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The association of cannabis use with fast-food consumption, overweight, and obesity among adolescents aged 12-15 years from 28 countries

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ABSTRACT

Background: Cannabis legalization and use have risen globally. However, the association between cannabis use, eating behaviors and body weight among adolescents is yet unexplored.

Objectives: This study examined the association between cannabis use, fast-food consumption, overweight and obesity in 28 countries using data from the 2010–2016 Global School-Based Student Health Survey.

Methods: Multivariable logistic regression and meta-analysis were performed among a sample of 83,726 adolescents (48.7% females) aged 12–15 years, mean (SD) age of 13.8 (0.9) years.

Results: The overall prevalence of cannabis use (in past 30 days) and fast-food consumption (in past 7 days) were 2.8% and 57.3% respectively. The overall prevalence of overweight and obesity was 14.7% and 4.2%, respectively. Cannabis use was significantly associated with fast-food consumption (OR = 1.33; 95%CI = 1.13–1.57) but not with overweight (OR = 0.95; 95%CI = 0.80–1.14) or obesity (OR = 1.16; 95%CI = 0.85–1.59). For obesity, there was a moderate level of between-country heterogeneity (I^2 = 51.9%) and significant positive associations with cannabis use were observed in Bahamas, Bangladesh, Namibia and Nepal.

Conclusion: The results highlight the association between cannabis use and dietary risks, providing evidence for public health interventions on the interrelated nature of cannabis use and fast-food consumption.

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Cannabis; adolescence; obesity; overweight; fast-food consumption

Introduction

Cannabis use among adolescents is common, with a lifetime prevalence of 4% (Carvalho et al., 2019). In the past 20 years, cannabis use has remained stable among American adolescents, yet has increased in some South American countries (Johnston et al., 2018; Observatorio Argentino de Drogas, 2016; Observatorio Chileno de Drogas, 2016; Observatorio Uruguayo de Drogas, 2016). Meanwhile, in Africa and Oceania, cannabis use has become a primary concern in treatment episodes among those seeking treatment for substance abuse (UNODC, 2015). However, the impact of cannabis on human health remains unclear (Volkow et al., 2014). Information on its potential adverse health outcomes and behaviors is necessary to inform health policies and the ongoing international debates around legalization of recreational cannabis use.

Obesity is a common and complex issue among adolescents. More than 340 million children and adolescents aged 5–19 had either overweight or obesity in 2016 worldwide (World Health Organization, 2021). Recent changes in the accessibility of high-calorie fast-food are linked to the rising cases of obesity (Romieu et al., 2017), especially among adolescents, who face significant changes in their eating choices (Chaudhri et al., 2008). Increased cannabis use during adolescence could be another contributing factor for it, however, studies on the association of cannabis use with unhealthy diets and overweight/obesity are scarce. Some data report that cannabis use can stimulate appetite and increase food and caloric intake (Baggio & Chong, 2020; Kruger et al., 2019; Roberts et al., 2019; Rodondi et al., 2006). Specifically, cannabis is known to induce 'munchies,' a phenomenon classified by a greater appetite as well as greater food consumption, driven by an increased appreciation of food; this process is theorized to be explained by the cannabinoid tetrahydrocannabinol (THC), and its stimulation of the endocannabinoid system (ECS) (Roberts et al., 2019). An American study found that among 275 adult

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participants, 77% reported eating unhealthy food when under the influence of cannabis; furthermore, participants reported eating larger amounts of food when intoxicated by cannabis (Kruger et al., 2019). Another recent study examined food purchasing patterns in super-markets of states that had recently undergone recreational marijuana legislation and found that sales of energy-dense foods increased significantly in the months following legalization (Baggio & Chong, 2020). However, there exists little large-scale empirical data on cannabis use and eating behaviors in humans, as most studies have use animal models, and those that have been conducted among humans have tended to be American-centric, and based on unhealthy food in generally, not specifically fast-food.

Another mechanism by which cannabis could lead to overweight is through alcohol. A study by Wen and colleagues found an association between implementation of medical marijuana and increasing frequency of binge drinking, possibly due to the increased simultaneous use of alcohol and cannabis (Wen et al., 2014), and binge drinking could in turn lead to overweight (Souza E Souza et al., 2020). However, the relationship between cannabis and alcohol seems to be complex; a study on substitution and complementarity of alcohol and cannabis, for instance, found that both substances act as substitutes and complements, suggesting that consumption of one substance may influence consumption of other, according to more lenient or restringing policies (Subbaraman, 2016). Tobacco is also heavily associated with cannabis use, with a large body of literature reporting an inverse association between the two (Agrawal et al., 2012). Given how tobacco could in turn influence appetite and body weight via its effect on appetite suppression (Chen et al., 2005), and with studies reporting associations between tobacco and weight status in adolescence (Wang, 2021), it may be that a diminished tobacco consumption due to increased cannabis use could remove its suppressant effect on appetite, leading to higher caloric intake. Altogether, this suggest a complex association between these substances, with patterns of substitution or simultaneous and sequential use (Roche et al., 2019; Schauer et al., 2016; Williams et al., 2004) which might in turn impact weight status.

