NOTE TO USERS

Page(s) not included in the original manuscript and are unavailable from the author or university. The manuscript was scanned as received.

Page x

This reproduction is the best copy available.

UMI®

ADOLESCENT SUBSTANCE USE: TRAJECTORIES OF USE, THE EFFECTS OF CHILDHOOD BEHAVIOUR PROBLEMS ON TRAJECTORIES OF USE, AND THE EFFECT OF PUBERTAL TIMING ON THE INITIATION OF HIGH USE BEHAVIOURS

By

ROCHELLE GARNER, B.A.&Sc., M.Sc.

A Thesis

Submitted to the School of Graduate Studies

in Partial Fulfillment of the Requirements

for the Degree

Doctor of Philosophy

McMaster University

February 2007

Your file Votre référence
ISBN: 978-0-494-28154-3
Our file Notre référence
ISBN: 978-0-494-28154-3

DOCTOR OF PHILOSOPHY (2007) McMaster University

(Epidemiology, Health Research Methodology) Hamilton, Ontario

TITLE: Adolescent Substance Use: Trajectories Of Use, The Effects Of Childhood Behaviour Problems On Trajectories Of Use, And The Effect Of Pubertal Timing On The Initiation Of High Use Behaviours

AUTHOR: Rochelle Garner, M.Sc. (University of Toronto), B.A.&Sc. (McMaster University)

SUPERVISOR: Dr. Michael H. Boyle

NUMBER OF PAGES: xiii, 245

Abstract

Adolescence is a period in the life course when the individual starts to exert greater autonomy and decision-making responsibility. One choice that is often made during adolescence is whether or not to experiment with substances such as tobacco, alcohol, marijuana or other drugs. A further choice is whether to engage in continued or regular use of such substances.

The three studies that comprise this thesis focus on the patterns of substance use exhibited by adolescents and factors that may be associated with such behaviours. Key among these factors is the role that gender may play in differentiating patterns of behaviour or of moderating the effects of other factors on substance use.

Project #1 describes the trajectories of tobacco and marijuana use among adolescents and examines gender differences in the patterns of use. Results indicate that patterns of initiation show no gender differences but that post-initiation use of substances do show important differences.

Project #2 describes trajectories of behaviour problems during childhood as reported by mothers, and determines how such behaviours are related to trajectories of substance use initiation during adolescence. Gender differences in these joint trajectories are also examined. Results indicate that children with high levels of externalizing or internalizing problems are most likely to follow early-initiating trajectories of substance use.

Finally, Project #3 models the relationship between pubertal timing and substance use behaviour. Results indicate that, relative to on-time maturing youth, late

maturers have the lowest hazard of initiating problematic substance using behaviours. Early maturers have the great hazard of initiation during early adolescence, but those who have not initiated problematic use prior to age 14 are less likely than on-time maturing youth to initiate these behaviours.

Acknowledgements

I gratefully acknowledge the encouragement and assistance of numerous individuals throughout the process of completing my dissertation studies.

To Dr. Michael Boyle, my primary supervisor, thank you for your guidance and insight at all stages of this process. You are an example to me of the type of leader and academic I hope to become, and have made this process more enjoyable than perhaps it should have been.

To my committee members – Dr. Tracy Vaillancourt, Dr. Peter Szatmari and Dr. Paul Contoyannis – thank you for accommodating my sometimes impractical time lines and sporadic communications. You have greatly eased this process and improved its outcome.

To the Garner family – John, Sandy and Kathryn – thank you for the love and encouragement that you have shown me from day one. Your prayers and kind words mean more than you will know.

To the Martin family – Mom and Dad, Jon and Leah, Laura and Mike – each of you, in your own way, have inspired me, not only as an academic, but simply as a person, to strive for betterment and to believe in my gifts and abilities. And here's to the ongoing case-control study of *S.waynus* exposure that plagues our family: may future generations reap the best of this epidemic.

And lastly, to my husband Michael – since you first stepped onto the doorstep on my life, you have urged me to believe in myself more than I did, to reach higher than I thought I could, and to dream bigger than I imagined I ought. You are adored, my dear.

Preface

This thesis includes material that was prepared in collaboration with members of the thesis committee. Committee members contributed their disciplinary expertise to the development of the project questions and aided the student in terms of problem-solving and manuscript editing. However, the manuscripts contained within this thesis are the original work of the PhD candidate, who was responsible for the project design, data analysis and manuscript preparation. As such, the work contained within this thesis meets the requirements for inclusion on the main text of this thesis.

Table of Contents

BACKGROUND 1
Canada's Drug Strategy 3
Strategies in the United States: Healthy People 2010 4
Monitoring of Substance Use 6
Prevalence Rates of Substance Use 7
General Population 7
Adolescents 8
Levels of Substance Use: Experimentation, Use and Abuse 11
Gender Differences in Substance Use 15
Tobacco Use 15
Alcohol Use 16
Marijuana Use 19
Other Drug Use 20
Gaps in the Literature 21
References 27
PROJECT OBJECTIVES AND RESEARCH QUESTIONS 37
Project #1: Trajectories of Substance Use Among Adolescents 37
Objective 37
Research Questions 37
Project #2: Joint Trajectories of Childhood Behaviour Problems and Adolescent Substance Use Onset 38
Objective 38
Research Questions 39
Project #3: Pubertal Timing and Risk for Substance Use 40
Objective 40
Research Questions 40
CONTEXT AND RELATIONSHIP BETWEEN STUDIES 43
OVERVIEW: DATA SOURCES 45
National Longitudinal Survey of Children and Youth (NLSCY) 45
Substance Use Questions in the NLSCY 46
Puberty Questions in NLSCY 48
Changes in the NLSCY Over Time 50
National Longitudinal Survey of Youth 1979 – Child and Young Adult Data (NLSY79-C) 51
Substance Use Questions in the NLSY79-C 53
Behaviour Problem Index 56
Changes in the NLSY79-C Over Time 58
References 59
OVERVIEW: ANALYSIS 61
Group-Based Developmental Trajectories 61
Derivation of the Likelihood Function 62

Trajectory Model Development and Selection *63*
Dual Trajectory Analysis: An Extension of Group-Based Techniques 64
Discrete-Time Survival Analysis 66
Building the Model *68*
Gender Differences or Sex Differences? 71
References 73
PROJECT #1: GENDER DIFFERENCES IN THE DEVELOPMENTAL TRAJECTORIES OF SMOKING AND MARIJUANA USE AMONG CANADIAN ADOLESCENTS 75
Abstract 79
Background 81
Methods 84
Participants *84*
Measures *85*
Analysis *87*
Results 89
Smoking Initiation *90*
Frequency of Smoking *91*
Marijuana Use Initiation *92*
Frequency of Marijuana Use *93*
Effect of Covariates on Trajectory Membership *95*
Discussion 97
References 104
PROJECT #2: JOINT TRAJECTORIES OF CHILDHOOD BEHAVIOUR PROBLEMS AND ADOLESCENT SUBSTANCE USE ONSET 123
Background 125
Methods 130
Data Source *130*
Participants *131*
Measures *132*
Analysis *133*
Results 136
Externalizing and Internalizing Problems in Childhood *136*
Smoking and Marijuana Initiation *138*
Behaviour Problems in Childhood and Substance Initiation in Adolescence *139*
Discussion 143
References 149
PROJECT #3: PUBERTAL TIMING AND RISK FOR SUBSTANCE USE 165
Abstract 169
Background 171
Methods 176
Participants *176*
Measures *177*
Analytic Approach *179*

Results 180
Participants and Pubertal Timing *180*
Attrition, Censoring and Missing Data Analysis *181*
Pubertal Timing and Onset of Substance Use *181*
Discussion 183
References 188
CONCLUDING DISCUSSION 201
Meeting Policy Goals 202
Future Steps *204*
Typologies of Substance Use 205
Who Is At Risk? 208
Limitations 209
Statistically Significant Versus (Clinically) Important Differences *209*
Potential Limitations of Group-Based Developmental Trajectories *211*
Limitations of the Data: Recommendations for Future Content *212*
Limitations: Recommendations for the Surveillance of Drug Use in Canada *218*
Summary of Recommendations 220
References 222
APPENDIX A: Recoding Of Substance Use Questions In The National Longitudinal Survey Of Children And Youth (NLSCY) 227
APPENDIX B: Recoding Of Substance Use Questions In The National Longitudinal Survey Of Youth 1979 – Children And Young Adults Data (NLSY79-C) 235

