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A 'standard joint'? The role of quantity in predicting cannabis-related problems

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The 'standard drink' concept is widely used as a standardized measure of alcohol consumption. There is no equivalent measure of cannabis consumption, perhaps due to challenges such as varied joint size, tetrahydrocannabinol content, and means of delivery. This study introduces a new measure of cannabis quantity and examines whether it predicts cannabis-related social problems with and without controlling for frequency of use. Cannabis-related problems, measured by the Alcohol, Smoking and Substance Involvement Screening Test (ASSIST), were predicted from cannabis use frequency (days in past month) and quantity (one joint = 0.5 g, five bong or pipe hits, 10 puffs), controlling for age and gender. The sample consisted of 665 participants aged 15–67 (mean = 28.2, SD = 11.8) from the British Columbia Alcohol and Other Drug Monitoring Project, High Risk Group Surveys, 2008 to 2009. Cannabis use frequency and quantity were positively associated with cannabis-related problems. Individuals who consumed cannabis daily and consumed more than one joint per day were at the greatest risk of problems. Controlling for frequency, the effect of quantity remained significant for failure to do what is expected due to cannabis use. This study suggests that quantity, above and beyond frequency, is an important predictor of cannabis problems. We discuss the potential usefulness and validity of this new measure in harm reduction.

Keywords: *Cannabis quantity, social harms, harm reduction*

INTRODUCTION

Cannabis is the most commonly used illicit drug in most countries, including Canada, the USA, and the UK (Adlaf, Begin, & Sawka, 2005; European Monitoring Centre for Drugs and Drug Addiction, 2009; Room, Fischer, Hall, Lenton, & Reuter, 2010; Substance Abuse and Mental Health Services Administration, 2009). In Canada, the prevalence of lifetime and past-year cannabis use is on the rise; from 23.2% in 1989 to 42.4% in 2008 for lifetime use, and from 6.5% in 1989 to 10.6% in 2008 for use in the past year (Adlaf et al., 2005; Health Canada, 2009). In the 2008 survey, around 25% of those who used cannabis in the last year reported that they used it every day. The rates of cannabis use among young people, aged 15–24, has declined slightly in recent years, from 37% in 2004 to 26.3% in 2009, but the rate of use by youth 15–24 years of age remains almost four times higher (26.3% *vs.* 7.6%) than that reported by adults 25 years and older (Health Canada, 2009). These high rates of cannabis use, especially among young people, have heightened concern about the impact of cannabis use on health and psychosocial outcomes.

To date there are no known and recommended 'safe' levels of cannabis consumption, yet the debate continues regarding the harmfulness of its use (Davis, Thomas, Jesseman, & Mazan, 2009). Research suggests that the major health risks are more likely to be experienced among regular, long-term users (Swift, Copeland, & Lenton, 2000). Chronic cannabis use, generally referred to as a pattern that entails weekly or more frequent use (Hall, 2009; Porath-Waller, 2009),

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has been associated with an increased likelihood of cannabis dependence (Hall & Pacula, 2003), chronic bronchitis and impaired respiratory function (Diplock & Plecas, 2009; Moore, Augustson, Moser, & Budney, 2005; Taylor & Hall, 2003), psychotic disorders and impaired cognitive functioning (Moore et al., 2007; Porath-Waller, 2009) as well as psychosocial effects such as impaired educational attainment in adolescents, and an increased likelihood of using other illicit drugs (Hall, 2009; Swift et al., 2000). Individuals who use cannabis may also experience acute adverse effects such as anxiety and panic, and an increased risk of motor vehicle crashes (Beirness & Porath-Waller, 2009; Hall, 2009; Swift et al., 2000).

Unfortunately, most of the research on cannabis-related harm emphasizes only frequency of consumption (Walden & Earleywine, 2008), including the Canadian Alcohol and Drug Use Monitoring Survey (Health Canada, 2009). Yet, consumption as measured by frequency of exposure does not necessarily reflect the extent of exposure to psychoactive substances (Taylor & Hall, 2003) and the extent to which the likelihood of harm differs as a function of levels of cannabis use remains to be established (Thomas, Flight, Richard, & Racine, 2006). A clear understanding of cannabis-related harm is hindered by the paucity of studies measuring quantity of consumption.

There are relatively few studies that have measured the quantity of cannabis use; yet, research suggest that quantity is an important predictor of cannabis-related problems, including dependence (Chen, Kandel, & Davies, 1997; Swift, Hall, Didcott, & Reilly, 1998), cognitive impairment (Bolla, Brown, Eldreth, Tate, & Cadet, 2002; Fried, Watkinson, James, & Gray, 2002), and respiratory and social problems (Walden & Earleywine, 2008), above and beyond the role of frequency (Bolla et al., 2002; Looby & Earleywine, 2007). For example, Looby and Earleywine (2007) examined predictors of cannabis dependence in a sample of 2881 daily cannabis users and found that participants who were cannabis-dependent reported smoking a greater number of joints per week and using a larger number of quarter ounces of cannabis per month than non-dependent daily users. Only 38.5% of daily users were cannabis-dependent suggesting that other factors, such as quantity, play a role in predicting some cannabis-related harm (Looby & Earleywine, 2007).