However, despite many pathways being suggested for the influence of marijuana on weight status, such as obesogenic diets and unhealthy behaviors, previous studies on cannabis use and overweight/obesity have found mixed results. A study has reported that enforcing medical marijuana laws is actually associated with a reduction in obesity risk (Sabia et al., 2017). Previous American studies have reported either positive, negative or null associations (Alshaarawy & Anthony, 2019; Bancks et al., 2018; Li et al., 2016; Rodondi et al., 2006), with previously reported negative and null associations possibly related to increases in metabolic rates associated with cannabis use (Rodondi et al., 2006). Further studies on this issue from diverse settings are necessary to understand the effect of cannabis on body weight, especially given the global concerns about the rising levels of obesity in adolescents (Abarca-Gómez et al., 2017).

Thus, the aims of the current study were to examine the association of cannabis use with fast-food consumption and overweight/obesity among young adolescents from 28 countries from Africa, Asia, and the Americas, which were predominantly low- and middle-income countries (LMICs). Studies from these countries are necessary as there are no data on this topic from LMICs or non-Organization for Economic Cooperation and Development (OECD) high-income countries. This is concerning, considering the growing prevalence of obesity in such areas and how dietary habits are considered among the main contributors of such increase (Ford et al., 2017). Furthermore, to date, there are no multinational studies exploring these associations, despite how these may reveal how differing policies and factors affect the health patterns of each country. Finally, the focus on adolescents is important as adolescence is the time in which health behaviors are likely formed, hence preventing obesity in adolescence could buffer other associated health consequences later in life (Solmi et al., 2018).

Methods

Data from the Global School-Based Student Health Survey (GSHS) were analyzed. Details are provided at http://www.who.int/chp/gshs and http://www.cdc.gov/gshs. the GSHS was developed by the US Centers for Disease Control and Prevention (CDC), World Health organization (WHO) and other UN allies. The aim of this survey was to examine and quantify risk and protective factors of major non-communicable diseases. The survey draws content from the CDC Youth Risk Behavior Survey (YRBS) which has established test-retest reliability (Brener et al., 1995). The selection process of this survey consisted of a standardized two-stage probability sampling design within each participating country. Schools were selected with probability proportional to size sampling in the first stage. In the second stage, classrooms including students aged 13–15 years within each selected school were randomly selected. All students in the selected classrooms were allowed to participate in the survey even if their age was not 13–15 years. Data collection was conducted during one regular class period. The questionnaire was translated into the local language in each country. Students recorded their response on computer scannable sheets with multiple-choice response options. A national government administration (most often the Ministry of Health or Education) and an institutional review board or ethics committee approved the GSHS survey in each country. Student privacy was protected via anonymous and voluntary participation. Informed consent was obtained as appropriate from the students, parents and/or school officials. Data were weighted for probability selection and non-response.

From all publicly available data, we selected all nationally representative datasets that included the variables used in the current analysis. If there were more than two datasets from the same country, we chose the most recent dataset. Furthermore, we deleted countries with more than 20% of the data on overweight or obesity missing. A total of 28 countries were included in the current study. The characteristics of each country or survey are provided in Table 1. Based on the World Bank classification at the time of the survey, with the exception of six countries (Bahamas, Barbados, Brunei Darussalam, French Polynesia, Seychelles, and Trinidad & Tobago), all remaining countries were LMICs. For included countries, the survey was conducted between 2010 and 2016.

Table 1. Survey characteristics and prevalence of cannabis use, fast food consumption, overweight, and obesity by country.

Country	Year	Response rate (%)	N[a]	Cannabis use (%)	Fast food consumption (%)	Overweight (%)	Obesity (%)
Bahamas	2013	78	1,308	6.1	72.1	24.4	21.3
Bangladesh	2014	91	2,753	1.6	53.3	8.1	1.3
Barbados	2011	73	1,504	9.3	62.4	17.7	14.2
Benin	2016	78	717	0.3	46.3	12.8	2.4
Bolivia	2012	88	2,804	2.6	56.9	17.3	4.7
Brunei Darussalam	2014	65	1,824	0.2	66.2	18.7	17.5
Dominican Republic	2016	63	954	4.0	46.7	20.1	12.3
East Timor	2015	79	1,631	5.8	67.0	4.7	1.2
Fiji	2016	79	1,537	5.1	64.2	19.4	8.2
French Polynesia	2015	70	1,902	10.4	71.4	23.9	22.1
Ghana	2012	82	1,110	7.4	69.9	7.2	1.9
Indonesia	2015	94	8,806	1.2	54.7	11.0	5.3
Jamaica	2017	60	1,061	10.9	58.4	15.6	10.1
Kiribati	2011	85	1,340	4.6	43.9	31.9	8.0
Laos	2015	70	1,644	0.6	44.8	9.4	2.2
Lebanon	2017	82	3,347	1.6	77.1	20.3	6.8
Malaysia	2012	89	16,273	1.0	48.3	14.1	9.7
Mauritius	2017	84	1,955	4.0	57.4	15.5	9.2
Mongolia	2013	88	3,707	1.1	55.2	10.1	1.8
Namibia	2013	89	1,936	4.6	53.9	5.7	1.9
Nepal	2015	69	4,616	2.5	75.3	6.7	0.5
Peru	2010	85	2,359	2.9	50.0	17.7	2.9
Philippines	2015	79	6,162	5.3	51.9	7.9	2.8
Seychelles	2015	82	2,061	8.0	70.5	16.9	12.6
Suriname	2016	83	1,453	2.7	63.8	17.6	11.5
Thailand	2015	89	4,132	5.3	80.1	13.5	6.6
Tonga	2017	80	1,946	5.7	69.6	30.0	25.1
Trinidad & Tobago	2017	90	2,363	5.3	67.1	16.4	17.8