List of Tables

BACKGROUND
Table 1 Prevalence rates of lifetime, past year and past month use of tobacco and alcohol from various surveys in Canada and the United States 23
Table 2 Prevalence rates of lifetime, past year and past month use of marijuana and other illicit drugs from various surveys in Canada and the United States 25

OVERVIEW: DATA SOURCES
Table 3 Number of NLSCY respondents by year of age for cycles 1 through 5 46
Table 4 Substance categories included in each cycle of the NLSCY, by age group 48
Table 5 Pubertal status questions included in the NLSCY 49
Table 6 Number of NLSY79-C respondents by age at interview, 1986-2002 53
Table 7 Substance categories asked in each cycle of the NLSY79-C, by age group 54
Table 8 Items from the Behaviour Problem Index (BPI) and their inclusion in the externalizing and internalizing subscales 57

OVERVIEW: DATA ANALYSIS
Table 9 Time indicator dummy variables in discrete-time survival analysis 69

PROJECT #1
Table 10 Characteristics of NLSCY children by inclusion status 113
Table 11 Smoking trajectory groups, proportion per group, overall and by gender 113
Table 12 Marijuana use trajectory groups, proportion per group, overall and by gender 114
Table 13 Odds ratios (95% CIs) and predicted membership probabilities for different risk scenarios for initiation of smoking trajectories 115
Table 14 Odds ratios (95% CIs) and predicted membership probabilities for different risk scenarios for frequency of smoking trajectories 116
Table 15 Odds ratios (95% CIs) and predicted membership probabilities for different risk scenarios for initiation of marijuana use trajectories 117
Table 16 Odds ratios (95% CIs) and predicted membership probabilities for different risk scenarios for frequency of marijuana use trajectories 118

PROJECT #2
Table 17 Mean (standard deviation) externalizing and internalizing scores by year of age, by gender 158
Table 18 Proportion of respondents reporting ever smoking or ever using marijuana by age at interview, by gender 158
Table 19 Joint and conditional probabilities of externalizing behaviour problems (top panel) and internalizing problems (bottom panel) with smoking initiation, by gender 159

Table 20 Joint and conditional probabilities of externalizing behaviour problems (top panel) and internalizing problems (bottom panel) with marijuana initiation, by gender 160
Table 21 Comparison of conditional probabilities of substance initiation across type of behaviour problem, by gender 161
Table 22 Comparison of conditional probabilities of substance initiation between males and females, by behaviour trajectory 161

PROJECT #3
Table 23 Mean (standard deviation) age-specific PDS scores, by gender and maturational timing category 196
Table 24 Effect of maturational status in nonproportional discrete survival models of substance use, by gender and behaviour category 197

CONCLUDING DISCUSSION
Table 25 Typologies of substance use developed by the Observatoire Français des Drogues et des Toxicomanies 205
Table 26 Typology of cannabis use proposed by the Senate Special Committee on Illegal Drugs 206

APPENDIX A
Table 27 Recoding of frequency of smoking questions from the NLSCY 229
Table 28 Recoding of frequency of alcohol use questions from the NLSCY 230
Table 29 Recoding of frequency of marijuana use questions from the NLSCY 232
Table 30 Recoding of frequency of other drug use questions from the NLSCY 233

APPENDIX B
Table 31 Recoding of frequency of smoking questions from the NLSY79-C 237
Table 32 Recoding of frequency of alcohol use questions from the NLSY79-C, Children (ages 10 through 14) 240
Table 33 Recoding of frequency of alcohol use questions from the NLSY79-C, Youth (ages 15 and up) 242
Table 34 Recoding of frequency of marijuana use questions from the NLSY79-C 244
Table 35 Recoding of frequency of other drug use questions from the NLSY79-C 247

List of Figures

BACKGROUND
Figure 1 Direct and indirect costs associated with substance abuse in Canada, 2002.....1
Figure 2 Current and target levels of selected Healthy People 2010 objectives.....6
Figure 3 Proportion of Canadians ages 15 and up reporting past year use of cigarettes, alcohol and marijuana.....8
Figure 4 Past year use of cigarettes, alcohol, marijuana and others drugs reported in the OSDUS, 1999-2005.....9
Figure 5 Proportion of twelfth-graders reporting substance use behaviours, 1993-200511
Figure 6 Proportion of Monitoring the Future respondents who perceive great risk for various behaviours, by survey year.....14
Figure 7 Prevalence of binge drinking in the past two weeks (MTF) or four weeks (OSDUS), by sex.....18
Figure 8 Proportion of Canadians aged 15 and over who reported using marijuana in the past year, by gender.....19

PROJECT #1
Figure 9 Smoking initiation trajectories, overall sample (n=6609).....119
Figure 10 Frequency of smoking trajectories, overall sample (n=2214).....119
Figure 11 Marijuana use initiation trajectories, overall sample (n=4468).....120
Figure 12 Trajectories of marijuana use frequency, overall sample (n=1079).....120
Figure 13 Trajectories of marijuana use frequency, males (n=501).....121
Figure 14 Trajectories of marijuana use frequency, females (n=578).....121

PROJECT #2
Figure 15 Trajectories of externalizing behaviour (top panel) and internalizing behaviour (bottom panel), by gender.....162
Figure 16 Trajectories of smoking initiation (top panel) and marijuana initiation (bottom panel), by gender.....163

PROJECT #3
Figure 17 Cumulative probability of initiating regular smoking (top left), drunkenness (top right), weekly marijuana use (bottom left) or other drug use (bottom right) by year of age among males, by pubertal timing group.....198
Figure 18 Cumulative probability of initiating regular smoking (top left), drunkenness (top right), weekly marijuana use (bottom left) or other drug use (bottom right) by year of age among females, by pubertal timing group.....199

Background

"For a country of Canada's size and diversity, there is considerable convergence in findings across provinces on the prevalence of alcohol and other drug use and related impacts. There are also important differences in terms of levels and patterns of use and risk of harms that are of significance not only to researchers, but also to decision-makers and ultimately to Canadians in all provinces."

Canadian Addiction Survey Detailed Report, 2005; p. 77

The number of illicit drug users worldwide is estimated to be approximately 200 million, roughly equivalent to 5% of the global population aged 15 to 64: a further 28% of the global population is estimated to use tobacco (United Nations Office on Drugs and Crime, 2005). The use of substances exerts a high price, in terms of both actual expenditure and the more elusive social costs. In Canada alone, the costs associated with substance abuse were estimated to be $39.8 billion in 2002 (see Figure 1), which reduces to a per capita cost of $1267 for every Canadian (Rehm et al., 2006).

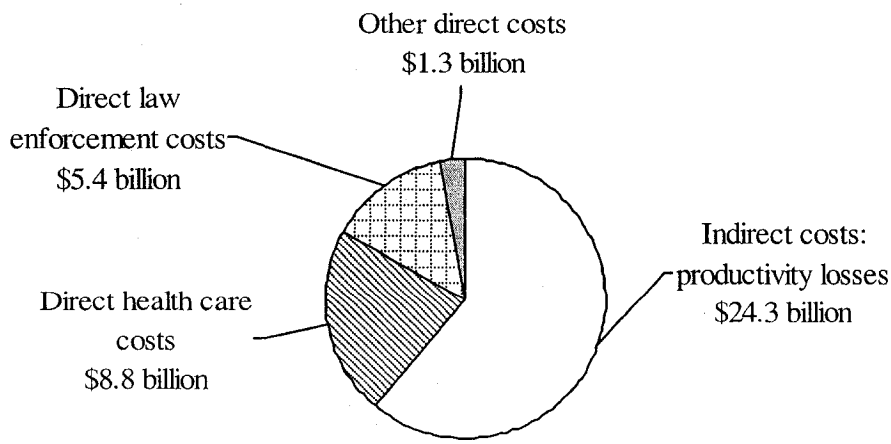

Figure 1 Direct and indirect costs associated with substance abuse in Canada, 2002

Source (Rehm et al., 2006)

The largest portion of these costs is attributed to tobacco use: approximately $17 billion (42.7%) or $541 per capita (Rehm et al., 2006). This includes lost productivity due to illness or long-term disability, inpatient and outpatient health care costs, and the cost of prevention programs. Alcohol abuse accounts for a further 37% of costs ($14.5 billion) and use of illegal drugs such as marijuana and cocaine accounts for the final 21% ($8 billion). What are not included in such figures are the less tangible and more difficult to quantify personal costs associated with substance abuse, such as the pain and suffering of friends and family members of substance abusing individuals, or the victims of crimes related to the abuse of substances.