It is also necessary to consider the quantity and frequency of cannabis consumption and related problems across different populations and contexts. In addition to populations who are heavy and frequent users, cannabis use and cannabis-related harm outcomes have been studied across a range of groups. For example, Fischer et al. (2010) have examined characteristics of cannabis users and associated harm outcomes in a nationally representative survey of Canadian adults. The researchers found that the group featuring the earliest onset and highest frequency of

cannabis use was disproportionately linked to key harms such as health problems and other illicit drug use (Fischer et al., 2010).

For effective intervention and harm reduction, cannabis-related harm outcomes also need to be considered across different age groups. Chen et al. (1997) conducted a study of the frequency and quantity of cannabis use and dependence with adolescents and adults in the USA and found that adolescents are dependent at a lower frequency and quantity of use than adults. These differences diverged as the level of use increased; nearly twice as many adolescents (35%) as adults (18%) who used cannabis daily in the last year were found to be dependent.

The number of studies reporting on the quantity of cannabis use was limited; the majority of studies reviewed focused on frequency only. Ellickson, D'Amico, Collins, and Klein (2005) prospectively studied the influence of age of cannabis initiation on physical and mental health outcomes, other illicit drug use, and cannabis-related problems in American youth. They focused on a young population of mixed ethnicity starting at grade 7 and followed up to grades 8, 9, 10, and 12. Ellickson et al.'s (2005) findings indicated that once the frequency of use is controlled for, age of initiation was only associated with other illicit drug use but not cannabis. DeWitt, Hance, Offord, and Ogborne (2000) reported on the impact of early age and the frequency of cannabis use on cannabis-related harm outcomes among lifetime users in Ontario, Canada. The authors concluded that early and frequent cannabis use is an important risk factor for hastening cannabis-related harms.

The consideration of quantity is important for understanding cannabis-related health outcomes. The unit of measurement typically employed in surveys is 'a joint' (per week or per day; Chen et al., 1997; Fried et al., 2002). However, to date there is no standardized measure of cannabis consumption. Alcohol researchers have developed the concept of a 'standard drink' as a standardized measure of alcohol consumption (Stockwell & Single, 1997). The concept of a 'standard drink' is a research tool for quantifying drinking levels and describing drinking patterns of individuals. It enables comparisons across studies and countries and is a useful tool for implementing drinking guidelines and disseminating messages to the general population (Stockwell & Single, 1997). However, quantifying cannabis use may be more challenging for several reasons. Different means of administration, including joints, blunts, pipes, bongs, and vaporizers, make it challenging to conceptualize a 'standard' consumption unit. Each mode of administration may contain different amounts of cannabis per dose and the potency of tetrahydrocannabinol content can vary greatly (Gray, Watson, & Christie, 2009). Methods for adjusting the self-reported measures to the number of joints (i.e., adjusting for different methods of administration)

have not been standardized among researchers (Gray et al., 2009).

An important goal of cannabis epidemiology is to link cannabis use with cannabis-related problems. This requires determining cannabis consumption as accurately as possible. The lack of a uniform definition of cannabis consumption among researchers hinders the reliability of self-report measures and makes it difficult to compare findings across studies. Improvement of the measurement of cannabis exposure could help improve prediction of cannabis-related problems, but the challenge is to establish criteria for standardizing units of measurement for cannabis use. This article, while attempting to provide a foundation for the development of a reliable and valid measure of cannabis use quantity, also aims to highlight some of the conceptual and methodological challenges posed by attempts to measure quantities of cannabis for personal use. For example, the amount of cannabis used does not necessarily correspond to the level of intoxication achieved, due to numerous individual factors such as whether or not the person is a frequent user, the method of ingestion, the user's physical constitution, as well as situational factors.

In relation to most of these issues, identical problems are posed by attempts to quantify levels and patterns of alcohol consumption. Strengths of alcoholic drinks on the legal market vary from 0.5% to over 70% in many countries – and of course it is possible to obtain 100% ethanol. Alcoholic drinks can be pre-mixed or otherwise combined with both non-alcoholic beverages and food. Individuals develop metabolic and functional tolerance to alcohol with continued use, especially heavy use (e.g., Fillmore & Vogel-Sprott, 1996). Speed of consumption and body weight also play a part in determining intoxication. Nonetheless, epidemiological research has continued to utilize the concept of the 'standard drink' (WHO, 2000) and there is voluminous evidence that quantity as well as frequency of consumption are critical dimensions to measure in predicting and understanding harmful outcomes (Rehm et al., 2009). This study introduces a new measure of quantity and examines the relation between quantity and frequency of cannabis consumption and self-reported cannabis-related problems. This was developed in the context of surveys of 'high risk' drug using populations as part of a comprehensive alcohol and other drug monitoring system (Duff, Michelow, Chow, & Stockwell, 2009; Stockwell et al., 2009). We attempted to account for different methods of administration by inquiring about the number of joints per day with one joint being equivalent to 10 puffs, five bong or pipe hits or 0.5 g of cannabis. The primary objective of this study was to evaluate the likelihood of experiencing cannabis-related problems at various quantity levels of use. A secondary goal was to gather preliminary evidence in support of the validity of our 'standard joint' measure.