[a]Only includes individuals aged 12–15 years.

Cannabis use

Past 30-day cannabis use was assessed with the question "During the past 30 days, how many times have you used marijuana?" Country-specific slang terms for marijuana were also included in the question. Marijuana use was defined as having used marijuana on at least one day in the past 30 days in line with a previous GSHS publication (Carvalho et al., 2019).

Fast-food consumption

Fast-food consumption was assessed with the question "During the past 7 days, on how many days did you eat food from a fast food restaurant?" with country specific examples on fast-food restaurants. This variable was dichotomized as at least once or not.

Overweight and obesity

Trained survey staff conducted measurement of weight and height. Body mass index (BMI) was calculated as weight in kilograms divided by height in meters squared. Obesity and overweight were defined as >2 SDs and >1 SD above the median for age and sex based on the 2007 WHO Child Growth reference, respectively, and adolescents below −2 SDs were considered to be underweight (Caleyachetty et al., 2018). All other participants were considered to be normal weight.

Covariates

The selection of control variables was based on past literature and included age, sex, food insecurity (a proxy of socioeconomic status), parental support, alcohol consumption, and smoking (Rodondi et al., 2006), as literature reports an inverse association between marijuana consumption and smoking, possibly due to substitution into marijuana from cigarettes (Choi et al., 2019) and a direct one with binge drinking, potentially because of an increased simultaneous use of the two substances (Wen et al., 2015). As in a previous GSHS study, food insecurity was used as a proxy for socioeconomic status as there were no variables on socioeconomic status in the GSHS (Carvalho et al., 2019). This was assessed by the question "During the past 30 days, how often did you go hungry because there was not enough food in your home?" Answer options were categorized as 'never,' 'rarely/sometimes,' and 'most of the time/always.' Low parental involvement was defined as answering 'rarely' or 'never' to all of these three questions: (a) 'during the past 30 days, how often did your parents or guardians check to see if your homework was done?'; (b) 'during the past 30 days, how often did your parents or guardians understand your problems and worries?'; and (c) 'during the past 30 days, how often did your parents or guardians really know what you were doing with your free time?' (Romo et al., 2016). Alcohol consumption was defined as having had one drink containing alcohol for at least one day in the past 30 days. Smoking was defined as having smoked at least on one day during the past 30 days.

Statistical analysis

Analyses were performed with Stata 14.1 (Stata Corp LP, College station, Texas). The association between cannabis use (exposure) and fast-food consumption, overweight, or obesity (outcomes) was assessed by country-wise multivariable logistic regression analyses. Analyses were adjusted for age, sex, food insecurity, parental support, alcohol consumption, and

smoking. The analysis on overweight and obesity excluded those with underweight (n = 4915) as our aim was to assess the association between cannabis use and overweight/obesity in comparison with normal weight. Furthermore, the analysis on overweight excluded those with obesity, and that on obesity excluded those with overweight.

Pooled estimates were obtained by meta-analysis with random effects based on country-wise estimates. To assess the level of between-country heterogeneity in the association of cannabis use with fast-food consumption, overweight, and obesity, we calculated the Higgins's I^2 which represents the degree of heterogeneity not explained by sampling error with a value of <40% often considered as negligible and 40–60% as moderate heterogeneity (Higgins & Thompson, 2002).

All variables were included in the regression analysis as categorical variables with the exception of age (continuous). Sampling weights and the clustered sampling design of the surveys were taken into account. Results from logistic regression analyses are presented as odds ratios (ORs) with 95% confidence intervals (CIs). Statistical significance was set at $p < .05$.