In 2005, there were approximately 119,000 criminal code traffic incidents in Canada: nearly 64% of these were for impaired driving. In the same year there were an additional 92,000 drug-related offences, 65% of which were for cannabis offences (Gannon, 2006). What these numbers fail to represent is the role that drugs and alcohol play in the perpetration of all offences. A report published by the Canadian Centre for Substance Abuse indicates that between 40% and 50% of crimes committed by Canadian federal and provincial inmates were attributed to the use of alcohol and/or illicit drugs: between 10% and 15% are attributable to illicit drugs only, between 15% and 20% were attributed to alcohol only, and between 10% and 20% were attributed to both alcohol and illicit drugs (Pernanen, Cousineau, Brochu, & Sun, 2002). The authors of the report indicate that the proportion of crimes associated with alcohol and/or illicit drug use may be higher if less serious crimes are taken into account.

Canada's Drug Strategy

Canada has long recognized the potentially detrimental impact that substance abuse could exert upon its citizens. As far back as 1908, the Canadian government enacted the *Opium Act* to prohibit the non-medical use of opiates (Collin, 2006). However, it has been primarily in the past 20 years that Canada has developed a more concrete approach to the issue. In May 1987, the federal government established Canada's first National Drug Strategy. The goal of this $210-million, five-year plan was to decrease the prevalence of drug abuse in Canada and "to reduce the harm to individuals, families and communities from the abuse of alcohol and other drugs through a balanced approach that is acceptable to Canadians" (Nolin & Kenny, 2002). This new approach balanced the government's previous focus on controlling the supply of drugs in Canada by incorporating a new focus on prevention and treatment of drug use in order to decrease the demand for substances.

Over time, the National Drug Strategy was modified in significant ways. In 1992, the initiative was merged with the National Strategy to Reduce Impaired Driving, creating a new initiative called Canada's Drug Strategy. In 1998, the federal government reaffirmed its commitment to the Drug Strategy, but significantly reduced the available funding (Collin, 2006). For many, this rendered the objectives of Canada's Drug Strategy near impossible to reach (Nolin & Kenny, 2002).

In addition to monetary support towards the Drug Strategy, the Canadian government also established the Canadian Centre on Substance Abuse (CCSA), a non-governmental organization that provides focus and leadership in the area of alcohol and

drug abuse (Nolin & Kenny, 2002). The CCSA works with the private sector, provincial health and addiction agencies, and other special interest groups to coordinate the collection and dissemination of information regarding substance use and prevention in Canada.

Most recently, in May 2003, the Canadian federal government unveiled its Renewed Drug Strategy for the country. In addition to investing $245 million over the next five years, the Renewed Drug Strategy identifies six key objectives:

1) Decrease the number of people, particularly youth, who abuse drugs;
2) Decrease the number of young Canadians who experiment with drugs;
3) Decrease the incidence of communicable diseases related to substance use (e.g. hepatitis, HIV);
4) Increase the use of alternative justice measures, such as drug treatment courts;
5) Decrease the illicit drug supply; and
6) Decrease the avoidable health, social and economic costs of substance abuse (Health Canada, 2003).

Strategies in the United States: Healthy People 2010

In 1990, the U.S. Department of Health and Human Services launched its *Healthy People 2000* campaign which identified health improvement goals and objectives to be reached by the year 2000. At the turn of the 21st century, the second iteration of the campaign, *Healthy People 2010*, was launched, with the purpose of promoting health and

preventing illness, disability, and premature death among the American people. Of the 28 focus areas identified by Healthy People 2010, two are related to the use of substances: tobacco use and substance abuse. The following indicators and targets have been selected to measure progress towards the Healthy People 2010 goals in the areas of tobacco use and substance abuse (see also Figure 2):

(1) Reduce cigarette smoking by adolescents;

(2) Reduce cigarette smoking by adults;

(3) Increase the proportion of adolescents not using alcohol or any illicit drugs during the past 30 days;

(4) Reduce the proportion of adults using any illicit drug during the past 30 days; and

(5) Reduce the proportion of adults engaging in binge drinking of alcoholic beverages during the past month (U.S. Department of Health and Human Services, 2000).

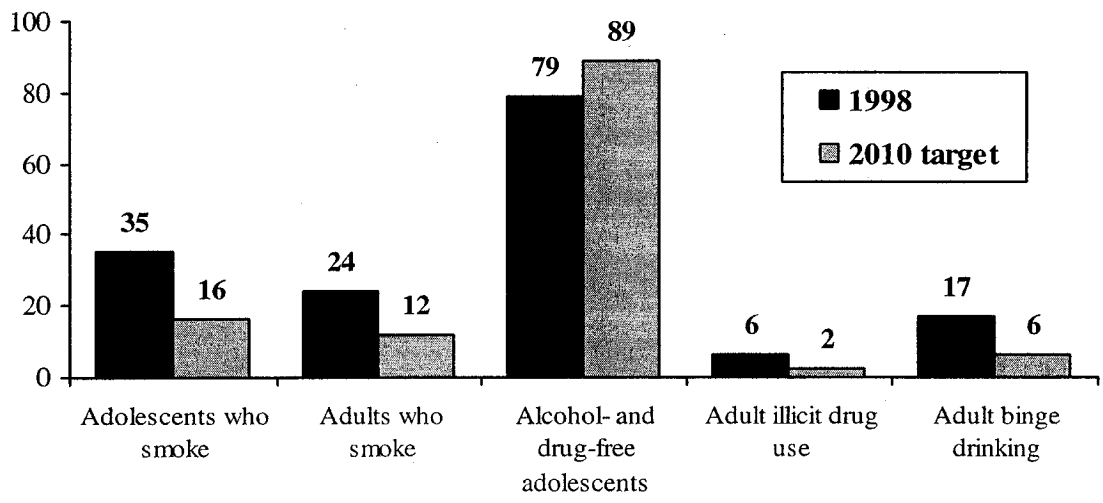

Figure 2 Current and target levels of selected Healthy People 2010 objectives

Source (U.S. Department of Health and Human Services, 2000)

Monitoring of Substance Use

If Canada and the United States are to meet their goals of substance use reduction as laid out in the Renewed Drug Strategy or Healthy People 2010, particularly reduced use among youth, there must be means by which to gauge progress towards these goals. The United States conducts several large-scale, nationally representative surveys that monitor the prevalence of lifetime and current use of substances. For example, the *National Survey of Drug Use and Health* (NSDUH), previously called the *National Household Survey on Drug Abuse*, is a nationally representative survey that has been conducted since 1971. The NSDUH collects information on the use of legal and illicit drugs from residents of households, non-institutional groups (e.g. shelters, rooming houses, dormitories) and from civilians living on military bases across the United States (Substance Abuse and Mental Health Services Administration, 2005a). Another long-running survey, *Monitoring the Future* (MTF), is an annual survey of the health (risk) behaviours and attitudes of American adolescents, college students, and adults up to age 45 (Johnston, O'Malley, Bachman, & Schulenberg, 2005a).

The availability of drug use information at the national level is less remarkable in Canada. Until December 2003, Canada had conducted only two general population surveys specific to the issue of drug use: the *National Alcohol and Other Drugs Survey* in 1989, and *Canada's Alcohol and Other Drugs Survey* in 1994. Apart from these surveys, only tobacco and alcohol use have been monitored at a national level on an ongoing basis (e.g. National Population Health Survey, Canadian Community Health Survey). In 2004, Health Canada and the Canadian Council on Addictions sponsored the *Canadian*

Addiction Survey (CAS), the latest national survey of drug use among Canadians aged 15 and over. In addition to the prevalence and incidence of substance use, the CAS also investigated the harms associated with substance use, both for the user and those around him/her, as well as Canadians' attitudes and opinions of current drug policies. Although there are plans to repeat the CAS in the future, there are no indications regarding when this may occur.