METHOD

Data collection and sample

The sample consisted of 665 participants aged 15–67 (mean $= 28.2$, SD $= 11.8$) from the British Columbia Alcohol and Other Drug (BC AOD) Monitoring Project, High Risk Group Surveys, 2008 to 2009. There were 226 females, 434 males, one was intersex and four were transgendered individuals.

The BC AOD Monitoring Project was initiated to monitor alcohol and drug use patterns and substance-related problems in three specific high-risk, illicit drug using populations (Stockwell et al., 2009). The high-risk populations were club drug users $(n = 213)$, street-involved youth $(n = 244)$, and adult injection drug users $(n = 208)$ in Vancouver and Victoria, BC, Canada.

The survey was administered face-to-face in an interview format with trained research assistants recording responses for each item on the survey instrument. Using data from the high-risk survey, we were able obtain a large population of regular cannabis users (use at least monthly) which allowed us to pinpoint levels of cannabis use that possibly play a critical role in experiencing cannabis-related problems.

Cannabis use frequency and quantity

Only those cases who reported they had used marijuana during the past 30 days ('And how about the past 30 days, on about how many of these days did you use marijuana, cannabis, or hashish?') were used in the analyses. This time period was chosen as it is contained within the last 3-month time window used by the WHO ASSIST (Alcohol, Smoking and Substance Involvement Screening Test) applied here to assess problems related to substance use. The other options were marijuana use the day before the interview (too narrow) or in the last 12 months (too broad).

We divided cannabis frequency and quantity into categories for the purpose of comparisons across levels of use and creation of a standardized measure of cannabis use. The purpose of categorizing frequency and quantity was to identify thresholds to help facilitate these comparisons. Having five categories for each measure also allowed for a fair balance between the two measures.

The distribution of responses for frequency of cannabis use was examined to derive five approximately equal frequency categories (1 = 1–4 days, 2 = 5–11 days, 3 = 12–20 days, 4 = 21–29 days, and 5 = 30 or more days). The same approach was taken for the cannabis use quantity item 'During the past 30 days, on those days when you used marijuana, cannabis, or hashish, roughly how many joints did you usually have?' (1 = less than one joint a day, 2 = exactly one joint a day, 3 = more than one and up to three joints a day, 4 = 3.5 to 8 joints a day, and 5 = 9 or more joints a day). Based on previous Canadian research (e.g., Conrad, 2007), consultation with local

cannabis users, and the Executive Director of the Vancouver Island Compassion Society (which provides medicinal cannabis on prescription to local residents), one joint was defined as equal to 0.5 g of cannabis, five bong or pipe hits, or 10 puffs.

We conducted a sensitivity analysis based on four categories of frequency (1 = 1–4 days, 2 = 5–18 days, 3 = 20–29 days, and 4 = 30 or more days) and quantity (1 = less than one joint a day, 2 = exactly one joint a day, 3 = more than one and up to three joints a day, and 4 = more than three joints a day). The goal was to examine how the measures of frequency and quantity perform under the two different categorizations and how results might be influenced by a potential loss of power when using five categories instead of four.

ASSIST items

The items of the ASSIST were used to measure cannabis-related problems (e.g., 'During the past three months, how often has your use of cannabis led to health, social, legal or financial problems?'). Participants responded by choosing one of the following score categories: 0 = never, 4 = once or twice, 5 = monthly, 6 = weekly, 7 = daily or almost daily) (Henry-Edwards, Humeniuk, Ali, Poznyak, & Monteiro, 2003; WHO ASSIST Working Group, 2002). The categorical outcome variables for the five cannabis-related problems (i.e., ASSIST items 3–7, being: urge to use cannabis; social, legal, or financial problems due to cannabis use; failure to do what is expected due to cannabis use; concern by friends about cannabis use, and failure to control cannabis use) were re-coded into dichotomous variables (0 = no problems, 1 = problems) for use as outcome variables in logistic regression analyses.

We created an additional dichotomous outcome variable by combining these five ASSIST items into one overall indicator of cannabis-related problems (0 = respondent experiences none of the five cannabis-related problems and 1 = respondent experiences one or more of the cannabis-related problems). This approach was taken in order to create an indicator of overall problems in preference to a modified version of the ASSIST. The ASSIST contains frequency-based response items which would introduce an artificial association with our frequency of use measure if used unadjusted. Furthermore, the assumption of normality was violated for the ASSIST (positively skewed distribution), as was the assumption of linearity of the scale's association with cannabis frequency and quantity. Hence, we used logistic regression on the dichotomized ASSIST (problems experienced/no problems experienced).