Results

The analyses included 83,726 adolescents aged 12–15 years [mean (SD) age 13.8 (0.9) years; 51.3% boys]. Sample characteristics divided by countries are reported in Table 2: Philippines was the country reporting more food insecurity (69.4%), East Timor reported the higher prevalence of low parental support (26.5%), Barbados the highest prevalence of alcohol consumption (46.4%) and Kiribati the highest prevalence of smoking (25.9%). Overall, the prevalence of cannabis use, fast-food consumption, overweight, and obesity were 2.8%, 57.3%, 14.7%, and 4.2%, respectively, although a wide range between countries was observed (Table 1). Figure 1 reports the country-wise association between cannabis use and fast-food consumption estimated by multivariable logistic regression. The overall estimate based on a meta-analysis was statistically significant (OR = 1.33; 95%CI = 1.13–1.57) with a low level of between-country heterogeneity (I^2 = 34.6%). There was a positive association (i.e., OR>1) between cannabis use and fast-food consumption in most countries, although statistical significance was reached only in Philippines (OR = 2.22; 95%CI = 1.41–3.51), Malaysia (OR = 2.37; 95% CI = 1.42–3.96), Namibia (OR = 2.78; 95%CI = 1.44–5.38), and Fiji (OR = 3.08; 95%CI = 1.04–9.15). Figure 2 illustrates the country-wise association between cannabis use and overweight. Statistical significance was not observed in any of the countries while the overall estimate was also non-significant (OR = 0.95; 95%CI = 0.80–1.14) with a low level of heterogeneity (I^2 = 0.0%). Finally, cannabis use was not significantly associated with obesity (Figure 3) based on the overall estimate (OR = 1.16; 95%CI = 0.85–1.59) but there was a moderate level of between-country heterogeneity (I^2 = 51.9%) with significant associations observed in Bahamas (OR = 2.94; 95%CI = 1.52–5.72), Namibia (OR = 3.06; 95%CI = 1.13–8.32), Bangladesh (OR = 12.82; 95%CI = 1.92–85.58), and Nepal (OR = 27.31; 95%CI = 5.14–145.17).

Table 2. Sample characteristics.

Country	Age [mean (SD)]	Male (%)	Foodinsecurity (%)[a]	Low parental support (%)	Alcohol consumption (%)	Smoking (%)
Bahamas	13.4 (1.0)	47.3	47.3	14.2	27.4	4.6
Bangladesh	14.0 (0.8)	63.4	61.7	9.1	1.4	6.9
Barbados	14.1 (0.8)	51.1	43.0	20.8	46.4	9.5
Benin	14.2 (0.9)	65.6	49.2	14.9	38.6	3.6
Bolivia	14.0 (0.9)	49.7	60.9	19.8	14.7	12.1
Brunei Darussalam	14.0 (0.9)	48.2	61.3	20.6	3.7	8.5
Dominican Republic	14.3 (1.0)	48.6	32.6	11.3	37.5	7.6
East Timor	14.1 (1.0)	46.3	49.2	26.5	12.3	15.3
Fiji	14.4 (0.6)	49.0	59.6	7.7	13.2	8.5
French Polynesia	13.7 (1.0)	49.7	65.4	11.8	32.7	15.7
Ghana	13.8 (1.0)	49.1	61.2	11.3	15.3	8.4
Indonesia	13.5 (1.0)	49.2	53.9	8.0	3.7	10.4
Jamaica	14.2 (0.8)	47.9	47.0	14.0	45.2	13.3
Kiribati	14.0 (0.9)	45.5	67.1	24.6	29.8	25.9
Laos	14.5 (0.8)	47.8	46.8	19.3	19.8	3.6
Lebanon	13.6 (1.0)	47.4	30.6	10.9	15.6	10.0
Malaysia	14.0 (0.9)	49.5	60.7	18.7	7.5	9.4
Mauritius	13.9 (0.8)	45.8	43.6	15.8	20.9	15.3
Mongolia	13.7 (1.0)	49.4	36.0	14.6	4.1	5.4
Namibia	14.1 (0.9)	42.9	53.9	11.8	23.0	8.1
Nepal	13.8 (1.0)	47.3	32.2	12.3	4.6	4.9
Peru	14.1 (0.8)	49.9	51.2	16.4	26.9	17.0
Philippines	13.9 (0.9)	48.1	69.4	22.8	17.5	11.5
Seychelles	13.5 (1.1)	49.5	44.2	16.0	45.4	18.3
Suriname	13.8 (1.0)	46.1	42.1	12.5	34.2	10.9
Thailand	13.7 (1.0)	49.6	53.6	16.8	17.6	9.4
Tonga	13.6 (1.1)	51.4	66.6	16.5	10.4	14.0
Trinidad & Tobago	13.6 (1.1)	48.3	49.1	14.9	26.5	8.9
Total	13.7 (0.9)	51.3	56.7	13.2	9.4	9.7

Abbreviation: SD Standard deviation
Data are % unless otherwise stated.
[a]Food insecurity referred to answering 'rare/sometimes' or 'most of the time/always' to the question "During the past 30 days, how often did you go hungry because there was not enough food in your home?"

