

# Dietary intake and nutritional status of US adult marijuana users: results from the Third National Health and Nutrition Examination Survey

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## Abstract

**Objectives:** This study examined dietary intakes and nutritional status of marijuana users and non-current marijuana users in US adults aged 20 to 59 years.

**Methods:** We used data from the Third National Health and Nutrition Examination Survey (NHANES III), 1988–1994. Information on self-reported drug use, including marijuana, was obtained as part of the NHANES III physical examination component. Nutritional status was assessed using height and weight, and blood biochemistries. Dietary intake was assessed using a 24-hour recall and a food-frequency questionnaire.

**Results:** Among adults 20–59 years of age, 45% reported ever having used marijuana in their lifetime. A total of 8.7% reported using marijuana in the past month. Current marijuana users had higher intakes of energy and nutrients than non-current marijuana users; however, body mass index (BMI) was slightly lower. We found higher cigarette-smoking rates and higher consumption of sodas and alcohol, specifically beer, among marijuana users than among non-current marijuana users. Marijuana users also consumed more sodium, fewer fruits, and more pork, cheese, and salty snacks. Nutritional status, using indicators of serum nutrients, serum albumin, haematocrit and haemoglobin, was similar between marijuana users and non-current marijuana users. Serum carotenoid levels were lower among marijuana users, independent of cigarette smoking.

**Conclusion:** Dietary intake was different among marijuana users than among non-current marijuana users. Although overall nutritional status was similar, serum carotenoid levels were lower in marijuana users. The long-term health effects of these differences in marijuana users deserve careful consideration in future research.

**Keywords**  
NHANES III  
Marijuana users  
Diet  
Nutritional status

Marijuana is the most commonly used illicit drug in the USA. Approximately one-third of the US population aged 12 years or older, or 72 million persons, have reported smoking marijuana at some point in their life<sup>1</sup>. Trends in marijuana use have not changed dramatically since 1991<sup>1</sup>. The National College Health Risk Behavior Survey found that 59.6% of students aged 25 years and older reported ever having used marijuana, with 8.3% reporting being current users of marijuana<sup>2</sup>.

In response to public pressure to allow for the medical use of marijuana, the Office of National Drug Control Policy of the United States evaluated the scientific evidence for the benefits and risks of using marijuana as a medicine<sup>3</sup>. We know little about the long-term effects of marijuana use on the human body and other concomitant health behaviours associated with marijuana consumption.

The report called for an increase in research to evaluate the health consequences of marijuana use and other behaviours associated with consumption of marijuana. It is important that we learn more about the changes in dietary habits that accompany marijuana use and their beneficial or detrimental effect in the development of chronic diseases later in life.

Use of psychoactive drugs, including marijuana, has been reported to affect food and beverage consumption, and body weight<sup>4–8</sup>. Mendelson studied chronic marijuana users in a laboratory setting and found that the participants increased caloric intake and gained weight during periods of active marijuana use<sup>5</sup>. Similarly, after administering marijuana to 12 healthy volunteers, Hollister found total food intake, and reports of hunger and appetite, to increase<sup>6</sup>. Foltin *et al.* also showed that

marijuana users increased their caloric intake and that this increase was mostly due to increases in between-meal snack items<sup>7</sup>. In a random double-blind study of eight subjects, Zwillich *et al.* showed that the metabolic rate was increased 15 to 120 min after marijuana administration<sup>8</sup>.

Most of these studies have focused on the immediate effect of marijuana use. Limited information is available about the intake of marijuana users in the free-living population. We examined dietary intake and related factors in the non-institutionalised US adult population among those reporting using marijuana and those not currently using marijuana.

## Methods

### Study population

The study population consists of participants of the Third National Health and Nutrition Examination Survey, 1988–1994 (NHANES III). The study design is described in detail in the *Plan and Operation of the Third National Health and Nutrition Examination Survey*<sup>9</sup>. NHANES III uses a highly stratified multistage probability design and employs over-sampling of the elderly, non-Hispanic blacks and Mexican-Americans.