Data analysis

Using logistic regression, individual cannabis-related problems, measured by the ASSIST, were predicted from cannabis use frequency (e.g., past 30-day use) and quantity (e.g., number of joints smoked during the past

30 days). Cannabis use quantity was used to predict individual problems after controlling for cannabis use frequency to determine the additional explanatory effect of quantity above and beyond frequency and to develop the concept of a 'standard joint' as a measure of consumption. Both frequency and quantity were entered into the regression models as categorical variables with contrasts (using the lowest as the reference category).

Next, the relationship between cannabis use frequency and quantity and overall cannabis-related problems was examined using logistic regression analysis with the dichotomous problem indicator comprising all five cannabis items of the ASSIST scale. For both the individual problems and the overall problem indicator, three regression models were examined: (a) an unadjusted model using only frequency or quantity as problem predictors, respectively; (b) a partially adjusted model using either frequency or quantity and controlling for age and gender; and (c) a fully adjusted model accounting for age, gender, and quantity in the model for frequency and accounting for age, gender, and frequency in the model for quantity. Age and gender were retained in the fully adjusted models regardless of their significance. Finally, we examined the possibility of interactions between cannabis frequency and quantity. No significant interactions were identified (results not reported).

RESULTS

Descriptive statistics

Table I reports the prevalence of cannabis use frequency and quantity in the last month, and the prevalence of experiencing cannabis-related problems. The largest proportion of respondents was daily smokers (34.9%), and the majority smoked more than one joint on those days when they used marijuana (60.6%). The most commonly reported cannabis-related problem was experiencing urges to use (67.2%); the other cannabis-related problems were reported by 21.1–34.7% of the sample.

Table II shows the cross-tabulations of the five categories of cannabis use frequency and quantity. From Table II, it is apparent that the heaviest use (nine joints or more daily) is associated with the most frequent use (30 days or more). More than half of the light users (less than one joint per day) smoke least frequently (1–4 days in the last month). A more even distribution is observed between quantity and frequency for the middle categories.

Relationship between cannabis use frequency, quantity, and individual cannabis-related problems

As summarized in Table III, cannabis use frequency during the previous month was a significant predictor of each of the cannabis-related problems. The associations remained statistically significant after controlling for age and gender and cannabis use quantity.

Table I. Cannabis use frequency, quantity, and cannabis-related problems.

	Total (n = 665)		Males (n = 434)[a]		Females (n = 226)[a]	
	N	(%)	N	(%)	N	(%)
Frequency						
1–4 days	173	(26.0)	99	(22.8)	74	(32.7)
5–11 days	97	(14.6)	60	(13.8)	36	(15.9)
12–20 days	91	(13.7)	57	(13.1)	33	(14.6)
21–29 days	72	(10.8)	47	(10.8)	25	(11.1)
30 days or more	232	(34.9)	171	(39.4)	58	(25.7)
Quantity						
0.1 to 0.8 joints per day	94	(14.1)	43	(9.9)	51	(22.6)
1 joint per day	168	(25.3)	102	(23.5)	64	(28.3)
1.1 to 3 joints per day	219	(32.9)	154	(35.5)	65	(28.8)
3.5 to 8 joints per day	139	(20.9)	100	(23.0)	36	(15.9)
9 or more joints per day	45	(6.8)	35	(8.1)	10	(4.4)
Cannabis-related problems						
Cannabis urges	447	(67.2)	290	(66.8)	154	(68.1)
Health, social, legal, financial problems	140	(21.1)	92	(21.2)	46	(20.4)
Failure to do what is expected	133	(20.0)	69	(15.9)	64	(28.3)
Concern by friends about use	231	(34.7)	153	(35.3)	77	(34.1)
Failure to control cannabis use	166	(25.0)	111	(25.6)	53	(23.5)

Note: [a]n = 4 transgendered and n = 1 intersex, included in total only.

Table II. Cross tabulations of cannabis use frequency and quantity categories.

		Cannabis use frequency					
		1–4 days	5–11 days	12–20 days	21–29 days	30 days or more	Total
Cannabis use quantity							
0.1–0.8 joints	Count	56	17	11	5	5	94
	% of total	8.4	2.6	1.7	0.8	0.8	14.1
1 joint	Count	72	30	31	15	20	168
	% of total	10.8	4.5	4.7	2.3	3.0	25.3
1.1–3 joints	Count	34	38	37	31	79	219
	% of total	5.1	5.7	5.6	4.7	11.9	32.9
3.5–8 joints	Count	8	10	10	16	95	139
	% of total	1.2	1.5	1.5	2.4	14.3	20.9
9 or more joints	Count	3	2	2	5	33	45
	% of total	0.5	0.3	0.3	0.8	5.0	6.8
Total	Count	173	97	91	72	232	665
	% of total	26.0	14.6	13.7	10.8	34.9	100.0

The reference group for each of the comparisons was respondents who smoked on 1–4 days during the last month. The strongest increase in problems was observed for urge to use cannabis; in fact, all respondents had significantly increased odds compared to the reference group. Those who smoked on 5–11 days were almost four times more likely to experience cannabis urges; those who smoked on 12–20 days were six times more likely, those who smoked on 21–29 days were nine times more likely, and those who smoked on 30 days or more were almost 11 times more likely to experience cannabis urge, even after quantity was controlled for. Generally, for all other problems, smoking cannabis on 12 or more days in the last month significantly increased participants' odds. Age was a significant covariate in the fully adjusted model for health, social, legal, and financial problems (OR = 0.967, 95%CI = 0.949–0.986), and for failure to do what is expected (OR = 0.955, 95%CI = 0.935–0.976), with younger respondents at a slightly

Table III. Regression model estimates of relationships between cannabis-related problems (ASSIST items) and cannabis use frequency.