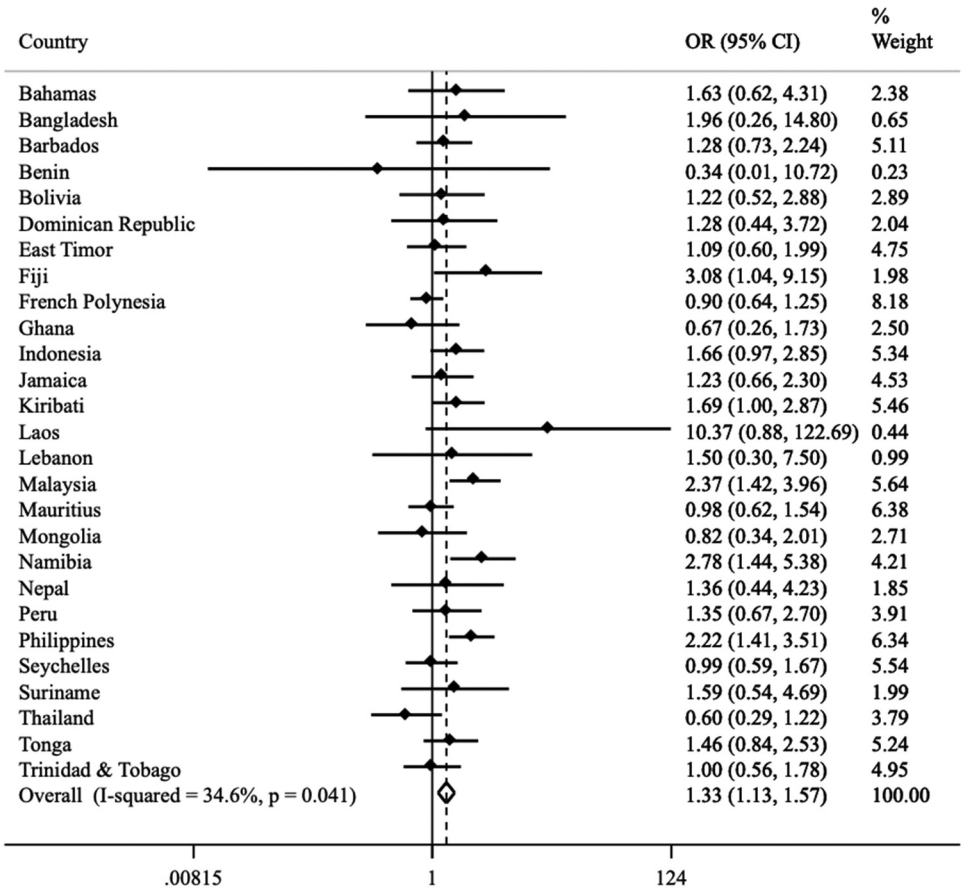

Figure 1. Association between cannabis use and fast-food consumption estimated by multivariable logistic regression. Abbreviation: OR Odds ratio; CI Confidence intervalModels were adjusted for age, sex, food insecurity, parental support, alcohol consumption, and smoking.Overall estimate was obtained by meta-analysis with random effects.Estimates from Brunei Darussalam could not be obtained because there were no individuals who did not consume fast food among users of cannabis.

Discussion

To the best of our knowledge, this is the first multi-country study assessing the associations between cannabis use, fast-food consumption and overweight and obesity, and to assess these associations among adolescents. We found that cannabis use was associated with a 1.33 (95%CI = 1.13–1.57) times higher odds for fast-food consumption, with strong associations (i.e., OR 2.0–3.0) being observed in countries such as Namibia and Malaysia. Cannabis use was not significantly associated with overweight nor obesity based on the overall estimate. However, for obesity, strong significant associations were observed in some countries (e.g., Nepal, Bangladesh). There was a moderate level of between-country heterogeneity for the association between cannabis use and obesity, possibly due to differences in socio-cultural factors, like variation in the availability of either cannabis or fast-food.

Our findings that cannabis use was associated with unhealthy food consumption are consistent with past literature. Roberts et al. (Roberts et al., 2019) explain how cannabis use can be accompanied by greater food consumption. Kruger et al. (Kruger et al., 2019) found that unhealthy foods were preferred over healthy ones when adults were under the influence of cannabis, and participants also reported eating more when intoxicated. Previous research has found that individuals under the influence of cannabis exhibit a significant increase in consumption of high carbohydrate foods (Foltin et al., 1988; Mohs et al., 1990; Smit & Crespo, 2001), often frequent in fast-foods.

