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Typologies of cannabis users and associated characteristics relevant for public health: a latent class analysis of data from a nationally representative Canadian adult survey

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Abstract

Cannabis is the most prevalently used illicit drug in Canada. Current policy consists primarily of universal use prohibition rather than interventions targeting specific risks and harms relevant for public health. This study aimed to identify distinct groups of cannabis users based on defined use characteristics in the Canadian population, and examine the emerging groups' associations with differential risk and harm outcomes. One thousand three hundred and three current (i.e. use in the past three months) cannabis users, based on data from the representative cross-sectional 2004 Canadian Addiction Survey (N = 13,909), were statistically assessed by a 'latent class analysis' (LCA). Emerging classes were examined for differential associations with socio-demographic, health and behavioral indicators on the basis of chi-square and analysis of variance techniques. Four distinct classes based on use patterns were identified. The class featuring earliest onset and highest frequency of use [22% of cannabis user sample or 2.2% (95% confidence interval (CI) = 1.8–2.7%) of the Canadian adult population] was disproportionately linked to key harms, including other illicit drug use, health problems, cannabis use and driving, and cannabis use problems. A public health framework for cannabis use is needed in Canada, meaningfully targeting effective interventions towards the minority of users experiencing elevated levels of risks and harms.

Introduction

Cannabis is the most commonly used illicit drug in the Canadian general population. Over the past two decades, its use prevalence has substantially increased, with 14% of Canadian adults reporting past-year use in 2004 (Adlaf *et al.*, 2005). Among Ontario high-school students, one in four (26%) reported past year-cannabis use in 2007 (Adlaf and Paglia-Boak, 2007). Canada was recently reported as having the highest cannabis use rate among developed countries (United Nations Office on Drugs and Crime, 2007).

Despite its high use rates in the general population, cannabis in Canada is governed by a rather crude policy framework, primarily defined by the *per se* criminalization of all use by way of the prohibition of simple possession of the Controlled Drugs and Substances Act (CDSA) (Fischer *et al.*, 2003). With this approach, any cannabis use is categorically defined as problematic, while abstinence is the implicitly promoted ideal (Fischer *et al.*, 2003; Strang *et al.*, 2000). This approach differs from other areas of substance use policy – e.g. alcohol – which have increasingly shifted towards policy frameworks oriented towards public health (Hall, 2007; Room *et al.*, 2005). There, rather than focusing on use *per se*, primary attention is given to characteristics or contexts of use known to predict risk or harm outcomes contributing to the burden on public health (e.g. binge drinking, alcohol-related violence, drinking and driving). Consequently, available intervention tools (e.g. prevention, treatment or legal control/enforcement) are selectively utilized to target relevant behaviors (Babor *et al.*, 2003).

The overall public health burden from cannabis use is limited, especially when compared to licit substances like alcohol or tobacco (Hall *et al.*, 1999; Nutt *et al.*, 2007). This is partly influenced by the fact that cannabis use does not result in any directly acute mortality (e.g. overdose; Gable, 2004; Rehm *et al.*, 2007). A substantive body of research has accumulated over recent years indicating a variety of possible acute and/or chronic health risks or harms associated with cannabis use which may substantially contribute to burden of disease related to cannabis use, and hence are most important from a public health perspective. These include primarily: psychomotor, cognitive and memory impairment; dependence; fatal and non-fatal motor-vehicle accidents (MVAs) under the influence of cannabis; respiratory impairments (including chronic bronchitis); the amplification or onset of psychosis in predisposed individuals (Arseneault *et al.*, 2007; Hall and Solowij, 1998; Hall and Pacula, 2003; Iversen, 2000, 2005; Kalant, 2004; Perkonigg *et al.*, 1999; Ramaekers *et al.*, 2004). However, epidemiological data clearly suggest that these problems only materialize in a relatively small minority of users. Analyses of epidemiological data furthermore suggest that several key cannabis use characteristics are predictive of such harm outcomes, including: frequent (e.g. weekly or more often) or chronic cannabis use, early onset (e.g. <16 years of age) of cannabis use (Chen *et al.*, 1997; Hall and Pacula, 2003; Henquet *et al.*, 2005; Patton *et al.*, 2002; Perkonigg *et al.*, 2008).

On this basis, cannabis use policy guided by principles of public health – i.e. one that primarily intervenes against users or forms of use most prone to resulting in health harms – would need to rest on an empirical understanding of the preeminent predictors of cannabis use related harms among users. Such information has not existed in detail for Canada to date. One of the methodological approaches to profiling subtypes of cannabis users is offered by latent class analysis (LCA) (Skrondal and Rabe-Hesketh, 2004) which assigns individuals into classes on a probabilistic basis based on specified characteristics. A growing number of recent studies have applied LCA to establish phenotypes of individuals with mental health problems (Kessler *et al.*, 2005), as well as substance users (Agrawal *et al.*, 2006; Lynskey *et al.*, 2006; Monga *et al.*, 2007; Patra *et al.*, 2009; Wittchen *et al.*, 2009). In one recent study, Grant *et al.* (2006) used LCA to explore cannabis abuse and dependence profiles by gender using a nationally representative US sample of cannabis users who had used 12 or more times in their lifetime (Grant *et al.*, 2006). A main methodological benefit of the LCA approach is that it groups users according to a multiplicity of defined characteristics, as opposed to examining these variables separately, and hence allows for the establishment and examination of multi-dimensional group profiles and their associated characteristics. On this basis, our present study focuses on current cannabis users (i.e. use in the past three months) within a national representative Canadian population sample, utilizing several cannabis use characteristics for classification, and subsequently examining social, behavioral and health related outcome indicators.

The specific objectives of this study were:

(1) to empirically group current cannabis users in Canada based on key characteristics of their use;
(2) to subsequently examine potential differentials between user groups in terms of social, health or behavior characteristics or outcomes
(3) to explore public health and policy implications

Methods

Sample

This study is based on data from the Canadian Addiction Survey (CAS), a random-digit-dialing, two-stage sampling design (telephone household and respondent), regionally stratified (21 regional units) general household survey of 13,909 Canadian residents 15 years of age or older. The survey was conducted through telephone interviews in English and French by Computer-Assisted-Telephone Interviewing (CATI) methods between December 2003 and April 2004. In order to maximize the content area without increasing the length of the interview, the sample was randomly split into three panels (Panel A: 4612, Panel B: 4639, Panel C: 4658) and some items were asked only of one or two panels. The sampling frame was based on an electronic inventory (Statplus) of all active telephone area codes and exchanges in Canada. Within households called for the survey, one respondent aged 15 years or older who could complete the interview in English or French was randomly selected according to the most recent birthday of household members. The selected individuals were interviewed by professional interviewers using a structured questionnaire. The CAS' overall response rate was 47% [see Adlaf and Ialomiteanu (2004) for more details about the CAS methodology]. The analysis sample for this present study was based on $N = 1475$ positive responses to the CAS item of whether respondents 'had used cannabis during the past three months'. Listwise deletion of missing data on variables of interest resulted in an overall analysis sample of $N = 1303$. There were no systematic differences found between included and excluded cases (analysis not shown). To strengthen the confidence in these data and to ensure that characteristics of CAS sample are similar to the Canadian population, this sample was weighted for all statistical analyses conducted, to correspond to the age, sex and provincial distribution of the Canadian population. The weights used for the CAS sample are a function of the sampling weight and a post stratification adjustment based on respective census information for Canada. Although this procedure does not remove all biases, it does provide a simultaneous adjustment for non-response and non-coverage of households without a telephone (Casady and Lepkowski, 1999). The sample size for certain specific statistical analyses, e.g. mental and physical health condition, reasons for cannabis use, and cannabis related driving risks, were lower than $N = 1303$ since some items were asked only of respondents of only one or two CAS panels and thus led to reduced sample sizes in the CAS.