Canadian data availability is greater at the provincial level. Since 1977, the Centre for Addiction and Mental Health (CAMH) has been monitoring the drug use of Ontario adults with the *CAMH Monitor* (Ialomiteanu & Adlaf, 2006), and of Ontario students with the *Ontario Student Drug Use Survey* (OSDUS) (Adlaf & Paglia-Boak, 2005). The CAMH Monitor and the OSDUS are the longest running surveys of drug use in Canada. Student drug use surveys are conducted in seven other Canadian provinces, although the historical period covered by each differs dramatically.

Prevalence Rates of Substance Use

General Population

The prevalence rates of cigarette, alcohol, marijuana and other drug use reported in various Canadian and U.S. drug-specific surveys are shown in Table 1 and Table 2 at the end of this chapter. According to the 2004 CAS, approximately 79% of the Canadian population aged 15 and up reported drinking alcohol in the past year, and 14% reported using marijuana. These rates are up slightly from those reported ten years prior in the 1994 Alcohol and Other Drugs Survey (see Figure 3). Although cigarette smoking was

not assessed in the Canadian Addiction Survey, figures from the 2005 Canadian Community Health Survey (CCHS) show that rates of past year smoking are down from past years.

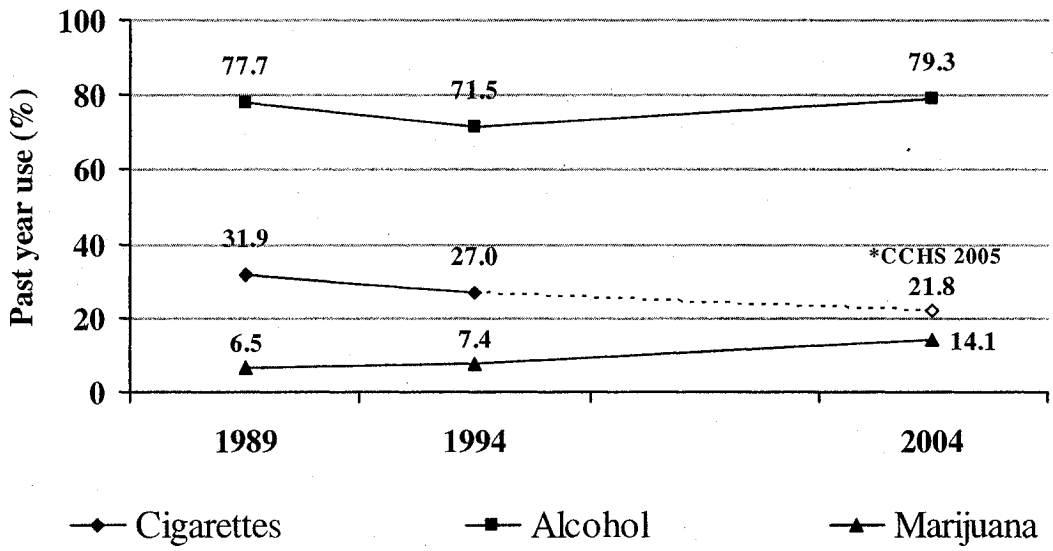

Figure 3 Proportion of Canadians ages 15 and up reporting past year use of cigarettes, alcohol and marijuana

Sources: National Alcohol and Other Drug Use Survey, 1989; Canada's Alcohol and Other Drugs Survey, 1994; Canadian Addiction Survey, 2004; Canadian Community Health Survey (CCHS), 2005

Adolescents

Although substance use in general has been identified as an important focus by various policies and researchers, it is particularly crucial to examine the patterns of substance use among youth, for it is during the teen years that most individuals who ever consume substances will first initiate these behaviours. According to the 2005 NSDUH in the United States, the mean age at first use for many illicit substances occurs during adolescence: mean age at initiation was 16.1 years for inhalants, 16.5 years for PCP, 17.4

years for marijuana, 18.3 years for LSD, and 19.7 years for cocaine (Substance Abuse and Mental Health Services Administration, 2006). Furthermore, the majority (64.3%) of new smokers in 2005 were under the age of 18, with a mean age at first use of 17.4 years. The average age at which individuals first began smoking daily was 19.4 years (Substance Abuse and Mental Health Services Administration, 2006). This is corroborated by other research that shows that weekly smoking occurs, on average, 20 months following initiation, and daily smoking 24 months following initiation (Gervais, O'Loughlin, Meshefedjian, Bancej, & Tremblay, 2006).

Rates of substance use are highest during the teen years (Health Canada, 1999), causing some to regard substance use as a teenage phenomenon. Substance use is so common among adolescents that, for some, experimentation is regarded as normative (Igra & Irwin, 1996). According to the 2005 OSDUS, 64% of Ontario students used at least one substance in the past year (Adlaf & Paglia-Boak, 2005). However, the rates of substance use seem to be in decline, at least among Ontario students. Figure 4 shows the prevalence of past year use for cigarettes, alcohol, marijuana and other illicit drugs from 1999 through 2005. While many substances show a decline in use since 1999, e.g. cigarettes and other drugs, what is apparent is that marijuana use has remained unchanged and has become more common in recent years than cigarette use.

Surveys in the United States show similar patterns in the rates of adolescent substance use. According to the Center for Disease Control and Prevention's 2005 *Youth Risk Behavior Surveillance* (YRBS) survey, 43% of students had drunk alcohol in the month prior to survey, 23% had smoked cigarettes, and 20% had smoked marijuana

(Centers for Disease Control and Prevention, 2006). Current use of other illicit substances was considerably lower, although not negligible. For example, 3% of students surveyed had used some form of cocaine at least once in the 30 days preceding the survey (Centers for Disease Control and Prevention, 2006).

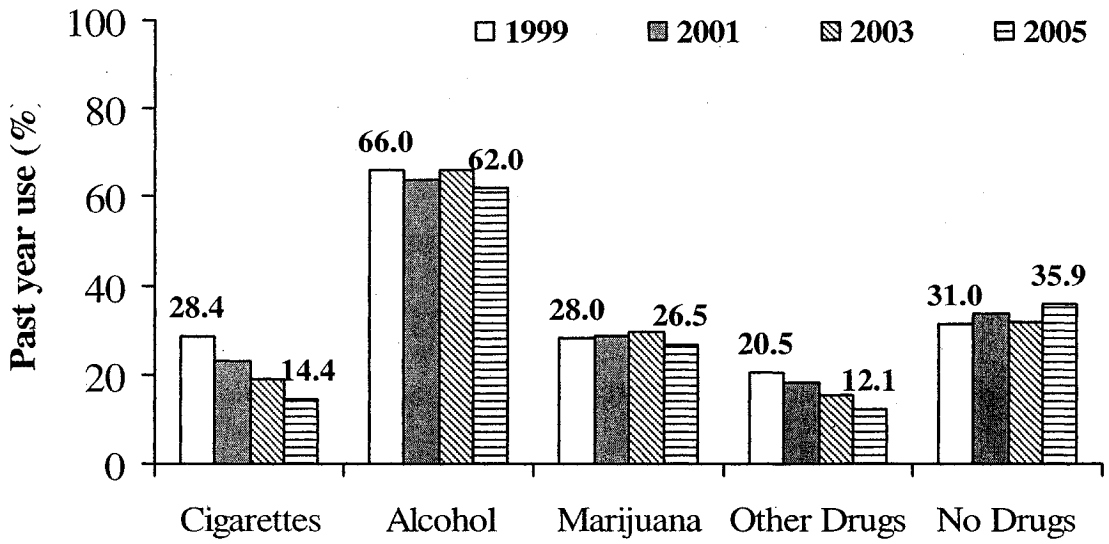

Figure 4 Past year use of cigarettes, alcohol, marijuana and others drugs reported in the OSDUS, 1999-2005

Source: Ontario Student Drug Use Survey, 2005

Significant changes in adolescent substance use have also occurred over time in the U.S. (Figure 5). According to MTF, between 1993 and 2005, annual use of marijuana among high school seniors increased significantly from 26% to 34%, and annual cocaine use increased from 3% to 5%, whereas annual alcohol and monthly cigarette use remained relatively stable (Johnston, O'Malley, Bachman, & Schulenberg, 2006a).