Individual cannabis problems	Unadjusted[a]		Partially adjusted[b]		Fully adjusted[c]	
	OR	95% CI	OR	95% CI	OR	95% CI
Health, social, financial, legal			**		**	
5–11 days	1.305	0.557–3.062	1.289	0.547–3.038	1.190	0.499–2.839
12–20 days	3.621*	1.750–7.493	3.267*	1.560–6.840	2.996*	1.404–6.394
21–29 days	6.419*	3.100–13.292	6.221*	2.980–12.989	5.363*	2.477–11.613
30 days or more	4.709*	2.545–8.712	4.478*	2.395–8.373	3.618*	1.786–7.329
Failure to do what expected			†		†	
5–11 days	1.795	0.845–3.813	1.873	0.865–4.055	1.677	0.764–3.684
12–20 days	2.764*	1.353–5.648	2.843*	1.360–5.941	2.483*	1.166–5.288
21–29 days	4.040*	1.961–8.326	4.398*	2.080–9.298	3.362*	1.535–7.365
30 days or more	3.500*	1.937–6.325	4.077*	2.196–7.567	2.644*	1.315–5.317
Cannabis urge			***		***	
5–11 days	3.448*	2.051–5.799	3.682*	2.172–6.242	3.533*	2.056–6.070
12–20 days	6.017*	3.405–10.631	6.208*	3.486–11.057	6.004*	3.322–10.849
21–29 days	10.175*	5.072–20.413	10.782*	5.335–21.788	9.245*	4.458–19.175
30 days or more	13.195*	8.056–21.614	14.885*	8.909–24.870	10.571*	5.918–18.882
Concern by friends						
5–11 days	1.370	0.774–2.427	1.381	0.778–2.450	1.329	0.741–2.383
12–20 days	2.119*	1.214–3.698	2.112*	1.207–3.698	2.011*	1.133–3.568
21–29 days	3.756*	2.091–6.747	3.699*	2.055–6.659	3.427*	1.848–6.355
30 days or more	2.464*	1.579–3.844	2.429*	1.545–3.819	2.174*	1.281–3.690
Cannabis control failure						
5–11 days	0.773	0.389–1.535	0.786	0.395–1.564	0.698	0.346–1.409
12–20 days	1.460	0.788–2.708	1.416	0.757–2.650	1.254	0.658–2.388
21–29 days	2.748*	1.485–5.085	2.786*	1.502–5.168	2.256*	1.174–4.336
30 days or more	2.061*	1.278–3.324	2.090*	1.285–3.400	1.533	0.866–2.715
Overall cannabis problems					***	
5–11 days	2.623*	1.536–4.477	2.825*	1.640–4.868	2.807*	1.604–4.912
12–20 days	4.103*	2.261–7.444	4.281*	2.342–7.825	4.234*	2.278–7.872
21–29 days	9.394*	4.077–21.644	10.041*	4.329–23.292	9.082*	3.810–21.648
30 days or more	13.657*	7.579–24.608	14.s933*	8.174–27.280	11.623*	5.904–22.885

Notes: Reference = 1–4 days.
[a]Cannabis frequency in model; [b]cannabis frequency in model and taking into account age and gender; and [c]cannabis frequency in model and taking into account age, gender and cannabis quantity.
*$p \leq 0.05$; **age $p \leq 0.05$; ***gender $p \leq 0.05$; and †age and gender $p \leq 0.05$.

decreased risk. Gender was a significant covariate in the fully adjusted models for failure to do what is expected (OR = 0.432, 95%CI = 0.281–0.663) and cannabis urge (OR = 0.620, 95%CI = 0.408–0.942), with males at a lower risk.

The logistic regression results for cannabis use quantity presented in Table IV indicate a dose–response relationship for two of the ASSIST items: social, financial, and legal problems and cannabis urges, since the odds of experiencing these cannabis-related problems increased consistently with the number of joints smoked. However, this dose–response relationship held only for up to eight joints per day for two other ASSIST items; the increase to nine or more joints a day did not result in increased odds for failure to do what is expected and cannabis control failure. For concern by friends, there was a general tendency for a dose–response relationship. In addition, cannabis

quantity remained a significant problem predictor for failure to do what is expected after controlling for cannabis use frequency. The reference group for each of the comparisons was respondents who smoked less than one joint per day on those days when they used marijuana. The last two columns of Table IV indicate that smoking one joint a day was not associated with an increase in the odds of experiencing social, financial, and legal problems or cannabis urges after controlling for cannabis use frequency (confidence intervals for odds ratios included 1). However, those who reported smoking more than one joint a day experienced an increase in the odds of the cannabis-related problems, compared to the reference group, albeit not statistically significant for four of the five harms. Those who reported smoking three-and-a-half to eight joints a day were almost three times more likely to experience failure to do what is expected and this increase was

Table IV. Regression model estimates of relationships between cannabis-related problems (ASSIST items) and cannabis use quantity.