Variables selected for analyses

Six cannabis use-related categorical variables ('age of onset', 'number of days used in past 30 days', 'how often used in past three months', 'quantity consumed in past 12 months', 'whether use was for medical reasons', and 'with whom used') were used for the LCA, as these were the variables available in the CAS best describing cannabis use characteristics for the purpose of user classification. Continuous variables such as 'age of onset' were categorized to allow for equal impact of value differences.

Variables chosen for the post-LCA analysis included available indicators describing social, health or behavioral characteristics or outcomes of cannabis use relevant for public health. The variables selected were: (1) sociodemographic variables which included: age (continuous), sex ('male' versus 'female'), marital status ('married' or 'with partner' versus other), education ('did not complete high school', 'completed high school', 'post-secondary' versus 'university education'), employment ('unemployed', 'student', 'retired/homemaker' versus 'employed'), income (≥$30,000 versus <$30,000), and household location ('rural' versus 'urban'); (2) physical and mental health indicators based on the Health Related Quality of Life Measures (Moriarty *et al.*, 2003; Ôunpuu *et al.*, 2000) included physical and mental health status (both 'poor' or 'fair' versus 'good' or 'excellent'), and poor mental health in the past 30 days (defined as 15 or more days with mental health problems in the past 30 days; 'yes' versus 'no'); (3) cannabis and other drug use characteristics, as operationalized by the variables: 'number of years of cannabis use' (continuous); 'setting of cannabis use' ('home' versus 'public place'); 'source of cannabis' ('traded', 'obtained for free', 'home grown' versus 'purchased'); important reasons to use cannabis ('to be sociable', 'to feel high', 'curiosity' versus 'medical purpose'); use of cannabis for a medical condition ('pain', 'depression/anxiety' versus 'other'); 'ever used alcohol'; 'daily alcohol use'; 'use of cocaine, heroin, speed, ecstasy or hallucinogens in the past 12 months' (all 'yes' versus 'no'); (4) variables for cannabis use and driving related risks included: 'ever driven a vehicle within two hours of cannabis use in the past 12 months' and 'ever been a passenger in a vehicle driven by someone who had used cannabis within two hours of driving' (both 'yes' versus 'no'); and (5) the ASSIST (Alcohol, Smoking and Substance Use Involvement Screening Test) scale (Newcombe *et al.*, 2005). The ASSIST scale was used to assess the risk of experiencing health and other problems related to cannabis use. The ASSIST scoring scale ranges from zero to 39. Two cut-off points were used: 'low' with a score of 0–3, refers to a

pattern of use associated with a low risk of experiencing problems from cannabis use; 'moderate/high' risk, with a score of 4–39, refers to a pattern of use that is associated with a medium or high risk of experiencing problems, possibly leading to dependence (Humeniuk *et al.*, 2008). Evaluations of the psychometric properties of the ASSIST scale have shown excellent internal consistency (Cronbach's alpha = 0.86) and good to excellent specificities (61–90%) and sensitivities (57–90%) in establishing cut-off scores for cannabis use related problems (Humeniuk *et al.*, 2008).

Statistical analysis

The LCA was performed to investigate possible distinct cannabis user profiles based on the specified characteristics. In short, LCA methodology sets out to identify the most parsimonious classification of individuals into groups (i.e. 'latent classes'), which are characterized by a high degree of homogeneity within classes and a high degree of heterogeneity between classes. Classes are established on the assumption that all underlying variables are statistically independent of one another. To determine the optimal number of latent classes emerging from the LCA, different classes were fitted starting from a model with one class (i.e. assuming that all cannabis users are the same), proceeding to two, three, four, and more classes, to the point where the model with the next higher number of classes would not provide a significantly better fit of the underlying data than the previous one (as identified by Vuong–Lo–Mendell–Rubin and Lo–Mendell–Rubin adjusted likelihood ratio tests – ALRTs) (Lo *et al.*, 2001). Other procedures considered for model selection were the Akaike Information Criterion (AIC) (Raftery, 1995), the sample-size Bayesian Information Criterion (BIC) (Li and Nyholt, 2001) and entropy (Raftery, 1995). To indirectly test the assumption of conditional independence, different models for the determination of latent classes were estimated, including or excluding age and sex. All models were estimated using maximum likelihood; multiple starting values were used to avoid the local maxima. Mplus (version 5.0) software (Muthen and Muthen, 2007) was used for the LCA.

Once the latent classes were determined, chi-square tests and Analysis of Variance (ANOVA, including Scheffe *post hoc* test where necessary) were conducted to determine differences between the associations of classes with the socio-economic, health and behavioral variables examined. All post-LCAs were carried out in SPSS Version 16 (SPSS Inc, 2006).

Results

Latent class model

Comparisons of the model-fit-statistics for the one- to five-class LCA models suggested that the four-class model provided the best fit (see Table 1 and Appendix). This solution had the lowest BIC and adjusted BIC scores with the highest entropy value of 0.84 (Raftery, 1995). The addition of co-variates did not result in a change to the four-class solution, indicating that the assumption of local independence was not violated.

Characteristics of the four latent classes

The four latent classes established by the LCA presented rather heterogeneous use patterns as per the characteristics examined – including a gradient of use frequency across classes – and can overall be described as follows (see Table 2):

- Class 1 (31.8% of sample) was in the majority described by age of cannabis use onset at or under age 21, occasional cannabis use, i.e. either no use or use on less

Table 1 Model comparisons and fit indices

Model	AIC	BIC	Adjusted BIC	Npar	Entropy	Lo–Mendell–Rubin ALRT test	*p*-Value for ALRT	Test for $K-1$ classes
Class 1	16144.72	16222.31	16174.66	15	NA	NA	NA	NA
Class 2	14966.59	15126.93	15028.459	31	0.84	1199.68	0.005	1 (H0) versus 2 classes
Class 3	14454.01	14697.11	14547.82	47	0.83	539.87	0.126	2 (H0) versus 3 classes
Class 4	14329.28	14655.14	14455.02	63	0.84	155.38	0.928	3 (H0) versus 4 classes
Class 5	14290.94	14699.56	14458.62	79	0.84	69.73	1.000	4 (H0) versus 5 classes

The Vuong–Lo–Mendell–Rubin and Lo–Mendell–Rubin ALRT tests (with $p > 0.05$) suggest that $K-1$ classes are sufficient and that K classes are not required.
Note: Npar, number of free parameters; NA, not available.