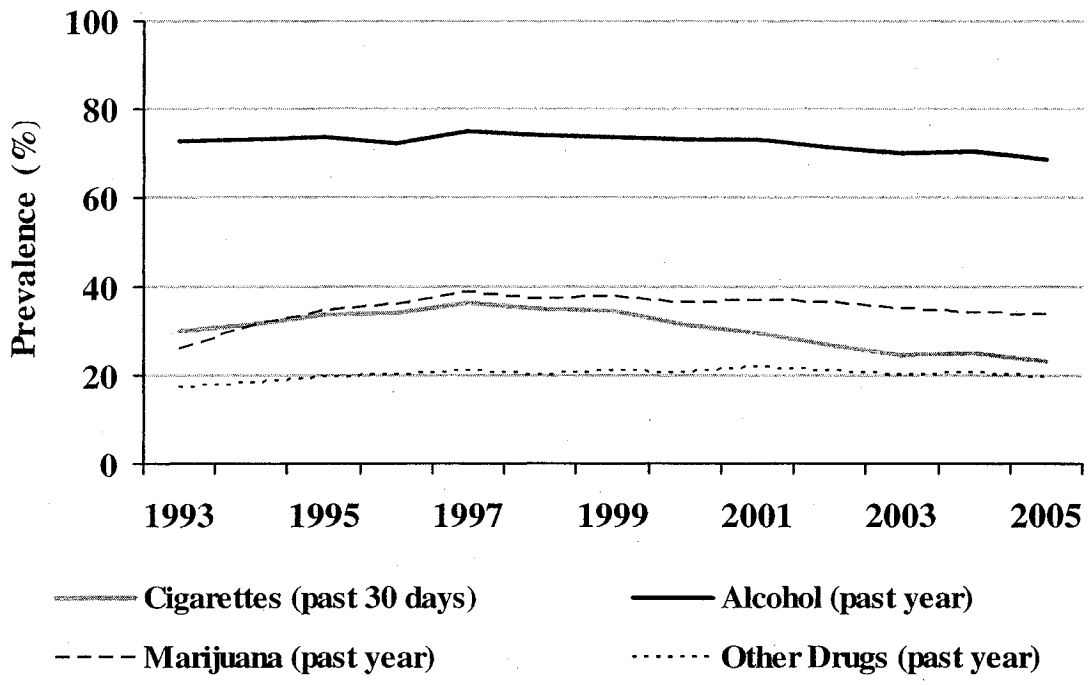

Figure 5 Proportion of twelfth-graders reporting substance use behaviours, 1993-2005

Source: Monitoring the Future, 2005

Levels of Substance Use: Experimentation, Use and Abuse

Individuals who initiate the use of substances vary drastically in their continued use of substances. It is therefore important to distinguish *experimentation*, which is often the result of curiosity, from *ongoing use*, which may result from habit or due to pressure from peers. Ongoing use may escalate and result in substance abuse. Rehm and colleagues define substance abuse in economic terms, as occurring when substance use results in the imposition of "costs on society that exceed the costs to the user of obtaining the substance" (Rehm et al., 2006; p.1). In other words, substance use becomes abuse

when others become implicated, whether through social systems or governmental policies, in another person's use of drugs.

Given that the economic costs and implications of substance use are not always apparent or easily estimable, the distinction between use and abuse is often based on the implication of harm. Substance *use* is consumption that does not result in harm: substance *abuse* is consumption that does result in harm. This harm can be either health-, socially- or judicially-related and can be experienced by the user or by another (Observatoire Français des Drogues et des Toxicomanies, 2006).

However, policy and research are not always clear regarding what levels of consumption are considered harmful and therefore abusive, nor regarding the criteria that are used to define harm. On the one hand, harm may be acute and proximal to consumption. For instance, according to the 2005 OSDUS, nearly 14% of drivers in grades 10 through12 reported driving within an hour of consuming two or more alcoholic drinks in the year prior to the survey and 20% reported driving after consuming cannabis. Furthermore, 29% of students reported being a passenger in a car with a driver who had been drinking, and 22% reported being a passenger in a car where the driver had been using drugs (Adlaf & Paglia-Boak, 2005). On the other hand, harm may be distal and occur subsequent to consumption. For example, the Senate Special Committee on Illegal Drugs deems any use of cannabis by those under age 16 as risky due to the "potential effects on the endogenous cannabinoid system and cognitive and psychosocial functions" (Nolin & Kenny, 2002, p.166). However, youth often do not perceive their use of

substances as harmful in the short-term, and cannot fully perceive the long-term effects of their use.

An individual's perception of the harm from substance use can be influenced by the larger social milieu. There have been significant age and cohort effects in the harms perceived to be associated with the use of various substances. For example, according to MTF surveys, more recent cohorts of respondents attribute lower levels of perceived risk to the use of marijuana than prior cohorts. Twelfth graders from the class of 2005 were less likely to perceive regular marijuana use as being dangerous than were 12th-grade cohorts in the late 1980s and early 1990s. In addition, 18-year-olds in more recent waves of the survey have consistently shown lower levels of perceived risk for smoking one or more packs of cigarettes per day than young adults, while 10th graders have been still lower and 8th graders lowest (Johnston, O'Malley, Bachman, & Schulenberg, 2006b). Furthermore, the rise in perceived risk for pack-a-day smoking appears to have ended in the past few years for those in the young adult strata, while there has been some slight further increase among 12th graders (see Figure 6).

The perception of harm has important and practical implications for proposed strategies to deter substance use among youth. The last decade has seen a greater focus placed on educating individuals, particularly youth, on the harms associated with tobacco use. More recently, the focus has shifted to the harmful effects of second-hand smoke. Consequently, though tobacco use was once an acceptable and even socially desirable behaviour, attitudes have shifted such that smokers are often maligned. Current smoking policies limit the freedom of smokers in favour of the betterment of society and the

protection of the health of its citizens. Concomitantly, there has been a drop in the number of people who report being current smokers. Conversely, the use of marijuana has become more socially acceptable and the perceived risk associated with its use has diminished, which is paired with a commensurate increase in the number of individuals who currently report using marijuana.

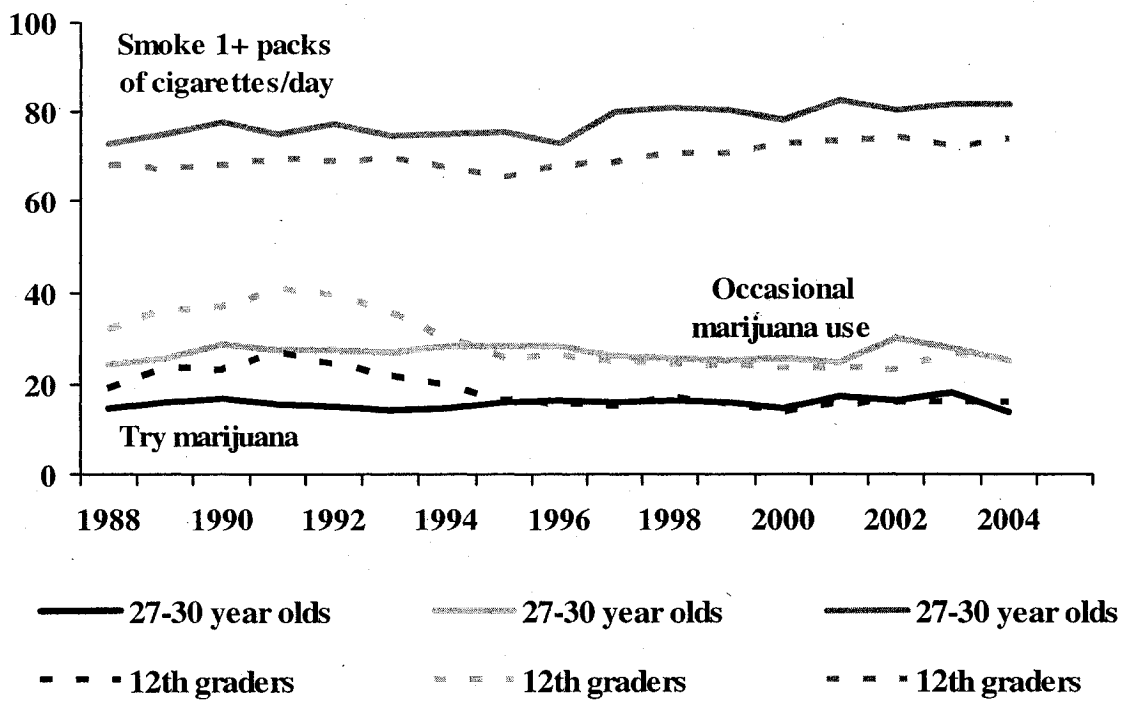

Figure 6 Proportion of Monitoring the Future respondents who perceive great risk for various behaviours, by survey year

Sources: (Johnston, O'Malley, Bachman, & Schulenberg, 2005a; Johnston, O'Malley, Bachman, & Schulenberg, 2005b)

Gender Differences in Substance Use

Men generally have higher rates of substance use than women. This gender gap is also evident during adolescence, although the differences are often smaller and may even be reversed among younger adolescents (Brady & Randall, 1999; Crosnoe, 2002; Kaminer, 1999). Gender differences also vary according to the substance used.