Individual cannabis problems	Unadjusted[a]		Partially adjusted[b]		Fully adjusted[c]	
	OR	95% CI	OR	95% CI	OR	95% CI
Social, financial, legal			**		**	
1 joint	1.197	0.556–2.578	1.220	0.562–2.651	0.977	0.437–2.185
1.1 to 3 joints	2.349*	1.165–4.739	2.367*	1.157–4.839	1.360	0.626–2.955
3.5 to 8 joints	3.049*	1.472–6.315	2.865*	1.354–6.062	1.361	0.586–3.159
9 or more joints	3.408*	1.398–8.306	3.502*	1.406–8.722	1.624	0.598–4.407
Failure to do what expected			†		†	
1 joint	1.258	0.586–2.697	1.501	0.685–3.289	1.322	0.592–2.953
1.1 to 3 joints	1.897	0.932–3.861	2.439*	1.165–5.107	1.679	0.766–3.680
3.5 to 8 joints	3.267*	1.581–6.750	4.526*	2.104–9.737	2.785*	1.193–6.499
9 or more joints	2.744*	1.102–6.831	3.974*	1.523–10.370	2.413	0.860–6.772
Cannabis urge			***		***	
1 joint	1.204	0.726–1.996	1.269	0.760–2.119	0.932	0.528–1.643
1.1 to 3 joints	2.367*	1.441–3.888	2.574*	1.547–4.280	1.042	0.579–1.876
3.5 to 8 joints	6.209*	3.331–11.574	7.031*	3.690–13.398	2.031	0.961–4.289
9 or more joints	8.348*	3.029–23.008	9.338*	3.351–26.016	2.686	0.875–8.243
Concern by friends						
1 joint	1.346	0.758–2.389	1.375	0.771–2.451	1.202	0.665–2.172
1.1 to 3 joints	1.848*	1.072–3.184	1.859*	1.070–3.229	1.293	0.713–2.344
3.5 to 8 joints	1.845*	1.031–3.303	1.843*	1.017–3.340	1.149	0.587–2.246
9 or more joints	3.227*	1.524–6.833	3.268*	1.528–6.993	2.038	0.890–4.664
Cannabis control failure						
1 joint	1.239	0.632–2.429	1.215	0.616–2.396	1.123	0.564–2.237
1.1 to 3 joints	1.942*	1.037–3.638	1.956*	1.037–3.692	1.574	0.797–3.107
3.5 to 8 joints	2.605*	1.353–5.017	2.637*	1.353–5.139	1.897	0.898–4.007
9 or more joints	2.378*	1.028–5.501	2.400*	1.028–5.603	1.692	0.675–4.241
Overall cannabis problems					***	
1 joint	1.370	0.810–2.317	1.450	0.851–2.469	1.131	0.640–2.000
1.1 to 3 joints	2.252*	1.337–3.795	2.423*	1.420–4.132	0.994	0.545–1.815
3.5 to 8 joints	6.291*	3.108–12.735	6.676*	3.255–13.691	1.756	0.774–3.985
9 or more joints	13.956*	3.187–61.120	15.360*	3.481–67.770	4.073	0.855–19.399

Notes: Reference = 0.1 to 0.8 joints/day.
[a]Cannabis quantity in model.
[b]Cannabis quantity in model and taking into account age and gender.
[c]Cannabis quantity in model and taking into account age, gender and cannabis frequency.
*$p \leq 0.05$; **age $p \leq 0.05$; ***gender $p \leq 0.05$; and †age and gender $p \leq 0.05$.

statistically significant. Age was a significant covariate in the fully adjusted model for health, social, legal, and financial problems (OR = 0.967, 95%CI = 0.949–0.986), with younger respondents at a lower risk. In the fully adjusted model for failure to do what is expected, age (OR = 0.955, 95%CI = 0.935–0.976) and gender (OR = 0.432, 95%CI = 0.281–0.663) were significant, with younger respondents and males at a lower risk. Gender was significant in the fully adjusted model for cannabis urge, with males at a lower risk (OR = 0.620, 95%CI = 0.408–0.942).