We limit this analysis to adults defined as aged 20 and above. Additionally, only participants up to age 60 years were asked about marijuana use. Our analytic sample thus consists of those participants aged 20–59 years. A sample of 14,883 persons 20–59 years old was selected and asked to complete an extensive in-home interview and a health examination at the mobile examination centre (MEC). A total of 12,229 (82% of the sample persons) were interviewed, and 11,271 (76% of the sample persons) were examined. The total analytic sample, excluding incomplete and unreliable dietary recalls and incomplete marijuana data, is 10,623 adults, which is 94% of those participants who were examined and 71% of the total persons sampled.

The household interview generally took place one to three weeks prior to the MEC health examination. Data on marijuana use were collected during the health examination. Non-current marijuana users included never users ( $n = 5843$ ) and those who reported ever having used marijuana, but who had not used marijuana in the past month ( $n = 3928$ ). Initial analysis showed these two groups to be similar in social characteristics (e.g. age and education) and dietary intake, and therefore they were combined ( $n = 9771$ ). We classified participants who reported using marijuana in the past month (number of days in the past month) by frequency of use: less than or equal to four days per month ( $n = 541$ ), five to 10 days per month ( $n = 135$ ), and 11 or more days per month ( $n = 176$ ). For the purpose of this paper, we shall refer to these groups as light, moderate and heavy users, respectively.

### Dietary intake assessment

One 24-hour dietary recall was collected during the visit to the MEC. The dietary interviewers used the Dietary Data Collection system, which is an automated, standardised, interactive dietary interview and coding system. The system was specifically developed for NHANES III by the University of Minnesota Nutrition Coordinating Center. Participants were asked to report all foods and beverages consumed, excluding plain drinking water, during the previous 24 hours, from midnight to midnight.

During the household interview, a food-frequency questionnaire (FFQ) with a one month reference period was administered by an interviewer. The FFQ did not include information on serving size and is not designed to provide quantitative nutrient data. It does provide information on the frequency of consumption of specific foods or food groupings, such as frequency of beer use or frequency of the use of salty snacks during the past month.

### Blood measurements

Blood concentrations were determined on a specimen obtained by venipuncture during the visit to the MEC. Details of the laboratory procedures can be found in the Laboratory Procedures Used in NHANES III<sup>10</sup>. The Coulter Counter Model S-PLUS JR with Coulter histogram differential is a quantitative, automated haematology analyser and was used to determine 16 haematologic parameters including haemoglobin and haematocrit. Albumin was measured with the Boehringer Mannheim Diagnostics (BMD, Indianapolis, IN) albumin system and the bromocresol purple binding agent. Folate was measured by using the Bio-Rad Laboratories 'Quantaphase Folate' radioassay kit. Serum levels of vitamin A (retinol), vitamin E (tocopherol) and carotenoids were measured by isocratic high-performance liquid chromatography with detection at three different wavelengths.

Serum total cholesterol was analysed enzymatically in the Johns Hopkins University Lipid Research Clinic Laboratory, using the method of Allain *et al.*<sup>11</sup> and the reagent mixture from BMD (Cholesterol/HP, catalogue no. 816302).

### Statistical analysis

Total and adjusted means and variances of dietary intake and blood biochemistries were calculated using SAS (Release 6.12, 1996; SAS, Inc., Cary, NC) and SUDAAN (Release 7.5.2, 1998; Research Triangle Institute, NC). Sample weights, provided by the National Center for Health Statistics, were used to correct for differential selection probabilities and to adjust for non-coverage and non-response. Adjustments for confounding variables were done using weighted general linear multivariate regressions and we report the least of square means. Significant differences between non-current marijuana users and marijuana users were determined by two-sided *t*-tests, and *P*-values are reported at levels  $\leq 0.05$  and  $\leq 0.0001$ .