Table 2 Four class solution: latent class conditional probabilities for cannabis use in past three months

Proportions for the class patterns	Class 1 *N* = 414 31.8%	Class 2 *N* = 263 20.2%	Class 3 *N* = 327 25.1%	Class 4 *N* = 299 22.9%	Overall *N* = 1303 100.0%
Age of onset					
at or before 15 years of age	0.288	0.428	0.384	0.600	0.410
between 16–17 years of age	0.291	0.291	0.353	0.191	0.283
between 18–21 years of age	0.253	0.218	0.211	0.191	0.222
between 22–25 years of age	0.072	0.016	0.015	0.007	0.032
26 or over years of age	0.096	0.047	0.038	0.011	0.053
Days used in past 30 days					
None	0.557	0.023	0.002	0.040	0.195
1–7 days	0.443	0.883	0.465	0.007	0.456
8–14 days	0.000	0.026	0.320	0.000	0.078
15–21 days	0.000	0.002	0.213	0.200	0.092
22+ days	0.000	0.065	0.000	0.753	0.179
How often used in past three months					
Less than monthly	0.905	0.081	0.004	0.000	0.313
Monthly	0.095	0.744	0.015	0.000	0.208
Weekly	0.000	0.161	0.940	0.025	0.255
Daily or almost daily	0.000	0.013	0.042	0.975	0.224
Quantity consumed in past 12 months					
More	0.195	0.195	0.231	0.254	0.216
Less	0.534	0.456	0.341	0.172	0.394
The same	0.270	0.348	0.428	0.574	0.390
Used cannabis for medical reasons in past 12 months					
Yes	0.114	0.228	0.522	0.531	0.323
No	0.886	0.772	0.478	0.469	0.677
With whom used cannabis					
Alone	0.041	0.100	0.175	0.256	0.132
Family, friends, or colleagues	0.959	0.900	0.825	0.744	0.868

Note: *N* = 1303 unweighted (percentages are from weighted sample).

than seven days in the past month, and a consumption of a lesser quantity of cannabis than in the past 12 months. The vast majority engaged in cannabis use for social reasons and did not use it medically.

- Class 2 (20.2%) was in the majority described by age of cannabis use onset at or under age 17, moderately regular/monthly cannabis use, i.e. use mainly on between one and seven days in the past month, and a consumption of a lesser or the same quantity of cannabis than in the past 12 months. The vast majority engaged in cannabis use for social reasons and did not use it medically.
- Class 3 (25.2%) was in the majority described by age of cannabis use onset at or under age 17, moderately regular/weekly cannabis use, i.e. use on between one and 14 days in the past month, and a consumption of a lesser or the same quantity of cannabis than in the past 12 months. For the majority of this class, cannabis use occurred socially; about half indicated that they had used it medically in the past year.
- Class 4 (22.9%) was in the majority described by age of cannabis use onset at or under age 15, frequent cannabis use, i.e. near-daily or daily in the past month, and a consumption of a higher quantity of cannabis than in the past 12 months. For the majority of this class, cannabis use occurred socially; about half indicated that they had used it medically in the past year.

Bi-variate associations

The age range of the analysis sample was between 15 and 84 years. Several significant differences between classes in their associations with the defined variables of interest

emerged (Table 3). Females and married individuals were most highly represented in Class 1; and Class 4 had on average the youngest members [$F = 6.34$, $p < 0.001$; multiple comparison Scheffe test revealed Class 4 was significantly different from classes 1 ($p < 0.005$), 2 ($p < 0.001$) and 3 ($p < 0.022$), respectively]. However, the mean age differences between classes were rather small (range: 28.4 years in Class 4 to 30.4 years in Class 2). Class 1 had the lowest, and Class 4 the highest proportion of respondents who were unemployed, did not have a completed high school education, and reported low income.

Class 1 reported the highest, and Class 4 the lowest proportion of respondents rating their physical and mental health status as 'good' or better. Indication of mental health problems was most common in Class 3 and least common in Class 1.

There were no differences between the classes in terms of the length of time between first and current use of cannabis. The highest proportion of cannabis use occured at home and by obtaining cannabis for free from or by sharing with others, and the smallest proportion of use occured in public places and by obtaining cannabis through purchasing, was reported by Class 1; the opposite constellations applied to Class 4. Class 1 indicated the highest proportion of 'sociability', and the least proportion of 'curiosity' or 'getting high', as the main reasons for cannabis use.

Class 1 had a slightly higher overall rate of alcohol use in the past 12 months than other classes (range: 91.2% in Class 4 to 96.2% in Class 1) but their daily use was among the lowest (range: 0.8% in Class 1 to 4.5% in Class 2). The use of other illicit substances was lowest in Class 1 and highest in Class 4. Both the prevalence of having been a driver or a passenger to a driver of a car under the influence of cannabis was highest in Class 3 and Class 4, and lowest in Class 1.

Differences between classes emerged on all subvariables of the ASSIST-scale. 'Health/social/legal problems' due to cannabis use was most commonly experienced by Classes 2, 3 and 4, and least commonly by Class 1; 'failure to do tasks normally expected' was least commonly reported by Class 1 and most commonly by Class 3 and 4. 'Concerns expressed by friends/relatives', 'tried to control cannabis use' and 'strong desire to use cannabis' on a daily basis were least commonly featured in Class 1, and most commonly by Class 4. 'Moderate or high' risk levels for cannabis use problems (ASSIST summary score) were lowest in Class 1, and highest in Classes 3 and 4, with both those latter classes indicating a 100% prevalence of medium/high risk levels for cannabis use problems in the ASSIST summary score.

Discussion

This study explored and identified typologies of cannabis users among a Canadian representative adult population sample by way of their use characteristics based on LCA methodology, and examined potential differences in associated social, health and behavioral characteristics. The LCA model identified four different classes of cannabis users, mainly characterized by differences in frequency of cannabis use and age of onset.

Distribution of classes, use patterns and problem indicators

Most relevant from a public health perspective – i.e. a view focusing primarily on characteristics or patterns of cannabis use associated with key risk or harm outcomes – our findings suggest that respective problem indicators were most concentrated in Class 4, i.e. those users characterized by the highest (near-daily or daily) frequency as well as early onset of cannabis use (Chen *et al.*, 1997; Copeland *et al.*, 2001; Hall and Babor, 2000; Hall and Pacula, 2003; Perkonigg *et al.*, 1999). This population translates into about 2.2% (95% CI = 1.8–2.7%) of the general Canadian adult population. Notably, most problem and harm indicators examined rose in prevalence through the classes (e.g., Classes 1 to 4) identified by the LCA, and in the majority of instances peaked in Class 4. Importantly, this progression of indicators from Class 1 to Class 4 is observed as a cross-sectional phenomenon rather than able to suggest risk or harm indicators as a possible effect of cannabis use 'careers' (i.e. correlated with age) or cohort effects possibly determining the composition of groups. In fact, Class 4 is composed, on average, of slightly younger cannabis users than the other groups, while however average age is relatively similar among groups (varying from 31.1 years in Class 1 to 28.4 years in Class 4). Our study thus did not observe the usual strong delineations between frequency of use and age characteristics found in many other studies in which high frequency use of cannabis is mainly concentrated in the early to mid-twenties, and lesser frequency patterns are associated mainly with older age groups (Anthony, 2006; Bachman *et al.*, 1997; Perkonigg *et al.*, 1999). Of course, it would be highly valuable to have the opportunity to observe the further progression and possible changes of cannabis use patterns and outcomes of the different classes longitudinally.

Socio-demographic factors

Notably, the cannabis user classes identified are associated with various socio-economic characteristics – e.g.