Several hypotheses may be proposed on the association between cannabis and fast-food. First, cannabinoid tetrahydrocannabinol (THC) and its stimulation of the ECS may be implicated: cannabis-induced hyperphagia is likely a result of natural changes in endocannabinoid-mediated hunger; furthermore, adjustments in sensory and food-reward processes, which lead to improved appetite and food appreciation, may also play a role (Roberts et al., 2019). Consuming greater fast-food may be linked to individuals' judgments and decision-making being affected when under the influence of cannabis (Kruger et al., 2019). Finally, there may be shared underlying factors leading to both fast-food eating behaviors and cannabis consumption, such as parental factors, neighborhood level safety, or peer-influence. More research is needed to elucidate the effects of these mechanisms.

Interestingly, while cannabis use was associated with fast-food consumption, it was not associated with overweight and obesity. This is consistent with past research on the association between cannabis use and weight status, which has been examined longitudinally in various studies (Alshaarawy & Anthony, 2019; Bancks et al., 2018; Jin et al., 2017; Rodondi et al., 2006). Rodondi et al. (Rodondi et al., 2006) found that among adolescents cannabis use was longitudinally associated with higher caloric intake, but not with higher BMI. Another longitudinal

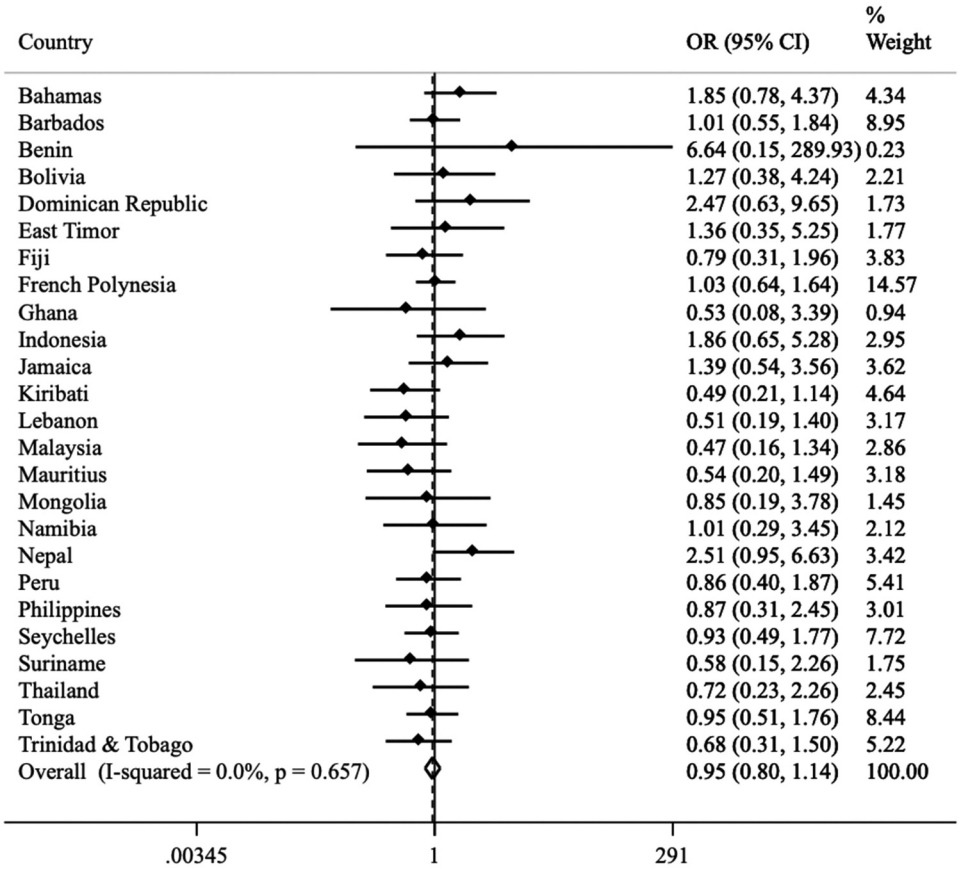

Figure 2. Association between cannabis use and overweight (vs. normal weight) estimated by multivariable logistic regression. Abbreviation: OR Odds ratio; CI Confidence intervalModels were adjusted for age, sex, food insecurity, parental support, alcohol consumption, and smoking.Individuals with underweight or obesity were deleted from the analysis.Overall estimate was obtained by meta-analysis with random effects.Estimates from Bangladesh, Brunei Darussalam, and Laos could not be obtained because there were no individuals with overweight among users of cannabis.

study found that marijuana use was not significantly associated with adiposity 15 years later in mid-life (Bancks et al., 2018). Similarly, Jin and colleagues (Jin et al., 2017) found no association between adolescent cannabis use and weight gain in mid-life. However, there are some contrasting results. Longitudinal results report cannabis users being less likely to have increased BMI over a 3-year time period (Alshaarawy & Anthony, 2019). Furthermore, one cross-sectional study on African American women found that the risk of having overweight or obesity was lower among marijuana users (Li et al., 2016). Research has pointed out how weight status perception, rather than objective weight, is more consistently associated with risky health behaviors in adolescents (Jiang et al., 2014). Therefore, future studies may wish to consider weight perception when assessing the association between weight status and cannabis use.