**Table 1** Social characteristics of US adults, 20–59 years of age, according to marijuana use in the past month

	Non-current users (n=9771)	1–4 month <sup>-1</sup> (n=541)	5–10 month <sup>-1</sup> (n=135)	11+ month <sup>-1</sup> (n=176)
Age (years±SE)	38±0.2	31±0.5	31±0.8	32±0.9
Race (%)				
White	75	73	75	74
Black	11	17	17	13
Mexican–American	6	4	5	4
Married (%)	69	47	51	61
Gender (%)				
Male	47	64	65	77
Female	53	36	35	23
Income (%)				
<\$20,000	26	41	52	43
\$20,000–49,999	46	39	38	49
\$50,000+	28	20	11	8
Poverty income ratio<1.0 (%)	12	23	12	13
Education (%)				
Less than high school	19	22	16	32
High school	34	42	47	35
More than high school	47	35	37	33
Smokers (%)	29	60	67	70
Number of cigarettes in the past 5 days (mean±SE)	26.8±1.4	50.0±3.9	52.4±8.8	73.2±8.2
Body mass index (mean±SE)	26.6±0.1	25.0±0.4	26.1±0.6	24.7±0.3

## Results

Among adults 20–59 years of age, 45% reported ever having used marijuana, with 8% using it once or twice, 12% using three to 10 times, 12% using 11–99 times, and 13% using marijuana 100 times or more in their lifetime. A total of 8.7% of the sample population reported using marijuana in the past month, with 5.5% using one to four times a month (light users), 1.3% using five to 10 times a month (moderate users), and 1.9% using 11 or more times a month (heavy users).

Table 1 shows the social characteristics of adults, 20 to 59 years of age, who participated in NHANES III by marijuana use. Non-current users were older than users and the proportion of men was higher among users than non-current users. The proportion of participants with annual household income of greater than \$50,000 was highest in the non-current users and lowest in the heavy users. Similarly, the proportion of participants with an education level of more than high school was highest in the non-current users and lowest in the heavy users.

The proportion of participants who reported smoking cigarettes was lowest in the non-current users and highest in the heavy users. Among those who reported smoking cigarettes, the mean number of cigarettes in the past five days was also lowest in the non-current users and highest in the heavy users. As shown in Table 1, mean body mass index (BMI) was lower in the heavy users than in the non-current users ( $P < 0.0001$ ) and these differences remained after adjusting for age, gender, education, cigarette smoking and caloric intake ( $P = 0.003$ ) (data not shown). A similar proportion was underweight (BMI < 18.5) among the heavy users (1.3%) and all other groups (2.6% non-users, 2.3% light users, 1.0%

moderate users). The proportion overweight or obese (BMI  $\geq 25$ ) was also similar among all groups: 54% among non-current users, 42% among the light users, 49% among the moderate users, and 42% among the heavy users.

Dietary intake is shown in Tables 2 and 3. Total caloric intake was highest in the heavy users. Light, moderate and heavy users consumed 24%, 28% and 41%, respectively, more calories than non-current users. After adjusting for age, sex and education, the calories were 13%, 17% and 25%, respectively, higher than for the non-current users. The percentage of energy from fat was lower among the heavy users than among the non-current users, whereas the percentage of calories from alcohol was higher in the heavy users than in the non-current users.

Absolute and energy-adjusted values are provided for the grams of protein, carbohydrate, fat and alcohol (Table 2), and micronutrients (Table 3). The absolute intake reflects the actual amount consumed and is of interest for examining differences in intake among the users and non-current users. The energy-adjusted values are of interest for examining the amount of nutrient relative to the total energy intake. Absolute intakes among heavy users were higher for all macronutrients and alcohol than among the non-current users. Fat and alcohol intake remained higher after energy adjustment.