Table 3 Latent class membership by socio-demographics and consequences of cannabis use in past three months

Characteristics		Class 1[1]	Class 2	Class 3	Class 4		ANOVA/
Weighted prevalence in general adult population		31.8%	20.2%	25.1%	22.9%		
95% CI		3.3	1.9	2.6	2.2	Overall	Chi-square
		(2.8–3.9)	(1.5–2.3)	(2.1–3.1)	(2.1–3.1)	100.0%	(df)
Sociodemographics							
Age (range: 15–84 years)	Mean (SD)[2]	31.1 (12.0)	30.4 (12.3)	30.5 (12.1)	28.4 (11.0)	30.2 (11.9)	6.37 (3)***
Gender (col%)	Female	*38.9*	36.0	*27.3*	*26.0*	32.5	37.80 (3)***
Marital status	Married or with partner	*42.7*	*29.9*	33.3	*27.4*	34.5	43.14 (3)***
Education	Incomplete high school	*12.1*	*11.7*	14.0	*27.1*	15.8	182.06 (9)***
	Completed high school	26.7	*17.0*	28.4	*35.2*	27.2	
	Post-secondary	*41.6*	39.5	*41.4*	*27.3*	38.0	
	University	19.6	*31.9*	*16.2*	*10.4*	19.1	
Employment	Employed	*67.6*	*66.9*	61.7	*52.9*	62.7	48.93 (9)***
	Unemployed	*6.3*	9.0	10.7	*12.9*	9.4	
	Student	19.6	19.2	18.6	*25.7*	20.6	
	Other (retired, homemaker)	6.5	*4.9*	*9.0*	8.5	7.3	
Annual household income	Less than $30000	*12.8*	*28.5*	20.4	21.9	19.7	133.30 (12)***
	$30000–$49000	*18.6*	*8.0*	*11.2*	14.2	13.7	
	$50000–$79000	21.0	21.9	22.3	*16.1*	20.5	
	$80000 and more	*26.7*	21.7	*26.5*	*15.0*	23.2	
	Did not know/ refused	20.9	19.9	*19.6*	*32.7*	23.0	
Household location	Rural	11.1	*7.0*	10.6	10.6	10.1	6.71 (3)[ns]
Physical & mental health indicators							
Overall physical health condition[3]	Good, better, or excellent	*95.1*	93.5	95.2	*85.7*	92.5	21.28 (3)***
	Poor or fair	*4.9*	6.5	4.8	*14.3*	4.8	
Overall mental health condition[3]	Good, better, or excellent	*98.7*	*95.7*	92.6	*69.3*	89.2	133.02 (3)***
	Poor or fair	*1.3*	*4.3*	7.4	*30.7*	10.8	
Poor mental health in past 30 days[3]	No	*46.3*	31.7	*28.7*	33.8	36.3	20.60 (3)***
	Yes	*53.7*	68.3	*71.3*	66.2	63.7	
Cannabis and other drug use characteristics							
Number of years used cannabis	Mean (SD)	12.93 (11.1)	13.2 (10.1)	14.2 (11.1)	13.0 (10.3)	13.3 (10.8)	1.99 (3)[ns]
Cannabis use setting	Home	*54.4*	*45.0*	*28.2*	*23.2*	39.0	184.54 (3)***
	Public places	*45.6*	*55.0*	*71.8*	*76.8*	61.0	

Source of cannabis	Paid	*18.9*	*39.3*	*63.9*	*78.1*	47.3	663.98 (9)***
	Traded	1.4	0.8	0.8	*3.0*	1.5	
	Got it free or shared	*79.0*	*57.4*	*32.6*	*15.4*	49.0	
	Home growing	*0.7*	2.4	2.7	*3.5*	2.2	
Most important reason to use cannabis[4]	To be sociable	*32.2*	*15.2*	*15.4*	21.1	21.6	88.95 (9)***
	To feel high	*5.5*	*19.5*	9.1	*14.9*	11.7	
	Curiosity/recreation	*55.9*	65.0	*71.1*	60.1	62.8	
	Other (e.g. medication)	*6.3*	*0.3*	4.3	3.9	3.9	
Used alcohol in past 12 months	Yes	*96.2*	95.5	94.7	*91.2*	94.6	18.06 (3)***
Used alcohol in past 12 months	Daily	*0.8*	*4.5*	1.4	2.5	2.0	23.62 (3)***
Used cocaine or heroin or speed or ecstacy or hallucinogens in past 12 months (omnibus category)	Yes	*7.5*	21.3	*25.6*	*33.2*	20.4	156.05 (3)***
Medical condition[5] (among those who had medical use)	Pain	*66.4*	54.6	*50.6*	56.8	55.4	22.32 (6)***
	Anxiety/depression	26.2	*17.6*	25.9	26.8	25.2	
	Other	*7.5*	*27.8*	*23.4*	16.4	19.4	
Cannabis use and driving							
Cannabis use and driving episodes among those who drive (in past 12 months)[6]	No	*91.9*	*78.5*	*35.1*	*37.5*	63.8	218.49 (3)***
	Yes	*8.1*	*21.5*	*64.9*	*62.5*	36.2	
Driving as a passenger with a driver who used cannabis in previous two hours[7]	Yes	*37.6*	*56.1*	*87.4*	*89.6*	66.3	221.49 (3)***
ASSIST scale							
Health/social/legal problems due to cannabis use in past three months	No	*98.3*	*91.0*	*92.5*	*92.4*	94.1	41.49 (3)***
	Yes	*1.7*	*9.0*	*7.5*	*7.6*	5.9	
Had strong desire to use cannabis in past three months	No	*79.7*	*68.2*	*50.2*	*29.0*	58.8	1123.69 (12)***
	Once or twice	17.2	17.0	*23.0*	*11.9*	17.5	
	Monthly	*2.9*	*10.9*	*11.5*	*2.1*	6.4	
	Weekly	*0.2*	*3.9*	*12.7*	*17.5*	7.9	
	Daily or almost daily	*0.0*	*0.0*	*2.7*	*39.5*	9.4	
Failure to do task normally expected in past three months	No	*94.3*	92.8	*90.0*	*89.4*	91.9	15.18 (3)***
	Yes	*5.7*	7.2	*10.0*	*10.6*	8.1	

Table 3 *Continued*

Characteristics		Class 1[1]	Class 2	Class 3	Class 4		ANOVA/
Weighted prevalence in general adult population		31.8%	20.2%	25.1%	22.9%		Chi-square
95% CI		3.3 (2.8–3.9)	1.9 (1.5–2.3)	2.6 (2.1–3.1)	2.2 (2.1–3.1)	Overall 100.0%	(df)
Friend/relative ever expressing concerns about cannabis use	No	*94.2*	80.8	*76.3*	*62.8*	80.2	259.21 (6)***
	Yes, but not in past three months	*5.1*	*16.0*	14.3	*19.8*	12.8	
	Yes, in past three months	*0.7*	*3.3*	*9.4*	*17.3*	7.1	
Ever tried to control cannabis use	No	*68.7*	*68.1*	*53.7*	*38.6*	58.1	168.58 (6)***
	Yes, but not in past three months	*19.0*	*19.2*	*26.1*	*29.4*	23.1	
	Yes, in past three months	*12.3*	*12.7*	20.2	*32.0*	18.7	
Risk level for cannabis problem (ASSIST scale summary score)	Low risk	*54.0*	*42.4*	*0.0*	*0.0*	26.1	849.36 (6)***
	Moderate/high risk	*46.0*	*57.6*	*100.0*	*100.0*	73.9	

Note: $N = 1303$ unweighted (percentages are from weighted sample).