Our study reported a moderate level of between-country heterogeneity for the association between cannabis use and obesity. Cannabis use can vary between countries, and this may partly be driving this between-country difference. Evidence suggests that the manner in which cannabis is used (i.e., smoking vs. ingesting), as well as its composition and THC concentration, varies greatly between countries, with differential effects on health (Hall, 2015; World Health Organization, 2016). Evidence suggest that THC ingestion specifically, downregulates cannabinoid receptor type 1 (CB1R) and is associated with reduced obesity rates (Clark et al., 2018). Our findings of a positive association between cannabis use and obesity in some specific countries are novel. Similarly, while previous studies have reported cannabis use as a risk factor for low physical activity which may lead to an increased risk for obesity, this association is not consistent across countries (Ashdown-Franks et al., 2020). Future research is hence needed to better clarify this between-country heterogeneity in this relationship.

The relationships between cannabis use, fast-food consumption and obesity are complex. Based on our findings, while cannabis use may affect food consumption, it does not play a role in adolescent obesity. This may be explained by metabolic rates. In an experimental study, cannabis smoking caused a 28% increase in metabolic rate (Zwillich et al., 1978). This increased metabolic rate among cannabis users could explain the lack of association between cannabis use and obesity, despite higher fast-food consumption (Rodondi et al., 2006).

Clark and colleagues (Clark et al., 2018) suggest that acute cannabis consumption causes down-regulation of cannabinoid receptor type 1 (CB1), which decreases energy storage and increases metabolic rates; this process then reverses the impact of elevated dietary omega-3/omega-6 ratios. Alternatively, the null relationships with weight status may be attributable to (i) cannabis users replacing healthful foods with fast-food but maintaining a similar total calorific intake to non-users despite the poorer

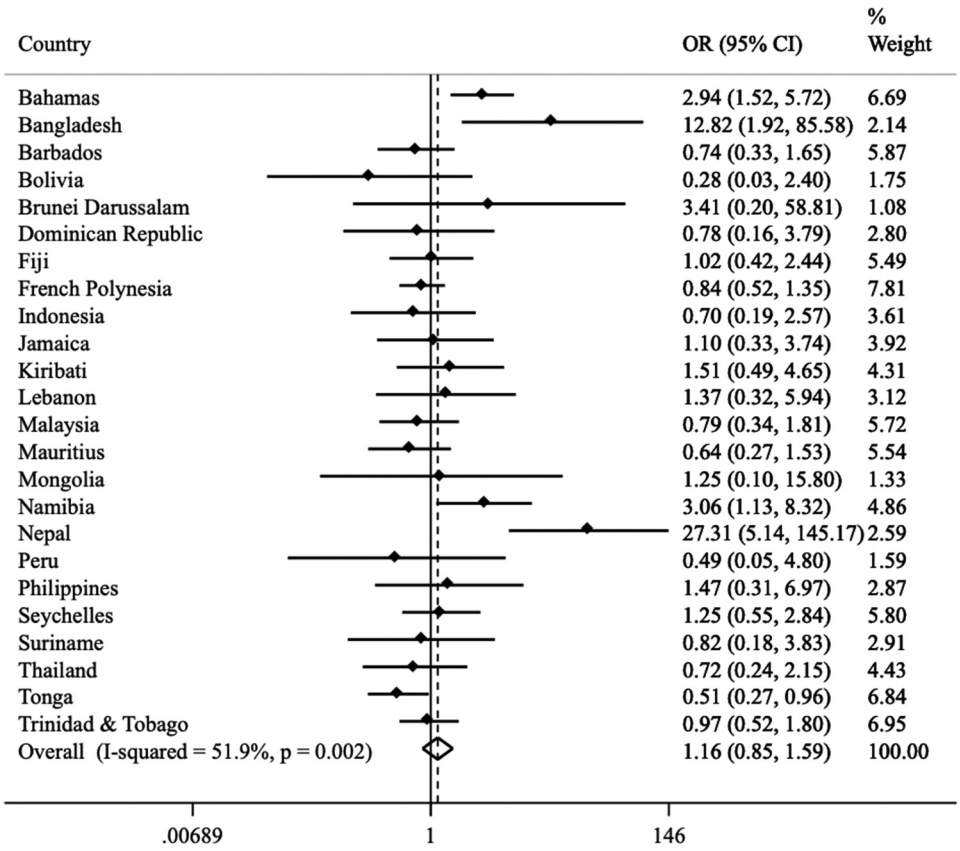

Figure 3. Association between cannabis use and obesity (vs. normal weight) estimated by multivariable logistic regression. Abbreviation: OR Odds ratio; CI Confidence intervalModels were adjusted for age, sex, food insecurity, parental support, alcohol consumption, and smoking.Individuals with underweight or underweight were deleted from the analysis.Overall estimate was obtained by meta-analysis with random effects.Estimates from Benin, East Timor, Ghana, and Laos could not be obtained because there were no individuals with obesity among users of cannabis.

nutritional value, or (ii) the young age of the studied sample, meaning that insufficient time has passed for adverse eating habits to have significantly affected weight across these populations.

