment	Results
Christensen <i>et al.</i> <sup>(41)</sup>	Cross-sectional	December 2019–April 2020	USA	579	Self-reported; the Radimer/Cornell hunger and food insecurity questionnaire	40.6 % were food insecure.
Davitt <i>et al.</i> <sup>(40)</sup>	Cross-sectional	April 2020	USA	1434	Self-reported; USDA ERS six-item Core Food Security Survey Module	17 % were food insecure
Maciel <i>et al.</i> <sup>(42)</sup>	Cross-sectional	August 2020–February 2021	Brazil	4774	Self-reported; Brazilian food-insecurity scale	38.6 % were food insecure; 7.7 % and 4.5 % were moderately and severely insecure, respectively.
Maneerattanasuporn <i>et al.</i> <sup>(74)</sup>	Cross-sectional	Not listed	Thailand	409	Self-reported; USA, Household Food Security Survey	Around 50 % of the students were food insecure
Mialki <i>et al.</i> <sup>(39)</sup>	Cross-sectional	April–May 2020	USA	3206	Self-reported; the ten-item USA Adult Food Security Survey Module	59.6 % became less food secure due to pandemic
Murray <i>et al.</i> <sup>(75)</sup>	Cross-sectional	March 2020	Australia	1858	Self-reported; Student Sustainability Survey	38 % were food insecure
Owens <i>et al.</i> <sup>(38)</sup>	Cross-sectional	May 2020	USA	502	Self-reported; the validated two-item Food Sufficiency Screener and six-item USDA Food Security Survey Module (FSSM)	34.5 % were insecure
Soldavini <i>et al.</i> <sup>(43)</sup>	Cross-sectional	March–May 2020	USA	2039	Self-reported ten-item USA, Adult Food Security Module	Prevalence increased by one-third during the pandemic



mental conditions including stress, depression and anxiety<sup>(79)</sup>, along with other factors such as boredom<sup>(51,64)</sup> and food insecurity<sup>(37)</sup>. Other dietary habits, however, such as cooking frequency improved during the pandemic<sup>(31,32,35–37,40,56)</sup>, which could be related to the closure of on-campus cafeterias and restaurants, boredom and fear of infection from eating out/ordering foods<sup>(36)</sup>. Nevertheless, there was an increase in the total amount of energy intake<sup>(51,54)</sup>, which, along with the modifications in the dietary quality and habits, led to unfavourable weight changes. Studies have shown that no less than 20 to 30% of students gained weight during the pandemic<sup>(30,31,58,67,69)</sup>, and this was related to factors such as the male gender<sup>(33,35,50,68)</sup>, increased intake of refined carbohydrates, alcohol, fats, and take away foods<sup>(32)</sup>, increased snacking<sup>(32)</sup>, reduced sleep quality<sup>(65)</sup>, delay in meal-timing<sup>(65)</sup>, low levels of physical activity<sup>(52,65–67)</sup> and food insecurity<sup>(38)</sup>.

COVID-19 pandemic affected the students' abilities to attain food and increased the prevalence of food insecurity among this population<sup>(36–42)</sup>, with over 30% of students being food insecure in the USA<sup>(38,39,41)</sup>, Brazil<sup>(42)</sup>, Thailand<sup>(74)</sup> and Australia<sup>(75)</sup>. Factors that predicted food insecurity among college students during the pandemic included loss or reduction of employment, receipt of financial aid, furlough, alterations in living arrangements and housing status, lower cooking self-efficacy, consumption of more take-out or fast food, low diet quality, pre-COVID-19 financial status, the non-White ethnicity and closure of college campuses<sup>(38–42,74)</sup>.

The pandemic was associated with emotional eating among the college population<sup>(64)</sup> which has been linked with the replacement of healthy foods with comfort foods rich in saturated fats and refined carbohydrates. These changes could have resulted in an insufficient dietary fibre<sup>(80)</sup> and phytochemicals intake<sup>(81)</sup>.

The sudden changes in the students' lifestyle during the pandemic could affect their health by elevating their risk of various chronic diseases. The reduction in physical activity levels, the unhealthy dietary habits such as skipping meals and snacking, along with the simultaneous weight gain, have been shown to be associated with an increased risk of dyslipidemia, insulin resistance, chronic systemic inflammation, hypertension<sup>(82,83)</sup> and CVD<sup>(84)</sup>. Food insecurity also increases the risk of chronic conditions such as obesity and diabetes<sup>(85)</sup>. Additionally, food insecurity is associated with eating disorder – related impairment, binge eating and compensatory fasting<sup>(41)</sup>.

The findings of this literature review offer public health professionals and policymakers valuable information on the impact of the Covid-19 pandemic on students' diet quality and dietary habits, which can assist them to be better prepared and take effective action during future outbreaks. Governments and academic institutions should ensure that students' dietary behaviours are not compromised during the pandemic by raising awareness and placing a strong emphasis on the urgency of adopting a healthy dietary pattern<sup>(86)</sup>. Nutrition education interventions should be offered through various media outlets<sup>(87)</sup> and entrenched in school curricula<sup>(88)</sup> to instruct the students on the importance of cooking, increasing the consumption of fruits, vegetables, whole grains and fish, and avoiding unhealthy behaviours such as binge drinking, snacking and

breakfast skipping. A meta-analysis by Deliens *et al.*<sup>(87)</sup> showed that nutrition education, improvement of self-regulation towards dietary intake and point-of-purchase messaging strategies, could enhance the students' dietary intake. Mental health support must be provided through counselling centers free of charge to help students cope with anxiety, depression and stress without resorting to emotional eating during the pandemic<sup>(64)</sup>.