Tobacco Use

Although tobacco use among youth has decreased significantly in the past decade (Adlaf & Paglia, 2004), its use continues to be a public health concern. According to the *Global Youth Tobacco Survey*, an international survey of smoking behaviour developed by the World Health Organization, smoking among adolescent females has increased globally. Consequently, there are currently no significant gender differences in smoking behaviour among adolescents in more than half of the 120 global sites surveyed (The Global Youth Tobacco Survey Collaborative Group, 2003; Warren, Jones, Eriksen, & Asma, 2006). Similarly, the NSDUH in the United States found that the rate of lifetime cigarette use among girls aged 12 to 17 rose significantly from 22% in 1965 to 36% in 1980, while the rate for boys remained relatively unchanged during that period (Substance Abuse and Mental Health Services Administration, 2003). Since 1980, smoking rates for girls have been nearly the same as the rates for boys. Similar results have been found in other studies and surveys (Johnston, O'Malley, & Bachman, 2003; Young, Corley, Stallings, Rhee, Crowley, & Hewitt, 2002). Results such as these

indicate that there has been a historical increase of young female smokers, while a commensurate change has not occurred for adolescent males.

Some researchers find that girls initiate smoking earlier than boys, and begin daily smoking at a significantly younger age than boys (White, Pandina, & Chen, 2002), whereas others have found the opposite to be true (Lucas & Lloyd, 1999). Nevertheless, despite age of initiation, more girls than boys tend to progress from experimentation to become regular smokers (Lucas & Lloyd, 1999).

Alcohol Use

The majority of studies examining gender differences in substance use concern the use and abuse of alcohol. Between the early 1980s and the early 1990s, the male-to-female ratio for the prevalence of alcohol disorders decreased dramatically, such that the rate of alcohol dependence among women has approached that of men (Greenfield, Manwani, & Nargiso, 2003). This may indicate important cohort effects in alcohol use among youth. Furthermore, despite lower levels of alcohol consumption, women often experience more severe medical sequelae and progress from onset of drinking to alcohol dependence more quickly than men (Greenfield et al., 2003).

Among adolescents, research indicates that there is little or no difference between males' and females' lifetime use of alcohol. Past year use is also similar for males and females (Adlaf & Paglia-Boak, 2005). However, two specific drinking behaviours – binge drinking and drunkenness – may be more salient measures of alcohol consumption, as there is a growing recognition that the harmful effects of alcohol use among

adolescents is related more to the quantity of alcohol consumed on a particular occasion than to the frequency of drinking episodes (Rehm et al., 1996).

Binge drinking is most often defined as drinking five or more beverages on a single occasion. Males are significantly more likely to binge drink than females. Among twelfth graders in the 2004 MTF survey, 34% of males and 24% of females reported binge drinking in the two weeks prior to the survey (Johnston et al., 2005a). However gender differences in binge drinking seem to increase with age. While the gender difference in the 2004 MTF was large in twelfth grade, it was modest in tenth grade (24% of males and 20% of females), and small in eighth grade, with females actually reporting a higher prevalence of binge drinking (11% of males and 12% of females). This trend has also been found in Canadian provincial surveys of student drug and alcohol use (Adlaf & Paglia-Boak, 2005; Alberta Alcohol and Drug Abuse Commission, 2005; Patton, MacKay, & Broszeit, 2005). Trends in the prevalence of binge drinking are shown in Figure 7.

Hill and colleagues (2000) report that male youth are more likely than their female counterparts to increase their heavy drinking as they move through adolescence. Conversely, young women were more likely to avoid binge drinking or to decrease their involvement in such behaviours throughout high school. However, Toumbourou and colleagues (2003) found that, upon graduation from high school, females were more than twice as likely as males to escalate their drinking behaviours.

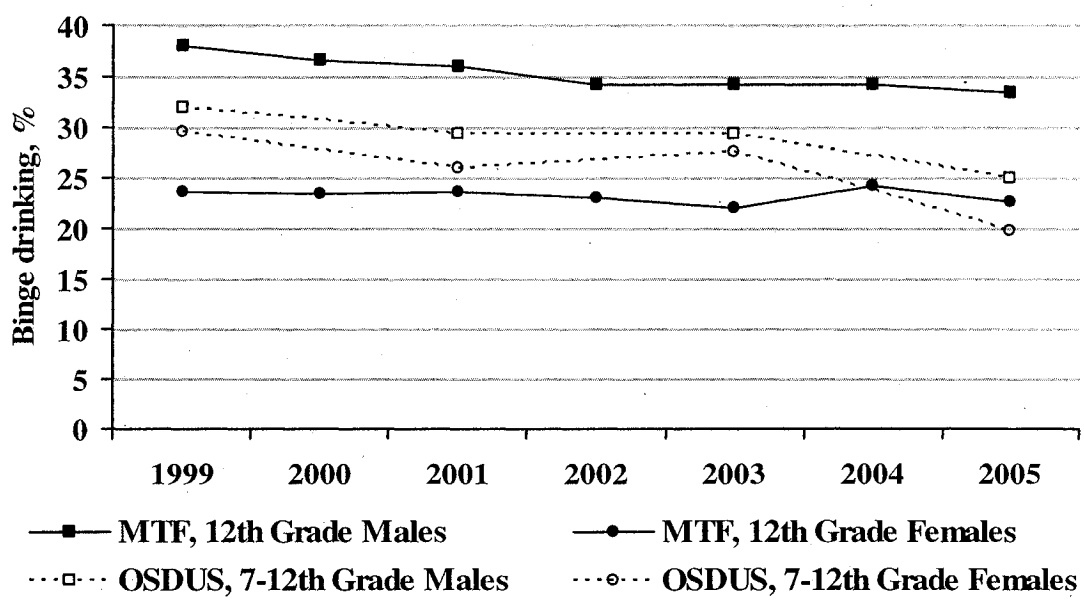

Figure 7 Prevalence of binge drinking in the past two weeks (MTF) or four weeks (OSDUS), by sex

Sources: Monitoring the Future (MTF), 2005; Ontario Student Drug Use Survey (OSDUS), 2005

There are those who argue that using the same definition of binge drinking (i.e. five or more drinks per occasion) for both genders may significantly underestimate this behaviour among females (Greenfield et al., 2003; Toumbourou, Williams, Snow, & White, 2003). This is because lower quantities of alcohol produce the same deleterious effects in women as compared to men (Wechsler, Dowdall, Davenport, & Rimm, 1995).

Regarding the outcomes of drinking, 58% of the 12th graders and 20% of the 8th graders in the 2005 MTF reported having been drunk at least once in their life (Johnston et al., 2006a). Among Ontario students, there was no significant difference in the prevalence of past-year drunkenness for either males (23%) or females (22%).

Marijuana Use

According to the Canadian Community Health Survey, 16% of males and 9% of females aged 15 and up reported marijuana use in 2002, with use peaking at ages 18 and 19, and declining thereafter (Tjepkema, 2004); see also Figure 8. However, in the youngest age group (15-17 years), adolescent males and females reported similar rates of current marijuana use (Tjepkema, 2004). Gender-specific marijuana initiation rates show that, between 1965 and 1995, there was a four-fold increase in the number of young female (age 10-14 years) users while there was a doubling of the number of male marijuana users (Greenfield et al., 2003). As a result, marijuana use rates are currently closer between young male and female users than they have ever been in the past.