Women tend to consume fewer calories than men, and more men than women use marijuana. Therefore, we compared dietary intake between male non-current marijuana users and male marijuana users, and found the macronutrient intakes to be higher in users than in non-current users. We also compared women non-current marijuana users and women marijuana users, and again found macronutrient intakes to be higher in users than in

**Table 2** Dietary intake of macronutrients in US adults, 20–59 years of age, according to marijuana use in the past month

	Non-current users (n=9771)		1–4 month <sup>-1</sup> (n=541)		5–10 month <sup>-1</sup> (n=135)		11+ month <sup>-1</sup> (n=176)	
	Mean±SE	Adjusted†	Mean±SE	Adjusted†	Mean±SE	Adjusted†	Mean±SE	Adjusted†
Total calories	2271±22	2253	2823±78**	2557**	2917±130**	2639**	3196±181**	2835**
Fat (%)	34.0±0.3	34.0	33.9±0.6	33.8	30.8±1.1*	30.7*	31.6±0.9*	31.5
Carbohydrate (%)	49.4±0.3	49.3	46.2±1.2*	46.3*	44.7±1.9*	44.7*	49.2±1.2	49.6
Protein (%)	15.2±0.1	15.3	14.5±0.3*	14.9	13.7±0.6*	14.1	14.4±0.7	14.8
Alcohol (%)	2.8±0.1	2.7	6.9±0.9**	6.6**	12.1±1.9**	11.8**	5.9±1.1*	5.5*
Protein (g)	85±1.0	85	102±3.8**	84	98±5.7*	77	116±7.5**	85
Carbohydrate (g)	275±2.9	272	318±10.5**	254*	318±17.1*	243	378±21.0**	274
Fat (g)	88±1.3	87	108±4.0**	85	101±7.0	73*	116±8.0*	77*
Alcohol (g)	10±0.6	10	29±3.8**	24*	55±11.1*	49*	30±6.5*	22*
Fibre (g)	16.6±0.2	16.5	18.3±1.0	15.9	18.3±1.4	15.3	20.9±1.6*	16.2

† Adjusted for age, sex and education for percentage of energy; adjusted for age, sex, education and energy for grams of protein, fat, carbohydrate and alcohol.

\* Significantly different from non-current users,  $P \leq 0.05$ .

\*\* Significantly different from non-current users,  $P \leq 0.0001$ .

non-current users (data not shown). We therefore report the combined, gender-adjusted data.

Vitamins B<sub>12</sub> and B<sub>6</sub>, folate, thiamin, riboflavin, niacin, calcium, phosphorus, iron, zinc, potassium and sodium were higher among the heavy users than among the non-current users. Most of these differences were reduced or disappeared after energy adjustment. Energy-adjusted intakes of carotenes and vitamin C were significantly lower among the heavy users than among non-current users.

We subsequently examined the food-frequency data (Table 4). The frequencies do not include serving sizes and although we can determine the frequency of consumption, we cannot compare the serving size. Marijuana users had a higher frequency of beer, liquor, regular sodas, pork, cheese and salted snacks consumption than non-current users, whereas frequency of diet sodas and fruits consumption was lower.

Table 5 shows serum values for various health

indicators and serum nutrient levels. Although serum haemoglobin and haematocrit levels were higher in the marijuana users than in the non-current users, the differences were clinically small. Serum albumin, cholesterol and triglycerides were similar between marijuana users and non-current users. Most of the serum carotenoids were lower in the heavy users than in the non-current users.

## Discussion

We examined food consumption, nutrient intake and serum nutrients among US adults, aged 20–59 years, who participated in the NHANES III and who reported using marijuana in the past month compared with those who did not report using marijuana in the past month. Marijuana users were younger, had a lower income, were more likely to be smokers and were less likely to have completed high school than non-current marijuana

**Table 3** Dietary intake of micronutrients in US adults, 20–59 years of age, according to marijuana use in the past month