The findings of this review also suggest that weight gain, a manifestation of unhealthy lifestyle behaviours, should be addressed. Even amid a complete lockdown, universities should offer weight-loss counselling services, educate the students on various weight management guidelines and heavily encourage the students to engage in outdoor physical activities such as hiking, biking, swimming, etc.<sup>(48)</sup>. The faculty has a critical role to play by building and implementing online curricula designed to promote healthful eating to students of any major<sup>(89)</sup>. The online lessons should place emphasis on improving the behaviours, attitudes and self-efficacy of students to help them amend their diets and achieve weight management goals during the pandemic<sup>(90)</sup>.

This review also highlights the need to mitigate college students' food insecurity during the COVID-19 pandemic by implementing a robust, comprehensive policy response. This entails expanding the eligibility of governmental economic relief efforts to involve students, increasing access to healthy foods by raising awareness of food assistance programs and establishing food banks and food pantries near university campuses to support students during challenging times<sup>(38)</sup>.

According to the International Food Policy Research Institute, there had been a global food price crises with a dramatic surge in the prices of staple foods such as rice, beans, maize and soybeans. This has been a concern especially for low-income countries due to their governments' limited ability to protect the purchasing power of their underserved communities and prevent the high food prices from leading to food insecurity and altering diet quality<sup>(91)</sup>. To fight food insecurity, especially in developing countries, it is crucial to place emphasis on commodities' distribution and supply chain management system<sup>(92)</sup>. Necessary policy actions should be taken by the governments to stabilise food prices during pandemics. These include supplying markets during pandemics with staple foods from the public food distribution system<sup>(92)</sup>. Furthermore, policies should be established to prevent the sellers from raising the prices of foods during such crises<sup>(92)</sup>.

To our knowledge, this review is the first to take a comprehensive approach to identifying peer-reviewed journal articles published globally that delve into the effect of COVID-19 on dietary habits, diet quality, food insecurity prevalence and body weight changes of college students. It also drew from existing literature to present and consolidate the evidence for the various factors associated with the high prevalence of food insecurity and obesity among students during the pandemic. However, most of the displayed findings were generated from cross-sectional investigations which render it challenging to assess causality and make robust conclusions<sup>(30–36,38–43,49,52,55,58,63,65,67–69,74)</sup>. Nevertheless, findings from various longitudinal studies also confirmed a significant increase in body weight of college students during the pandemic<sup>(48,54,66,70)</sup> and a decrease in diet



quality<sup>(54,55)</sup>. Another limitation is the use of self-reported measures, in most of the studies, to assess and determine changes in diet quality<sup>(31,32,55,60)</sup>, dietary habits<sup>(32,50,51,60)</sup> and body weight<sup>(30–35,48,52,58,65,67–69)</sup> along with the prevalence of food insecurity<sup>(36,38–43,74,75)</sup>. When it comes to diet, for instance, most investigations relied on one survey administered at one-time point to measure intake during the pandemic and compare it retrospectively with pre-pandemic times, which may possibly be subjected to recall bias<sup>(31,50,55)</sup>. Other studies based dietary analyses on a single 24-h recall instead of repeated recalls and thus might have failed to capture usual intake<sup>(51)</sup>. Since no training was provided to participants, their perception of food portions could have led to an under/over-estimation of their actual intake<sup>(60)</sup>. Furthermore, most studies on dietary intake and habits did not conduct nutrient analysis at the level of the macro and micronutrient but exclusively assessed the intake of foods and food groups during the pandemic<sup>(31,32,37,49,64)</sup>. The majority of the studies collected body weight data by self-reporting tools such as online questionnaires instead of weight scales which could have led to social desirability bias and memory recall bias<sup>(32,48)</sup>. When it came to assessing the prevalence of food insecurity, various studies used a convenience sample which might have impacted the generalisability of the findings<sup>(39,40)</sup>.

Our systematic review has limitations. For instance, we did not contact relevant experts to include data from unpublished manuscripts and thus our systematic review might be subjected to publication bias<sup>(93)</sup>. Furthermore, we might have missed a number of articles published on this topic due to a lack of access to databases such as Web of Science. Nevertheless, by following inclusive search strategies, we made extensive efforts to identify all relevant published studies.

It is recommended, from a research standpoint, to conduct longitudinal investigations to assess the long-term effects of the pandemic on the dietary habits, body weight and food security status of students in case of subsequent pandemic waves. These studies should rely on direct means of measuring body weight such as weight scales and diet such as repeated 24-h recalls<sup>(94)</sup>. This would lead to more robust conclusions regarding the cause-and-effect relationships between the different factors presented in this review and these outcomes among higher education students. Furthermore, additional research should be conducted to explore the effect of the pandemic on the macro and micro-nutrient levels among college students.

### Conclusion

The COVID-19 outbreak has exacerbated the students' diet quality and placed them at high risk of food insecurity. Students engaged in unfavourable dietary habits such as binge eating, breakfast skipping and unhealthy snacking. This, along with other factors such as the male gender, reduced sleep quality, lack of physical activity, pre-pandemic weight status and meal-timing loneliness, have increased the susceptibility of college students to weight gain. Thus, higher education institutions and governments should improve students' access to nutritious foods and implement nutrition education interventions through the school curricula to instruct the students on the importance of following a

healthy dietary pattern. In case of future outbreaks, it would also be recommended to conduct longitudinal investigations to assess the long-term effects of the pandemic on the dietary habits, body weight and food security status of students.

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