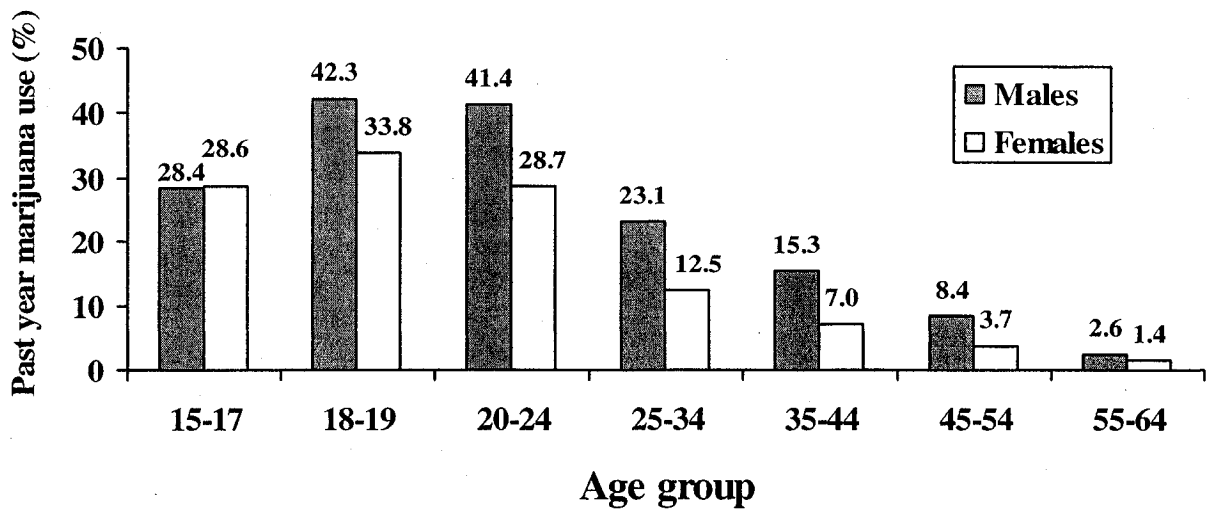

Figure 8 Proportion of Canadians aged 15 and over who reported using marijuana in the past year, by gender

Source: Canadian Community Health Survey 2002; Tjepkema, 2004

A study by Holdcraft and Iacono (2004) found that adult men had a higher prevalence of abuse/dependence for each of four substances – cannabis, amphetamine, cocaine, hallucinogens – than adult women. However, among both men and women, the mean age at which symptoms of cannabis and amphetamine dependence first occurred was in the late teen years: 17.21 years for males and 17.76 years for females.

Other Drug Use

The use of illicit substances is much less prevalent than the use of tobacco, alcohol or marijuana. Among Canadians aged 15 years and older in 2002, 14% reported ever using illicit substances other than marijuana, while the proportion reporting illicit drug use in the past year dropped to 2% (Tjepkema, 2004). Studies examining gender differences in the use of other illicit substances have found a range of results. A study of Canadian university undergraduates found that males were significantly more likely than females to report using illicit drugs other than marijuana in the past 12 months (Adlaf, Gliksman, Demers, & Newton-Taylor, 2003; Tjepkema, 2004). Ecstasy use among U.S. college undergraduates was similarly distributed by gender (Boyd, Mccabe, & d'Arcy, 2003), whereas gender differences have been reported in other populations (Pedersen & Skrondal, 1999; Tjepkema, 2004). Use of club drugs (e.g. GHB, LSD, methamphetamine) is higher among men than women (Pedersen & Skrondal, 1999; Fendrich, Wislar, Johnson, & Hubbell, 2003). However, abuse of prescription medications is significantly higher among women (Simoni-Wastila, 2000). Such findings indicate that the relationship between gender and drug use can vary by substance,

indicating that drug-specific examinations are important for accurate assessments of gender differences.

Gaps in the Literature

Despite a growing interest in gender differences in substance use, a survey of the literature reveals certain gaps in knowledge that need to be addressed. Many studies draw evidence of gender differences from results of studies in clinical populations rather than general population samples (Brecht, O'Brien, von Mayrhauser, & Anglin, 2004; Doherty, Garfein, Monterroso, Latkin, & Vlahov, 2000; Zilberman, Tavares, & el Guebaly, 2003). Such results may yield biased estimates of gender differences because they refer to individuals whose use is significantly more severe than that of the general population. Furthermore, men and women may differ in their willingness to access treatment (Mojtabai, Olfson, & Mechanic, 2002), further biasing results from treatment samples. It is therefore necessary to examine gender difference using general population samples in order to determine whether reported differences in substance use are generalizable, or whether they are due to a gender bias in selection for treatment (Rutter, Caspi, & Moffitt, 2003).

Similarly, the vast majority of studies focus on the use of one substance only, most often alcohol (Hill, White, Chung, Hawkins, & Catalano, 2000; Toumbourou et al., 2003). Alternately, they use a composite measure of substance use that does not distinguish between the variety of substances used (Thomas, 1996). The former does not allow for an examination of gender differences across substances, while the latter may

mask gender-specific patterns of use that would emerge if the use of each substance was considered separately.

Furthermore, many studies use only cross-sectional data, which does not allow for an examination of use over time, which has been shown in other cases to vary by gender (Griffin, Scheier, Botvin, & Diaz, 2000). It also does not take into account possible heterogeneities in the developmental paths of substance using behaviours. There is a growing recognition that studies must pay greater attention to individual growth curves and to the description of intra-individual change (Hill et al., 2000; Toumbourou et al., 2003; White et al., 2002). Use of cross-sectional data precludes such an examination.

Table 1 Prevalence rates of lifetime, past year and past month use of tobacco and alcohol from various surveys in Canada and the United States

Population / Sample	Ages / Grades	Tobacco			Alcohol		
		Lifetime	Past Year	Past Month	Lifetime	Past Year	Past Month
National Surveys, United States							
National Survey on Drug Use and Health, 2004 (Substance Abuse and Mental Health Services Administration, 2005b)	12+	67.3	29.1	24.9	82.4	65.1	50.3
Monitoring The Future, 2004 (Johnston et al., 2005b)	19-30	n/a	37.4	28.0	89.9	84.3	67.7
Student Drug Use Surveys, United States							
Monitoring The Future, 2005 (Johnston et al., 2006a)	8th Graders	25.9	n/a	9.3	41.0	33.9	n/a
	10th Graders	38.9	n/a	14.9	63.2	56.7	n/a
	12th Graders	50.0	n/a	23.2	75.1	68.6	n/a
Youth Risk Behaviour Surveillance, 2005 (Centers for Disease Control and Prevention, 2006)	Grades 9-12	54.3	n/a	23.0	74.3	n/a	43.3
National Surveys, Canada							
National Alcohol and Other Drug Use Survey, 1989 (Eliany, Giesbrecht, Nelson, Wellman, & Wortley, 1992)	15+	57.7	31.9	n/a	93.4	77.7	n/a
Canada's Alcohol and Other Drugs Survey, 1994 (Mac Neil & Webster, 1997)	15+	54.5	27.0	n/a	87.2	71.5	n/a
Canadian Addiction Survey, 2004 (Adlaf, Begin, & Sawka, 2005)	15+	n/a	n/a	n/a	92.8	79.3	n/a
Canadian Campus Survey, 2004 (Adlaf, Demers, & Gliksman, 2005)	Undergraduates	n/a	17.3	n/a	80.1	85.7	77.1
Provincial Adult Drug Use Surveys, Canada							
Ontario CAMH Monitor, 2001 (Adlaf & Ialomiteanu, 2006)	18+	50.4	24.7	n/a	93.0	79.5	n/a
Yukon Addictions Survey, 2005 (Government of Yukon, 2006)	15+	n/a	28.0	n/a	90.0	79.0	n/a