	Non-current users (n=9771)		1–4 month <sup>-1</sup> (n=541)		5–10 month <sup>-1</sup> (n=135)		11+ month <sup>-1</sup> (n=176)	
	Mean±SE	Adjusted†	Mean±SE	Adjusted†	Mean±SE	Adjusted†	Mean±SE	Adjusted†
Vitamin A (IU)	6465±150	6303	5987±387	5640	6009±792	5526	6412±799	5521
Carotenes (RE)	515.8±15.2	505.6	435.5±35.7*	412.4	511.8±83.8	482.5*	443.2±72.8	375.1*
Vitamin E (mg TE)	9.9±0.2	9.6	11.4±0.8*	9.3	10.1±0.9	7.7	11.4±0.9	7.9
Vitamin C (mg)	105±2.2	103	98±6.8	83*	119±17.1	101	98±10.1	72*
Vitamin B <sub>12</sub> (mcg)	5.3±0.2	5.3	6.5±0.4*	5.4	5.5±0.4	4.2*	9.4±1.9*	7.4
Vitamin B <sub>6</sub> (mg)	1.9±0.2	1.9	2.4±0.3*	2.1	2.5±0.2*	2.1	2.5±0.2*	1.9
Folate (mcg)	279±3.6	276	357±26.1*	317	322±16.6*	273	373±34.4*	297
Thiamin (mg)	1.7±0.02	1.7	2.1±0.1*	1.7	1.8±0.1	1.4*	2.2±0.1*	1.6
Riboflavin (mg)	2.0±0.02	2.0	2.5±0.1*	2.1	2.2±0.1	1.7*	2.8±0.2*	2.1
Niacin (mg)	24.4±0.3	24.3	30.3±1.4**	25.7	28.5±1.7*	23.1	34.1±2.3**	26.1
Calcium (mg)	852±12.8	831	1002±47*	813	907±55	686*	1171±127*	868
Phosphorus (mg)	1337±14	1325	1601±56**	1315	1520±74*	1188	1848±131*	1362
Iron (mg)	15.5±0.2	15.3	19.0±1.0*	16.5	15.7±0.9	12.5*	20.4±1.7*	15.8
Zinc (mg)	12.0±0.1	12.1	15.8±0.9**	13.6	13.3±1.0	10.7	16.1±1.2*	11.9
Potassium (mg)	2893±27	2883	3258±130*	2836	3246±163*	2735	3605±244*	2800
Sodium (mg)	3663±43	3634	4440±159**	3600	4216±238*	3234*	5024±472*	3630

† Adjusted for age, sex, education and energy intake.

\* Significantly different from non-current users,  $P \leq 0.05$ .

\*\* Significantly different from non-current users,  $P \leq 0.0001$ .

**Table 4** Frequency of consumption of specific foods and beverages in US adults, 20–59 years of age, according to marijuana use in the past month†

	Non-current users (n=9771)	1–4 month <sup>-1</sup> (n=541)	5–10 month <sup>-1</sup> (n=135)	11+ month <sup>-1</sup> (n=176)
Beer	5.2±0.2	8.5±0.8*	18.2±3.1*	15.7±6.5
Wine	1.5±0.1	1.9±0.3	2.7±0.6**	2.3±0.5
Liquor	1.6±0.1	2.7±0.4**	3.8±0.7**	2.9±1.0
Regular soda	17.5±0.5	19.6±3.1	17.6±3.5	35.0±7.8**
Diet soda	13.1±0.4	9.7±1.3**	9.0±2.1	7.2±1.5**
Kool-aid, Hi-C, Hawaiian punch, Tango	6.1±0.3	7.2±1.29	5.5±1.0	8.0±1.5
Fruits, excluding juice	24.7±0.4	19.6±1.2**	19.9±2.2**	20.8±2.6
Fruit juices	19.3±0.4	15.9±1.1**	18.9±3.4	17.4±1.9
Vegetables	72.1±0.9	68.8±2.1	71.1±3.3	71.5±3.1
Pork and ham	4.0±0.1	4.6±0.3**	5.5±0.8**	5.8±0.7**
Beef	11.6±0.2	12.8±0.7	12.5±1.7	14.0±1.6
Bacon, sausage, luncheon meats	7.7±0.2	8.5±0.6	9.1±1.1	9.6±1.3
Cheese, all types	12.7±0.3	14.8±0.9**	17.4±1.9**	15.7±1.6
Salted snacks, chips, popcorn, pretzels	9.0±0.2	9.1±0.7	10.9±1.2	12.6±1.3**

† Adjusted for age, sex, education and race–ethnicity.