Relationship between cannabis use frequency, quantity, and overall cannabis problems
Logistic regression results for the fully adjusted models showed that cannabis use frequency but not quantity,

significantly predicted overall cannabis-related problems (see data in Tables III and IV). Frequency was still a significant predictor of overall cannabis-related problems after controlling for age, gender, and quantity. Males were at a significantly lower risk for overall cannabis problems predicted by the frequency of use (OR = 0.640, 95%CI = 0.411–0.998). Compared to those smoking on only 1–4 days per month, those who smoked cannabis on 5–11 days per month were nearly three times more likely to experience overall problems, those who smoked on 12–20 days were four times more likely, those who smoked on 21–29 days had a nine-fold increase, and those who smoked on 30 or more days were nearly 12 times more likely to experience overall cannabis problems (see data in Table III). Quantity of cannabis use per day did predict overall problems in the partially adjusted model but did

not do so when the frequency of use was included in the model (Table IV).

Conducting a sensitivity analysis based on four categories of frequency and quantity, a further problem area, experiencing cannabis urges was significantly predicted by cannabis use quantity.

DISCUSSION

The objective of this study was to examine whether the quantity of cannabis use is a predictor of cannabis-related problems over and above the frequency of use. To date, most of the evidence of cannabis-related problems is drawn only from research on frequency because different methods of administration and variation in dosage and potency make it challenging to quantify cannabis consumption (Gray et al., 2009). To explore the relationship between the quantity of consumption and cannabis-related problems, we developed a new measure of quantity and examined the relation between the number of joints per day (one joint = 10 puffs, five bong or pipe hits, or 0.5 g), and cannabis-related problems as measured by the ASSIST. The findings suggest that the quantity of cannabis use is an important predictor of cannabis-related problems, even after accounting for the effects of frequency of use. This is in line with previous research considering quantity as relevant in predicting cannabis-related outcomes (Walden & Earleywine, 2008).

Consistent with the literature, frequency of cannabis use predicted cannabis-related problems, such as urges to use, health, social, legal, or financial problems, failure to do what was expected, concern from friends or relatives, and failure to control or cut down use (Davis et al., 2009; Hall, 2009). Individuals using cannabis on 12 or more days per month were at significantly greater risk of experiencing cannabis-related problems compared to those only using on up to 11 days per month. Our finding that those who use cannabis with the highest frequency are at greater risks for harms is also in line with existing research showing results for Canadian adults sampled from the general population (Fischer et al., 2010) and lifetime users in Ontario, Canada (DeWitt et al., 2000).

After controlling for the effects of frequency, the quantity of cannabis use also predicted failure to do what is expected. Those consuming three-and-a-half to eight joints per day were at a significantly greater risk than those consuming less. Consistent with past research, frequency remained a stronger predictor than quantity (Walden & Earleywine, 2008). However, measures of frequency and quantity are highly related ($r = 0.348$, $p = 0.000$) and this makes it challenging to determine their unique effects. From our cross-tabulations of frequency and quantity, it became clear that the two measures are strongly related but certainly do not form a perfect association; rather, frequency and quantity are two different important dimensions in the patterns of cannabis consumption

that need to be considered with regard to public health outcomes. That is, while frequency and quantity are correlated, there was considerable variation in the distribution of cannabis consumption over time. For example, Table II shows that while there was only a small number of infrequent heavy users, our sample contained a large proportion of frequent moderate to heavy users.

With respect to the regression results, the significance of quantity in predicting cannabis problems even after frequency is controlled for suggests that both components are important predictors of cannabis-related problems. We emphasize that despite the importance of quantity, there is only a limited body of research that considers its impact on harm outcomes. This study makes a contribution to filling this research gap; we show that a relatively simple measure of cannabis use quantity captured significant information above and beyond the frequency of use and was able to predict important harm outcomes. This study also highlights that one is not doing justice to the entire population of cannabis users and their patterns of consumption if one uses only one dimension of this pattern – a measure of frequency but not quantity – to examine harm outcomes. This is also an important implication for those aiming to study patterns of cannabis use and harm outcomes in the general population.

The significance of quantity predicting cannabis-related problems has important research and public health implications. In research settings, the quantification of marijuana use is particularly important because self-reported use of substances is essential for monitoring patterns of substance use and linking cannabis consumption to various outcomes. Indeed, a cannabis user who smoked 10 joints per day for 5 years would almost certainly show greater cannabis-related health effects than a cannabis user smoking one joint per day for 5 years. Establishing acceptable criteria for standardizing units of measurement for cannabis use might pave the way for greater harmonization in the way in which cannabis use is quantified and thereby aid cross-study and cross-cultural comparisons. Further, a better understanding of how patterns of use influence health outcomes would enable clinicians to more accurately identify people at particular risk of experiencing acute and/or chronic problems from their cannabis use. Given the high rates of cannabis use in Canada, a better understanding of the health and social implications of cannabis use are a particular public health concern. An important caveat needs to be considered regarding the implications of our findings. While our study focuses on high-risk populations, further studies are needed to assess this issue in the general population. However, studies such as ours on high-risk populations are a necessary first step since we need to understand cannabis consumption in heavy-user groups first to be able to design specific studies focused on the general population where one would

encounter a significantly smaller proportion of heavy- or high-risk users.