[1] Class 1 is the referent.

[2] Scheffe test for *post hoc* analysis showed significant differences between Class 1 with each of the other classes. Italic figures are minimum adjusted standardized residuals of absolute 2.0.

[3] Based on lower sample size ($N = 445$) due to missing data because of sample design.

[4] Based on lower sample size ($N = 680$) due to missing data because of sample design.

[5] Among those who used cannabis for treatment.

[6] Based on lower sample size ($N = 354$).

[7] Based on lower sample size ($N = 446$) because of sample design and respondent eligibility.

*** $p < 0.001$; ns, not significant.

sex, education, income. This emphasizes the relevance of 'population health' principles, specifically the role of socio-economic determinants, in influencing cannabis use patterns and related problem outcomes, as shown elsewhere in their role as determinants of health outcomes for other forms of substance use (Galea *et al.*, 2004; Hall and Pacula, 2003). Specifically, Class 4 included a markedly larger proportion of individuals who had not completed high-school education, and a markedly lower proportion of employed individuals. Thus, although cannabis use is a phenomenon occurring across socio-economic status (SES) groups, problems and harms are disproportionately concentrated in lower SES strata which needs to be taken into account for interventions delivery (Lillie-Blanton and Laveist, 1996; Macleod *et al.*, 2004).

Settings and sources of cannabis use and other drug use

Relevant links between use typologies and settings were observed. While Class 1, i.e. occasional users, featured the highest rate of 'social' cannabis use mainly occurring within the protected boundaries of the home, use for non-social reasons (e.g. recreation, intoxication, or medical use) was most pronounced in high-frequency classes and mostly situated in public places. These data offer important implications for interventions. Specifically, cannabis use among occasional users in many instances likely unfolds as a social phenomenon, and interventions (e.g. prevention) may best be delivered utilizing these circumstances [e.g. peer-models for prevention, designated drivers, etc. (Coggans and McKellar, 1994; Hammersley *et al.*, 2001; Valente *et al.*, 2004)]. Cannabis use among higher-frequency users is likely driven by other motives, e.g. more compulsive use in non-social contexts, and thus likely requiring more therapeutically-based interventions (Anthony, 2006; Coffey *et al.*, 2002). Furthermore, the higher rate of use in public places likely renders this latter group of high frequency users more exposed to the adverse consequences of drugs policing, which typically concentrates its law enforcement efforts on public spaces (Fischer *et al.*, 2003; Johnson *et al.*, 1977; King and Mauer, 2006). The prevalence of alcohol use was high across and did not differ between classes. A somewhat different picture emerged for illicit drug use: its prevalence increased steeply across Classes 2, 3 and 4. The co-occurrence of high-frequency cannabis use with the use of other illicit drugs confirms evidence from other studies, and represents major concerns for public health, specifically given the high morbidity and mortality risks related to substances like heroin, cocaine or amphetamines (Degenhardt *et al.*, 2006; Kaye and Darke, 2000; Rehm *et al.*, 2006). A related concern is that Class 4 users were most likely to obtain their cannabis commercially, suggesting a higher involvement in illicit drug markets and hence a potentially higher likelihood of exposure to other illicit drugs (MacCoun and Reuter, 1997; Reinarman *et al.*, 2004).

Cannabis use and driving

An exceptional concern from a public health perspective is Driving Under the Influence of Cannabis (DUIC), given the evidence for increased risk of fatal and non-fatal MVA involvement (Ashbridge *et al.*, 2005; Drummer *et al.*, 2003; Kelly *et al.*, 2004; Ramaekers *et al.*, 2002). The prevalence of DUIC also increased sharply across Classes 2, 3 and 4, indicating an important association between the frequency of cannabis use and DUIC as shown by other studies (Fergusson and Horwood, 2001; Jones *et al.*, 2006; Lewis *et al.*, 2005). The increase across classes was quite pronounced, with less than 10% of Class 1 reporting past-year DUIC activity, yet >60% reporting such in Classes 3 and 4. The potential for harms especially in the latter classes is exacerbated by the high alcohol and other illicit drug use prevalence rates known to substantially amplify the risks for possible MVA involvement in co-occurrence with cannabis use (O'Kane *et al.*, 2002; Ramaekers *et al.*, 2004). Clearly, DUIC is a major problem in need of effective interventions in Canada and has recently been given extended legislative and enforcement resources (Barnett *et al.*, 2007). However, it appears that measures aiming at controlling cannabis use patterns may at least be as important an intervention point as enforcement measures in addressing the phenomenon of DUIC.

Health outcomes

In terms of other health consequences, Class 4 featured the highest levels of problems in both physical and mental health domains. Differences however were most starkly pronounced in the latter, where almost one-third of members of Class 4 rated their mental health as 'fair or poor' compared to only 1% in Class 1. While the data used are unspecific with regard to the exact nature of the problems compromising respondents' health status, this likely confirms that frequent cannabis use has been found to co-occur with a range of mental health problems, e.g. emotional distress or depressive symptoms, for which cannabis use in some instances may possibly constitute a form of 'self-medication' (Fergusson and Horwood, 1997;

Kandel, 1984; Khantzian, 1997; Moore *et al.*, 2007). The vastly higher prevalence of moderate or high risks for cannabis use related problems – as measured by the ASSIST summary score – in the frequent use classes (i.e. classes 3 and 4) provides a further indicator for the relatively substantially more risky or problematic use patterns in these groups on the basis of a validated assessment instrument.

Conclusions and implications for interventions and public health

This study overall provides key implications for interventions towards cannabis use within a public health framework (Hall and Babor, 2000; Hall and Pacula, 2003). Most cannabis users in Canada use this drug infrequently, and presumably without major health risks. Public health concerns, however, rise considerably across the identified user classes and are most pronounced for Class 4, i.e. highly frequent users. Appropriate interventions should most pressingly be targeted especially at this sub-population of users. On this basis, a fundamental re-assessment of interventions available and implemented for cannabis use in Canada is urgently needed, since most available interventions – whether in the form of law enforcement targeting cannabis use or referrals to treatment – are not built on these premises.

One key element is prevention. Since a substantial proportion of young (e.g. age 15–25 years) Canadians are involved in cannabis use and include high-frequency users, this population ought to become a primary target for systematic (primary and secondary) prevention efforts. These efforts need to include realistic, adequately tailored and health-focused education about the possible risks and harms of cannabis use and ways to reduce these (Boys *et al.*, 2001; Swift *et al.*, 2000; White and Pitts, 1998). Furthermore, effective monitoring strategies need to be established to identify young high-risk (e.g. early onset or frequent) users and link them to appropriate interventions (e.g. brief interventions or treatment). Rather than primarily relying on parental monitoring with its inherent shortcomings, these measures may best, most broadly and equitably implemented in schools or other educational settings, similar to other broad-based public health measures so delivered (DiClemente *et al.*, 2001; Kirby *et al.*, 1994). For the sizeable adult cannabis user population in Canada, 'lower risk cannabis use' guidelines – akin to those in place for alcohol – outlining evidence-based guidelines to reduce risks and harms related to cannabis use might be an additionally useful population based intervention tool, and could be developed and disseminated by public health authorities (Bondy *et al.*, 1999; Dawson, 2000).