\* Significantly different from non-current users,  $P \leq 0.05$ .\*\* Significantly different from non-current users,  $P \leq 0.0001$ .

users. We found caloric intake to be higher among marijuana users than among non-current users and that the intake increased as frequency of marijuana use increased (Table 2). Although energy intake was higher among marijuana users, their BMI was somewhat lower. Additionally, most of the indicators of nutritional status (serum nutrients, serum albumin, haematocrit and haemoglobin) were not different between marijuana users and non-marijuana users.

The higher caloric intake findings agree with other smaller studies looking at the effect of marijuana use on caloric intake<sup>5–8</sup>. Foltin *et al.* found a 40% increase in caloric intake among marijuana users<sup>7</sup>, while we found that users had 24 to 40% higher intakes than non-current users. We also showed that the higher caloric intake came from higher absolute amounts of protein, carbohydrates, fat and alcohol, and more specifically from the higher frequency of beer, liquor, sodas, pork, cheese and salty

snacks consumption. It has been suggested that in addition to stimulation of appetite, the reason for higher intakes among marijuana users may be related to the notion that marijuana is often used in social groups where food and alcoholic beverages may be more readily available<sup>6</sup>.

In contrast to some studies that have reported an increase in body weight with marijuana use<sup>5</sup>, we found BMI to be somewhat lower among marijuana users than in non-marijuana users. Given the higher caloric intake, one might expect higher body weights among users than non-current users; however, other factors may affect this relationship. For example, higher energy intake may be an indicator that physical activity and/or metabolic rate could be higher among marijuana users than among non-current users. When we adjusted caloric intake for participation in leisure-time physical activity in addition to age, sex and income, we found that the caloric differences remained the same. We also adjusted for

**Table 5** Serum nutrient levels and other serum health indicators in US adults, 20–59 years of age, according to marijuana use in the past month

	Non-current users (n=9771)		1–4 month <sup>-1</sup> (n=541)		5–10 month <sup>-1</sup> (n=135)		11+ month <sup>-1</sup> (n=176)	
	Mean±SE	Adjusted†	Mean±SE	Adjusted†	Mean±SE	Adjusted†	Mean±SE	Adjusted†
Haemoglobin (g l <sup>-1</sup> )	142±0.3	143	145±1.0*	142*	148±1.8*	145*	149±1.8*	143*
Haematocrit (%)	41.9±0.08	42.1	43.0±0.3*	42.2*	43.4±0.6*	42.6*	44.0±0.5*	42.5*
Albumin (g l <sup>-1</sup> )	42.2±0.2	42.1	42.8±0.3*	41.9	43.2±0.5*	42.3	42.8±0.3*	41.7
Triglycerides (mmol l <sup>-1</sup> )	1.6±0.03	1.6	1.3±0.08*	1.5	1.4±0.1	1.5	1.4±0.08*	1.4
Cholesterol (mmol l <sup>-1</sup> )	5.2±0.02	5.2	4.8±0.1**	5.1	5.0±0.1	5.3	4.9±0.1*	5.1
Folate (nmol l <sup>-1</sup> )	14.1±0.4	13.8	12.6±0.8	14.1	13.3±1.3	14.6	14.8±1.4	16.8
Red-cell folate (nmol l <sup>-1</sup> )	427±6.3	401	385±9.7	392	390±17.1	395	393±22.3	399
Vitamin A (μmol l <sup>-1</sup> )	2.00±0.01	2.01	2.03±0.04	2.05*	2.1±0.7	2.07	2.1±0.1	2.06
Vitamin E (μmol l <sup>-1</sup> )	25.6±0.3	25.9	22.6±0.5**	25.1	22.8±0.7*	25.2	22.1±0.7**	24.6
Beta-carotene (μmol l <sup>-1</sup> )	0.35±0.02	0.34	0.27±0.03*	0.32	0.23±0.02**	0.29*	0.24±0.03*	0.30*
Alpha-carotene (μmol l <sup>-1</sup> )	0.09±0.02	0.08	0.06±0.01*	0.07	0.06±0.01**	0.07**	0.06±0.01**	0.07*
Lutein/zeaxanthin (μmol l <sup>-1</sup> )	0.37±0.01	0.37	0.33±0.01**	0.35	0.33±0.02*	0.36	0.30±0.02*	0.32*
Lycopene (μmol l <sup>-1</sup> )	0.46±0.01	0.45	0.47±0.02	0.44	0.50±0.02	0.46	0.43±0.02	0.40
Beta-cryptoxanthin (μmol l <sup>-1</sup> )	0.16±0.03	0.16	0.14±0.01*	0.14*	0.14±0.01*	0.14*	0.13±0.01*	0.14