This study examined whether this new cannabis quantity measure is significantly related to other key variables of interest, such as cannabis-related harms, as a starting point for considering guidelines for low-risk consumption of cannabis. Using this measure of cannabis quantity, the risk of experiencing cannabis-related problems for those who smoke one joint per day was not significantly greater than for the reference group (e.g., those who smoke 0.1–0.8 joints). Yet, the odds of problems increased substantially for those who smoke more than one joint compared to the reference group. These results give rise to a preliminary interpretation much along the lines of a 'standard drink' of alcohol. Proposed Canadian low-risk drinking guidelines for alcohol recommend that, in order to avoid alcohol-related problems, women should not exceed 10 standard drinks per week and men 15 standard drinks per week (Canadian Centre on Substance Abuse, 2010). This study suggests that one standard joint a day – when quantified as one joint = 0.5 g, five bong or pipe hits, or 10 puffs – does not significantly increase the odds of experiencing cannabis-related problems when compared to those who only smoke 0.1–0.8 joints a day, at least in this sample of BC cannabis smokers. Considering both frequency and quantity, our results show no evidence of harm for those who were infrequent light users.

Given our results, we conclude that some evidence of utility and concurrent validity was established for our measure in this BC sample. However, these results need to be viewed as preliminary and interpreted with several important caveats. For example, while our concept of a 'standard joint' – as quantified above – is a reasonable indicator of the actual amount smoked, it does not address other relevant issues and problems regarding mode of administration, subjective impact of consumption, and intoxication. However, we note that the same methodological issues exist in the alcohol research arena in relation to a 'standard drink'. In surveys of personal alcohol consumption, it is possible to identify contrasting groups of individual drinkers according to whether they typically drink a great many, a moderate number, or only one or two drinks. Furthermore, factors such as speed of drinking, metabolic tolerance, body weight, and degree of intoxication defy precise measurement in the medium of a survey.

As with low-risk drinking guidelines, promotion of low-risk levels of cannabis use – whether for persons prescribed cannabis for health reasons or for the general public – should only be based on a comprehensive review of all relevant health and safety aspects. We suggest, however, that a standardized measure of cannabis quantity for use in self-report surveys would be of value both in developing and communicating low-risk guidelines for cannabis. Future research should focus on the ongoing validation process of this new measure of cannabis quantity, with an eye toward formulating low-risk cannabis consumption guidelines.

This study had several limitations. Individuals may not sufficiently self-report on their cannabis consumption due to the illegal nature of the substance. They may also hesitate to report negative experiences and hence, occurrence of cannabis-related problems might be under-represented. However, attempts were made to limit such problems through guarantees of anonymity and confidentiality. In addition, respondents may not fully acknowledge the extent to which their cannabis use has contributed to health, social, legal, financial, or other problems.

With respect to methods of cannabis administration, we acknowledge that our measure does not take into account whether or not users mixed cannabis with tobacco. On the other hand, we attempt to account for the potential problem of joint sharing by having users report the number of puffs – an approach that has, to the best of our knowledge, not been taken in previous research.

A further limitation pertains to the representativeness of our results. That is, since our study was conducted in a Canadian context in two west coast cities, results may not be generalizable to populations in other countries. In addition, our results are not generalizable to other non-high-risk populations. Therefore, our findings should be replicated with other high-risk populations in different geographical locations and social contexts. Finally, this was a cross-sectional study that did not examine the long-term problems associated with cannabis use frequency and quantity. Future research using longitudinal designs following these high-risk cohorts over several time points would be valuable for assessing the long-term impact of cannabis-related problems.

Gender was a significant covariate in predicting cannabis urges and failure to do what is expected, with women being more likely to report these problems. Previous research has pointed out that existing measures of cannabis-related problems may contain gender-biased items (Lavender, Looby, & Earleywine, 2008). According to the notion of bias, discrepancies in cannabis problem scores may show true differences in problem severity but could also indicate the presence of gender bias. We acknowledge that males and females differ in their endorsement of both frequency and quantity of use as well as cannabis-related problems, and that this could be due to either true gender differences or bias. This is a possibility that could be explored. However, a formal analysis of differential item functioning was not conducted in the context of this study.

Future research might examine this potential issue in the context of using the ASSIST. Finally, we acknowledge the limitation of losing some statistical power using the five categories of frequency and quantity; nevertheless, we felt this was justified for the purposes

of this article. That is, categorizing both frequency and quantity this way provides improved clarity of interpretation of harm profiles.

In conclusion, both quantity and frequency of consumption are important predictors of cannabis-related problems. Our article contributes to knowledge regarding the measurement of cannabis use quantity and the associated harms. Hence, our results may be useful to those interested in harm reduction and cannabis policy. There is a need for more research that examines quantity as an important contributor to cannabis-related problems, so that we can advance understanding of which patterns of consumption pose particular risks for negative personal, social, and public health outcomes. This information would be essential for the purpose of creating accurate public health messages for the general population and for informing cannabis policy. This new measure of quantity may be an effective way to quantify cannabis consumption in surveys, but more research is needed to further validate and standardize such a measure of consumption across different populations.

ACKNOWLEDGMENTS

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