Similarly, the landscape of therapeutic interventions for problematic cannabis use requires improvements. Data from the Ontario treatment system show that admissions for cannabis have been rising, yet consist predominantly of externally initiated or required referrals, i.e. legal, school or workplace referrals (Rush and Urbanoski, 2007; Urbanoski *et al.*, 2005). These may often not involve those users with clinically established therapeutic needs. In fact, evidence suggests that the majority of cannabis users experiencing problems – e.g. those with dependence – do not seek treatment (Anthony, 2006). Especially for those cannabis users indicating a high problem propensity or even dependence and who are in clinically determined need of treatment, an appropriate range of evidence-based interventions – including brief interventions, cognitive/behavioral therapy – needs to be readily available and accessible (Copeland *et al.*, 2001; Kleber, 1989; McRae *et al.*, 2003); new options for therapeutic interventions (e.g. including strategies involving the medical provision of synthetic tetrahydrocannabinol (THC) or other cannabis replacement products for withdrawal management) should be rigorously evaluated (Levin and Kleber, 2008).

Finally, the current criminal status of cannabis use in itself may be counterproductive for public health ends in several ways (e.g. due to the stigmatizing users, hindering health-based prevention, pressure of users into illicit markets, etc. (MacCoun and Reuter, 1997; Wodak *et al.*, 2002). While not interested in getting involved in the ideological debate of the legal status of cannabis use, we suggest that the application of criminal control tools aiming at cannabis use should selectively occur only in those areas (e.g. DUIC) where evidence can demonstrate public health benefits.

Public health has become the leading paradigm in key areas of substance use policy. Given the large population – especially young people – exposed to cannabis use, and the existing morbidity and mortality consequences associated with identified use patterns, the time for a public health approach to cannabis use in Canada has come.

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Declaration of interest statement

The authors have no competing interests.

References

Adlaf E.M., Ialomiteanu A. (2004) *Canadian Addiction Survey 2004: Microdata eGuide*, Canadian Centre for Substance Abuse. http://www.ccsa.ca/2004%20CCSA%20Documents/ccsa-005363-2004.pdf [1 February 2007].

Adlaf E., Paglia-Boak A. (2007) *Drug Use Among Ontario Students 1977–2007: OSDUHS Highlights*, Centre for Addiction and Mental Health.

Adlaf E., Begin P., Sawka E. (2005) *Canadian Addiction Survey (CAS): A National Survey of Canadians' Use of Alcohol and Other Drugs: Prevalence of Use and Related Harms – A Detailed Report*, Canadian Centre on Substance Abuse.

Agrawal A., Lynskey M., Madden P., Bucholz K.K., Heath A.C. (2006) A latent class analysis of illicit drug abuse/dependence: Results from the National Epidemiological Survey on Alcohol and Related Conditions. *Addiction*, **102**, 94–104.

Anthony J. (2006) The epidemiology of cannabis dependence. In: *Cannabis Dependence: Its Nature, Consequences and Treatment* (eds Roffman R, Stephens R), pp. 58–105, Cambridge University Press.

Arseneault L., Cannon M., Witton J., Murray R.M. (2007) Causal association between cannabis and psychosis: Examination of the evidence. *Focus*, **5**, 270–278.

Ashbridge M., Poulin C., Donato A. (2005) Motor vehicle collision risk and driving under the influence of cannabis: Evidence from adolescents in Atlantic Canada. *Accident Analysis & Prevention*, **37**, 1025–1034.

Babor T., Caetano R., Casswell S., Edwards G., Giesbrecht N., Graham K., Grube J., Gruenewald P., Hill L., Holder H., Homel R., Osterberg E., Rehm J., Room R., Rossow I. (2003) *Alcohol: No Ordinary Commodity: Research and Public Policy*, Oxford University Press.

Bachman J.G., Wadsworth K.N., O'Malley P.M., Johnston L.D., Schulenberg J.E. (1997) *Smoking, Drinking, and Drug Use in Young Adulthood: The Impacts of Freedom and New Responsibilities*, University of Michigan.

Barnett L., MacKay R., Valiquet D. (2007) *Bill C-2: An Act to Amend the Criminal Code and to Make Consequential Amendments to Other Acts. Legislative Summary*, Parliamentary Information and Research Services.

Bondy S.J., Rehm J., Ashley M.J., Walsh G., Single E., Room R. (1999) Low-risk drinking guidelines: The scientific evidence. *Canadian Journal of Public Health*, **90**, 264–270.

Boys A., Marsden J., Strang J. (2001) Understanding reasons for drug use amongst young people: A functional perspective. *Health Education Research*, **16**, 457–469.

Casady R., Lepkowski M. (1999) Telephone sampling. In: *Sampling of Population* (eds Levy P, Lemeshow S), pp. 455–479, Wiley.

Chen K., Kandel D., Davies M. (1997) Relationships between frequency and quantity of marijuana use and last year proxy dependence among adolescents and adults in the United States. *Drug and Alcohol Dependence*, **46**, 53–67.

Coffey C., Carlin J.B., Degenhardt L., Lynskey M., Sanci L., Patton G.C. (2002) Cannabis dependence in young adults: An Australian population study. *Addiction*, **97**, 187–194.

Coggans N., McKellar S. (1994) Drug use amongst peers: Peer pressure or peer preference? *Drugs: Education, Prevention & Policy*, **1**, 15–26.

Copeland J., Swift W., Rees V. (2001) Clinical profile of participants in a brief intervention program for cannabis use disorder. *Journal of Substance Abuse Treatment*, **20**, 45–52.

Dawson D. (2000) US low-risk drinking guidelines: An examination of four alternatives. Epidemiology and prevention. *Alcoholism: Clinical and Experimental Research*, **24**, 1820–1829.

Degenhardt L., Hall W., Warner-Smith M. (2006) Using cohort studies to estimate mortality among injecting drug users that is not attributable to AIDS. *Sexually Transmitted Infections*, **82**, 56–63.

DiClemente R.J., Wingood G.M., Crosby R., Sionean C., Cobb B.K., Harrington K., Davies S., Hook III E., Oh M.K. (2001) Parental monitoring: Association with adolescents' risk behaviors. *Pediatrics*, **107**, 1363–1368.

Drummer O.H., Gerostamoulos J., Batziris H., Chu M., Caplehorn J., Robertson M.D., Swann P. (2003) The incidence of drugs in drivers killed in Australian road traffic crashes. *Forensic Science International*, **134**, 154–162.

Fergusson D.M., Horwood L.J. (1997) Early onset cannabis use and psychosocial adjustment in young adults. *Addiction*, **92**, 279–296.

Fergusson D.M., Horwood L.J. (2001) Cannabis use and traffic accidents in a birth cohort of young adults. *Accident Analysis & Prevention*, **33**, 703–711.

Fischer B., Ala-Leppilampi K., Single E., Robins A. (2003) Cannabis law reform in Canada: Is the 'saga of promise, hesitation and retreat' coming to an end? *Canadian Journal of Criminology and Criminal Justice*, **45**, 265–297.