† Adjusted for age, sex and education.

\* Significantly different from non-current users,  $P \leq 0.05$ .\*\* Significantly different from non-current users,  $P \leq 0.0001$ .

cigarette smoking and again found that the caloric differences remained (data not shown). Zwillich *et al.* found that the metabolic rate of marijuana users increased for up to 60 min after marijuana use in a placebo-controlled study of eight volunteers<sup>8</sup>. Although we could not test this hypothesis in our population-based study, a higher metabolic rate may be a plausible explanation that will need to be investigated further.

Some have suggested that drug users have diets poor in vitamins and minerals, which could be a public health concern<sup>3,12</sup>. We found that the majority of absolute vitamin and mineral intakes were higher among marijuana users than among non-current users, and energy-adjusted vitamin and mineral intakes were similar between marijuana users and non-current users. Moreover, intakes for most nutrients were within the Recommended Dietary Allowances (RDA) or the Dietary Reference Intakes (DRI). Only folate intake was below the DRI and this was the case for both marijuana users and non-current users.

Serum haemoglobin, haematocrit, albumin and most of the serum nutrients were within normal ranges for both marijuana users and non-current users. This is in agreement with Mendelson, who found no abnormalities in blood chemistries in 70 male chronic marijuana users<sup>5</sup>. We found, however, lower serum carotenoid levels among marijuana users than among the non-current users, which may be due to the oxidative effect of cigarette smoking. When we examined serum carotenoid levels stratified by cigarette smoking, we found that among non-cigarette smokers, marijuana users had lower carotenoid levels than non-current marijuana users. Similarly, among cigarette smokers, marijuana users had lower carotenoid levels than non-current marijuana users (data not shown). These results suggest that marijuana use is associated with lower serum carotenoid levels independent of cigarette smoking. Sarafian *et al.* found marijuana smoke to be a source of cellular oxidative stress<sup>13</sup>, which may in part explain the differences in serum carotenoids. The differences may also in part be due to the lower dietary carotenoid intake, higher alcohol intake, and lower frequency of fruit and vegetable consumption among the heavy users than among non-current users (Tables 3 and 4).

Using cross-sectional data limits our ability to assess cause-and-effect relationships. However, these data are very useful in estimating marijuana use and describing intake patterns among groups of individuals. The 24-hour recall does not reflect usual or individual intake and does not include supplemental intake. It does provide reasonable group estimates of dietary nutrient intake<sup>14</sup>. The FFQ does not provide quantitative nutrient information, but it does provide information on the usual consumption of specific foods or food groupings. Little is known about the cognitive impact of marijuana use on diet recall. We also do not have information on the

amount of marijuana smoked and do not know the extent of underestimation of marijuana frequency. Despite these limitations, we consider that these data provide reasonable estimates of dietary intake by marijuana use.

In summary, marijuana users had higher intakes of energy and nutrients than non-marijuana users and did not appear to have a poor nutritional status using indicators of body mass index, serum nutrients, serum albumin, haematocrit and haemoglobin. At the same time, marijuana users had a higher consumption of sodium, lower fruit intake, lower serum carotenoid levels, higher alcohol intake, and higher rate of cigarette smoking. The long-term health effects of these lifestyle habits among marijuana users deserve careful consideration in future research.

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