Considering the more consistent association of weight perception with substance use among adolescents (Jiang et al., 2014), weight stigma could be another mediator for the associations we studied. A greater engagement in substance consumption among adolescents who self-perceive as obese may be the result of stress coping due to weight stigma (Farhat, 2015). Cannabis use as the result of weight stigma can increase fast-food consumption by increasing caloric consumption (Schvey et al., 2011). In light of such evidence, our results could suggest that marijuana and fast-food consumption might be both consequences of weight stigma, a result of coping mechanism and/or dysregulation due to the stress associated with it (Douglas & Varnado-Sullivan, 2016; Puhl & Brownell, 2006; Puhl & Lessard, 2020).

Altogether, our findings indicate how countries reporting a high consumption of marijuana should consider its potential effects in terms of food intake among adolescents. This is especially relevant in those countries where childhood obesity and fast-food consumption are on the rise, and marijuana could hence potentially contribute by proxy to the obesogenic environment (Leandro et al., 2019; Poskitt, 2014). These results hence call for a need of a parallel focus on health-diet promotion in those areas where marijuana legalization is being considered. Regarding developed countries, a study on Canadian has reported how cannabis consumers report spending a lot more on fast-food across all age groups (Horak & Frei, 2022). Taxing fast-foods could be a solution; some results from countries such as UK, US, Germany and Australia show beneficial effect of policies taxing sugar-sweetened beverages on physical health outcomes (Park & Yu, 2019), and similarly, fast-food taxing could be considered, if well implemented with a parallel promotion of healthy eating habits (Holt, 2010). Finally, since fast-food seems to be specifically clustered in poorer areas, developed countries should consider modifying the food environment, tackling health inequalities and allowing an easier access to nutrient-dense food rather than energy-dense food in more deprived neighborhoods (Carrillo-Álvarez et al., 2019).

Despite its many strengths, this study has some limitations. Firstly, we could not examine the impact of healthcare systems and infrastructures, which can vary depending on the area studied. This is especially important considering how the use and legalization of marijuana varies across countries, with some literature suggesting that its use might be beneficial for people with obesity rather than detrimental (Clark et al., 2018; Greenway & Kirwan, 2019). At the same time, data on the association between marijuana and obesity are scarce (Ravi et al., 2018) or mainly focussed on medical marijuana (Caputi, 2019); moreover, some results from LMICs report how the use of cannabis is associated with lower physical activity in adolescents as well, which is in turn a risk factor for obesity

(Ashdown-Franks et al., 2019). Furthermore, the laws, policies and public attitudes toward cannabis vary among the countries examined and may have impacted the results we identified. For example, Jamaica has mostly decriminalized marijuana (Ministry of Justice, 2015), while producing, importing and selling recreational marijuana is prohibited in Bosnia and Herzegovina (CMS, 2020). This could have had an impact on our research goal, and further research is needed to prospectively examine such influences. As a whole, this reflects the complexity of the use of marijuana in relation to body weight, especially in LMICs, and further research is hence warranted.

In addition to the abovementioned limitations, our data were cross-sectional, and causation cannot be inferred; longitudinal analyses would provide a more comprehensive picture of the cannabis-obesity relationship. Second, cannabis use and fast-food consumption were calculated from self-report measures, which are subject to bias. Third, data on type of cannabis use was not available and future research should examine how different cannabis uses and compositions affect fast-food consumption and obesity. Moreover, we could not assess the influence of weight stigma and weight perception due to lack of data. Previous literature has reported evidence on how weight stigma increases caloric consumption (Major et al., 2014) and overeating (Romano et al., 2018). These could be crucial mediators of the relationship between cannabis use and obesity, and future studies may benefit from considering these variables. Furthermore, the current dataset does not provide information on timing of fast-food consumption with regards to cannabis use, which also represents a possible direction for future research. Finally, future research could also consider the impact of the specific area where people lived, and factors such as weather, wealth and climate and their potential influence on weight status and eating habits.

In conclusion, we found a significant association between cannabis use and fast-food consumption among adolescents. We did not find an association between cannabis use and overweight or obesity overall, but a positive association between cannabis use and obesity was found in selected countries. As dietary risks are associated with a range of physical diseases (Gakidou et al., 2017; Stuckler & Nestle, 2012) and poor mental health outcomes (Firth et al., 2020), both leading causes of global disease burden (Gakidou et al., 2017), future public health interventions should consider the interrelated nature of cannabis use and fast-food consumption in adolescents. Further research investigating how the association between cannabis use and increased fast-food consumption may increase the risk for chronic conditions is warranted, along with studies aiming to understand the between-country heterogeneity in this association.

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