Gable R. (2004) Comparison of acute lethal toxicity of commonly abused psychoactive substances. *Addiction*, **99**, 686–696.

Galea S., Nandi A., Vlahov D. (2004) The social epidemiology of substance use. *Epidemiologic Reviews*, **26**, 36–52.

Grant J., Scherrer J.F., Neuman R., Todorov A.A., Pricem R.K., Bucholz K.K. (2006) A comparison of the latent class structure of cannabis problems among adult

men and women who have used cannabis repeatedly. *Addiction*, **101**, 1133–1142.
Hall W. (2007) What's in a name? *Addiction*, **102**, 692–692.
Hall W., Solowij N. (1998) Adverse effects of cannabis. *Lancet*, **352**, 1611–1616.
Hall W., Babor T. (2000) Cannabis use and public health: Assessing the burden. *Addiction*, **95**, 485–490.
Hall W., Pacula R. (2003) *Cannabis Use and Dependence: Public Health and Public Policy*, Cambridge University Press.
Hall W., Room R., Bondy S. (1999) Comparing the health and psychological risks of alcohol, cannabis, nicotine and opiate use. In: *The Health Effects of Cannabis* (eds Kalant H, Corrigall W, Hall W, Smart R), pp. 476–506, Centre for Addiction and Mental Health.
Hammersley R., Jenkins R., Reid M. (2001) Cannabis use and social identity. *Addiction Research & Theory*, **9**, 133–150.
Henquet C., Krabbendam L., Spauwen J., Kaplan C., Lieb R., Wittchen H.U., van Os J. (2005) Prospective cohort study of cannabis use, predisposition for psychosis and psychotic symptoms in young people. *British Medical Journal*, **330**, 11.
Humeniuk R., Ali R., Babor T.F., Farrell M., Formigoni M.L., Jittiwutikarn J., de Lacerda R.B., Ling W., Marsden J., Monteiro M., Nhiwatiwa S., Pal H., Poznyak V., Simon S. (2008) Validation of the Alcohol, Smoking and Substance Involvement Screening Test (ASSIST). *Addiction*, **103**, 1039–1047.
Iversen L. (2000) *The Science of Marijuana*, Oxford University Press.
Iversen L. (2005) Long-term effects of exposure to cannabis. *Current Opinion in Pharmacology*, **5**, 69–72.
Johnson W.T., Petersen R.E., Wells L.E. (1977) Arrest probabilities for marijuana users as indicators of selective law enforcement. *American Journal of Sociology*, **83**, 681–699.
Jones C., Donnelly N., Swift W., Weatherburn D. (2006) Preventing cannabis users from driving under the influence of cannabis. *Accident Analysis & Prevention*, **38**, 854–861.
Kalant H. (2004) Adverse effects of cannabis on health: An update of the literature since 1996. *Progress in Neuropsychopharmacology & Biological Psychiatry*, **28**, 849–863.
Kandel D. (1984) Marijuana users in young adulthood. *Archives of General Psychiatry*, **41**, 200–209.
Kaye S., Darke S. (2000) A comparison of the harms associated with the injection of heroin and amphetamines. *Drug and Alcohol Dependence*, **58**, 189–195.
Kelly E., Darke S., Ross J. (2004) A review of drug use and driving: Epidemiology, impairment, risk factors and risk perceptions. *Drug and Alcohol Review*, **23**, 319–344.
Kessler R., Chiu W.T., Demier O., Walters E.E. (2005) Prevalence, severity, and comorbidity of 12-month DSM-IV disorders in the National Comorbidity Survey Replication. *Archives of General Psychiatry*, **62**, 617–627.
Khantzian E.J. (1997) The self-medication hypothesis of substance use disorders: A reconsideration and recent applications. *Harvard Review of Psychiatry*, **4**, 231–224.
King R., Mauer M. (2006) The war on marijuana: The transformation of the war on drugs in the 1990s. *Harm Reduction Journal*, **3**, 6.
Kirby D., Short L., Collins J., Rugg D., Kolbe L., Howard M., Miller B., Sonenstein F., Zabin L.S. (1994) School-based programs to reduce sexual risk behaviors: A review of effectiveness. *Public Health Reports*, **109**, 339–360.
Kleber H. (1989) Treatment of drug dependence: What works. *International Review of Psychiatry*, **1**, 81–99.
Levin F., Kleber H.D. (2008) Use of dronabinol for cannabise dependence: Two case reports and review. *American Journal of Addiction*, **17**, 161–164.
Lewis T.F., Thombs D.L., Olds R.S. (2005) Profiles of alcohol- and marijuana-impaired adolescent drivers. *Addiction Research & Theory*, **13**, 145–154.
Li W., Nyholt D.R. (2001) Marker selection by Akaike information criterion and Bayesian information criterion. *Genetic Epidemiology*, **21**, 272–277.
Lillie-Blanton M., Laveist T. (1996) Race/ethnicity, the social environment, and health. *Social Science & Medicine*, **43**, 83–91.
Lo Y., Mendell N., Rubin D. (2001) Testing the number of components in a mixture model. *Biometrika*, **88**, 767–778.
Lynskey M., Agrawal A., Bucholz K.K., Nelson E.C., Madden P., Todorov A.A., Grant J., Martin N.G., Heath A.C. (2006) Subtypes of illicit drug users: A latent class analysis of data from an Australian twin sample. *Twin Research & Human Genetics*, **9**, 523–530.
MacCoun R., Reuter P. (1997) Interpreting Dutch cannabis policy: Reasoning by analogy in the legalization debate. *Science*, **278**, 47–52.
Macleod J., Oakes R., Copello A., Crome I., Egger M., Hickman M., Oppenkowski T., Stokes-Lampard H., Smith G.D. (2004) Psychological and social sequelae of cannabis and other illicit drug use by young people: A systematic review of longitudinal, general population studies. *Lancet*, **363**, 1579–1588.
McRae A., Budney A.J., Brady K.T. (2003) Treatment of marijuana dependence: A review of the literature. *Journal of Substance Abuse and Treatment*, **24**, 369–376.
Monga N., Rehm J., Fischer B., Brissette S., Bruneau J., el-Guebaly N., Noel L., Tyndall M., Wild C., Leri F., Fallu J.-S., Bahl S. (2007) Using latent class analysis (LCA) to analyze patterns of drug use in a population of illegal opioid users. *Drug and Alcohol Dependence*, **8**, 1–7.
Moore T.H., Zammit S., Lingford-Hughes A., Barnes T.R.E., Jones P.B., Burke M., Lewis G. (2007) Cannabis use and risk of psychotic or affective mental health outcomes: A systematic review. *Lancet*, **370**, 319–328.
Moriarty D., Zack M.M., Kobau R. (2003) The Centers for Disease Control and Prevention's Healthy Days Measure

– population tracking of perceived physical and mental health over time. *Health and Quality of Life Outcomes*, **1**, 37.

Muthen L.K., Muthen B.O. (2007) *Mplus User's Guide*, Muthen & Muthen.

Newcombe D., Humeniuk R.E., Ali R. (2005) Validation of the World Health Organization Alcohol, Smoking and Substance Involvement Screening Test (ASSIST): Report of results from the Australian site. *Drug and Alcohol Review*, **24**, 217–226.

Nutt D., King L., Saulsbury C., Blakemore C. (2007) Development of a rational scale to assess the harm of drugs of potential misuse. *Lancet*, **369**: 1047–1053.

O'Kane C., Tutt D.C., Bauer L.A. (2002) Cannabis and driving: A new perspective. *Emergency Medicine*, **14**, 296–303.

Ôunpuu S., Krueger P., Vermeulen M., Chambers L. (2000) Using the US Behavior Risk Factor Surveillance System's Health-related Quality of Life survey tool in a Canadian city. *Canadian Journal of Public Health*, **91**, 67–72.

Patra J., Fischer B., Maksimowska S., Rehm J. (2009) Profiling poly-substance use typologies in a multi-site cohort of illicit opioid and other drug users in Canada – a latent class analysis (LCA). *Addiction Research & Theory*, **17**, 168–185.

Patton G.C., Coffey C., Carlin J.B., Degenhardt L., Lynskey M., Hall W. (2002) Cannabis use and mental health in young people: Cohort study. *British Medical Journal*, **325**, 1195–1198.

Perkonigg A., Lieb R., Hofler M., Schuster P., Sonntag H., Wittchen H.-U. (1999) Patterns of cannabis use, abuse and dependence over time: Incidence, progression and stability in a sample of 1228 adolescents. *Addiction*, **94**, 1663–1678.

Perkonigg A., Goodwin R.D., Fiedler A., Behrendt S., Beesdo K., Lieb R., Wittchen H.-U. (2008) The natural course of cannabis use, abuse and dependence during the first decades of life. *Addiction*, **103**, 439–449.

Raftery A.E. (1995) Bayesian model selection in social research. In: *Social Methodology* (ed. Marsden PV), pp. 111–196, Blackwell.

Ramaekers J., Berghaus G., van Laar M., Drummer O. (2002) Performance impairment and risk of motor vehicle crashes after cannabis use. In: *Proceedings of the International Scientific Conference on Cannabis* (eds Rodin Foundation), pp. 69–87, Ministry of Public Health of Belgium.

Ramaekers J., Berghaus G., van Laar M., Drummer O.H. (2004) Dose related risk of motor vehicle crashes after cannabis use. *Drug and Alcohol Dependence*, **73**, 109–119.

Rehm J., Taylor B., Room R. (2006) Global burden of disease from alcohol, illicit drugs and tobacco. *Drug and Alcohol Review*, **25**, 503–513.

Rehm J., Gnam W., Popova S., Baliunas D., Brochu S., Fischer B., Patra J., Sarnocinksa-Hart A., Taylor B. (2007) The cost of alcohol, illegal drugs, and tobacco in Canada in 2002. *Journal of Studies on Alcohol and Drugs*, **68**, 886–895.

Reinarman C., Cohen P.D., Kaal H.L. (2004) The limited relevance of drug policy: Cannabis in Amsterdam and in San Francisco. *American Journal of Public Health*, **94**, 836–842.

Room R., Babor T., Rehm J. (2005) Alcohol and public health: A review. *Lancet*, **365**, 519–530.

Rush B., Urbanoski K. (2007) Estimating the demand for treatment for cannabis-related problems in Canada. *International Journal of Mental Health and Addiction*, **5**, 181–186.

Skrondal A., Rabe-Hesketh S.E. (2004) *Generalized Latent Variable Modeling*, Chapman and Hall/ CRC.

SPSS Inc. (2006) *SPSS System for Windows*, Version 16, SPSS.

Strang J., Witton J., Hall W. (2000) Improving the quality of the cannabis debate: Defining the different domains. *British Medical Journal*, **320**, 108–110.

Swift W., Copeland J., Lenton S. (2000) Cannabis and harm reduction. *Drug and Alcohol Review*, **19**, 101–112.

United Nations Office on Drugs and Crime (2007) *World Drug Report 2007*, United Nations.

Urbanoski K., Strike C., Rush B.R. (2005) Individuals seeking treatment for cannabis-related problems in Ontario: Demographic and clinical profile. *European Addiction Research*, **11**, 115–123.

Valente T., Gallaher P., Mouttapa M. (2004) Using social networks to understand and prevent substance use: A transdisciplinary perspective. *Substance Use and Misuse*, **39**, 1685–1712.

White D., Pitts M. (1998) Educating young people about drugs: A systematic review. *Addiction*, **93**, 1475–1487.

Wittchen H.-U., Behrendt S., Höfler M., Perkonigg A., Rehm J., Lieb R., Beesdo K. (2009) A typology of cannabis-related problems among individuals with repeated illegal drug use in the first three decades of life: Evidence for heterogeneity and different treatment needs. *Drug and Alcohol Dependence*, **102**, 151–157.

Wodak A., Reinarman C., Cohen P. (2002) Cannabis control: Costs outweigh the benefits – For. *British Medical Journal*, **324**, 105–106.

Appendix

Table A1 Model comparisons, fit indices and class proportions

Models	Number of classes (c) or factors (f)	Log likelihood	Number of estimated parameters	AIC	BIC	Adjusted BIC	Class proportions (highest to lowest)
LCA model	2 c	–7452.29	31	14966.59	15126.93	15028.46	0.576, 0.424
	3 c	–7180.01	47	14454.01	14697.11	14547.82	0.434, 0.333, 0.233
	4 c	*–7101.64*	*63*	*14329.28*	*14655.14*	*14455.02*	*0.318, 0.251, 0.229, 0.202*
	5 c	–7066.47	79	14290.94	14699.56	14458.62	0.278, 0.274, 0.225, 0.212, 0.011
EFA model	*1 f*	*–7318.52*	*21*	*14679.03*	*14787.65*	*14720.95*	
	2 f	–7293.15	26	14638.3	14772.79	14690.2	
	3 f		cannot estimate standard error				
FMM Scenario 1	1 f 2 c	–7511.48	22	15066.95	15180.75	15110.86	0.567, 0.433
	1 f 3 c	–7291.59	24	14631.18	14755.32	14679.08	0.409, 0.380, 0.211
	1 f 4 c	*–7253.18*	*26*	*14558.36*	*14692.85*	*14610.26*	*0.325, 0.289, 0.208, 0.177*
	1 f 5 c	–7251.68	28	14559.36	14704.19	14615.25	0.292, 0.265, 0.208, 0.174, 0.060
FMM Scenario 2	2 f 2 c	–7511.48	22	15066.95	15180.75	15110.86	0.552, 0.448
	2 f 3 c	–7280.11	25	14610.21	14739.52	14660.11	0.398, 0.395, 0.206
	2 f 4 c	–7238.32	28	14532.64	14677.47	14588.52	0.325, 0.275, 0.205, 0.196
	2 f 5 c	–7223.23	31	14508.47	14668.81	14570.34	0.322, 0.274, 0.199, 0.139, 0.067

Note: The 1f EFA and 1f 4c FMM are clearly superior to all of the other fitted models (2f solution had a negative residual variance for the variable 'How often used Cannabis in past three months', therefore $K - 1$ factor was chosen, K refers to number of eigen values >1). AIC, Akaike Information Criterion; BIC, Bayesian Information Criterion; LCA, latent class analysis, EFA, exploratory factor analysis; FMM, factor mixture model. Values in italics refer to the best model in the respective analyses.