Population / Sample	Ages / Grades	Tobacco			Alcohol		
		Lifetime	Past Year	Past Month	Lifetime	Past Year	Past Month
Student Drug Use Surveys, Canada							
British Columia Adolescent Health Survey, 2003 (The McCreary Centre Society, 2004)	Grades 7-12	27.0	n/a	13.0	57.0	51.7	n/a
Alberta Youth Experience Survey, 2002 (Alberta Alcohol and Drug Abuse Commission, 2005)	Grades 7-12	n/a	16.2	n/a	n/a	56.3	n/a
Alcohol and Other Drug Use by Manitoba Students (Patton et al., 2005)	Grades 7-12	n/a	n/a	n/a	68.9	58.8	n/a
Ontario Student Drug Use Survey, 2005 (Adlaf & Paglia-Boak, 2005)	Grades 7-12	33.0	14.4	n/a	65.5	62.0	n/a
New Brunswick Student Drug Use Survey, 2002 (Liu, Jones, Grobe, Balram, & Poulin, 2002)	Grades 7-12	43.3	20.7	n/a	n/a	48.2	30.4
Nova Scotia Student Drug Use Survey, 2002 (Poulin, 2002b)	Grades 7-12	n/a	23.2	n/a	n/a	51.7	30.3
Prince Edward Island Student Drug Use Survey, 2002 (Van Til & Poulin, 2002)	Grades 7-12	n/a	18.2	n/a	n/a	48.0	n/a

n/a Data not available in referenced report

Table 2 Prevalence rates of lifetime, past year and past month use of marijuana and other illicit drugs from various surveys in Canada and the United States

Population / Sample	Ages	Marijuana			Other Drugs		
		Lifetime	Past Year	Past Month	Lifetime	Past Year	Past Month
National Surveys, United States							
National Survey on Drug Use and Health, 2005 (Substance Abuse and Mental Health Services Administration, 2005b)	12+	40.2	10.6	6.1	29.4	8.2	3.4
Monitoring The Future, 2004 (Johnston et al., 2005a)	19-30	n/a	27.0	15.2	n/a	17.6	7.9
Student Drug Use Surveys, United States							
Monitoring The Future, 2005 (Johnston et al., 2006b)	8th Graders	16.5	12.2	n/a	12.1	8.1	n/a
	10th Graders	34.1	26.6	n/a	18.0	12.9	n/a
	12th Graders	44.8	33.6	n/a	27.4	19.7	n/a
Youth Risk Behaviour Surveillance, 2005 (Centers for Disease Control and Prevention, 2006)	Grades 9-12	38.4	n/a	20.2	2.1-12.4	n/a	n/a
National Surveys, Canada							
National Alcohol and Other Drug Use Survey, 1989 (Eliany et al., 1992)	15+	23.2	6.5	n/a	3.5-4.1	0.4-1.4	n/a
Canada's Alcohol and Other Drugs Survey, 1994 (Macneil & Webster, 1997)	15+	28.2	7.4	n/a	n/a	n/a	n/a
Canadian Addiction Survey, 2004 (Adlaf, Begin, & Sawka, 2005)	15+	44.5	14.1	n/a	0.7	0.4	n/a
Canadian Campus Survey, 2004 (Adlaf, Demers, & Gliksman, 2005)	Undergrads	51.4	32.1	16.7	n/a	8.7	2.2
Provincial Adult Drug Use Surveys, Canada							
Ontario CAMH Monitor, 2001 (Adlaf & Ialomiteanu, 2006)	18+	34.4	11.2	n/a	n/a	n/a	n/a
Yukon Addictions Survey, 2005	15+	n/a	21.0	n/a	n/a	n/a	n/a

Population / Sample	Ages	Marijuana			Other Drugs		
		Lifetime	Past Year	Past Month	Lifetime	Past Year	Past Month
(Government of Yukon, 2006)							
Student Drug Use Surveys, Canada							
British Columia Adolescent Health Survey, 2003 (The McCreary Centre Society, 2004)	Grades 7-12	37.0	n/a	n/a	n/a	n/a	n/a
Alberta Youth Experience Survey, 2002 (Alberta Alcohol and Drug Abuse Commission, 2003)	Grades 7-12	n/a	27.6	n/a	n/a	1.2-10.4	n/a
Alcohol and Other Drug Use by Manitoba Students (Patton et al., 2005)	Grades 7-12	30.1	n/a	n/a	n/a	n/a	n/a
Ontario Student Drug Use Survey, 2005 (Adlaf & Paglia-Boak, 2005)	Grades 7-12	31.1	26.5	n/a	n/a	12.1	n/a
New Brunswick Student Drug Use Survey, 2002 (Liu et al., 2002)	Grades 7-12	n/a	34.9	16.9	n/a	1.9-11.7	n/a
Nova Scotia Student Drug Use Survey, 2002 (Poulin, 2002)	Grades 7-12	n/a	36.5	n/a	n/a	1.6-12.2	n/a
Prince Edward Island Student Drug Use Survey, 2002 (Van Til & Poulin, 2002)	Grades 7-12	n/a	23.7	n/a	n/a	1.5-6.3	n/a

n/a Data not available in referenced report

References

Adlaf, E. M., 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: Detailed Report.* Ottawa: Canadian Centre on Substance Abuse.

Adlaf, E. M., Demers, A., & Gliksman, L. (2005). *Canadian Campus Survey 2004.* Toronto: Centre for Addiction and Mental Health.

Adlaf, E. M., Gliksman, L., Demers, A., & Newton-Taylor, B. (2003). Illicit drug use among Canadian University undergraduates. *Can.J.Nurs.Res., 35,* 24-43.

Adlaf, E. M. & Ialomiteanu, A. (2006). *CAMH Monitor eReport: Addiction and Mental Health Indicators Among Ontario Adults in 2001, and Changes Since 1977.* Toronto: Centre for Addiction and Mental Health.

Adlaf, E. M. & Paglia, A. (2004). Drug use among Ontario students 1977-2003: Detailed OSDUS findings. Toronto, ON, Centre for Addiction and Mental Health. CAMH Research Document Series No. 13.

Adlaf, E. M. & Paglia-Boak, A. (2005). *Drug use among Ontario students 1977-2005: Detailed OSDUS findings.* Toronto, ON: Centre for Addiction and Mental Health.

Alberta Alcohol and Drug Abuse Commission (2003). *Use of illicit drugs among Alberta youth: The Alberta Youth Experience Survey 2002.* Edmonton, Alberta: Alberta Alcohol and Drug Abuse Commission.

Alberta Alcohol and Drug Abuse Commission (2005). *Use of alcohol among Alberta youth: The Alberta Youth Experience Survey 2002*. Edmonton, Alberta: Alberta Alcohol and Drug Abuse Commission.

Boyd, C. J., Mccabe, S. E., & d'Arcy, H. (2003). Ecstasy use among college undergraduates: Gender, race and sexual identity. *Journal of Substance Abuse Treatment, 24,* 209-215.

Brady, K. T. & Randall, C. L. (1999). Gender differences in substance use disorders. *Psychiatric Clinics of North America, 22,* 241-252.

Brecht, M. L., O'Brien, A., von Mayrhauser, C., & Anglin, M. D. (2004). Methamphetamine use behaviors and gender differences. *Addict.Behav., 29,* 89-106.

Centers for Disease Control and Prevention (2006). Youth Risk Behavior Surveillance — United States, 2005. *Morbidity and Mortality Weekly Report, 55,* 1-108.

Collin, C. (2006). *Substance abuse issues and public policy in Canada: I. Canada's federal drug strategy.* (Rep. No. PRB. 06-15E). Ottawa: Parliamentary Information and Research Service, Library of Parliament.

Crosnoe, R. (2002). Academic and health-related trajectories in adolescence: The intersection of gender and athletics. *Journal of Health and Social Behavior, 43,* 317-335.

Doherty, M. C., Garfein, R. S., Monterroso, E., Latkin, C., & Vlahov, D. (2000). Gender differences in the initiation of injection drug use among young adults. *J.Urban Health, 77,* 396-414.

Eliany, M., Giesbrecht, N., Nelson, M., Wellman, B., & Wortley, S. (1992). *Alcohol and Other Drug Use by Canadians: A National Alcohol and Other Drugs Survey (1989) -- Technical Report.* Ottawa: Minister of Supply and Services Canada.

Fendrich, M., Wislar, J. S., Johnson, T. P., & Hubbell, A. (2003). A contextual profile of club drug use among adults in Chicago. *Addiction, 98,* 1693-1703.

Gannon, M. (2006). Crime statistics in Canada, 2005. *Juristat, 26,* 1-23.

Gervais, A., O'Loughlin, J., Meshefedjian, G., Bancej, C., & Tremblay, M. (2006). Milestones in the natural course of onset of cigarette use among adolescents. *Canadian Medical Association Journal, 175,* 255-261.

Government of Yukon (2006). *Yukon Addictions Survey (YAS) Preliminary Results 2005: A survey of Yukoners' use of alcohol and other drugs.* Whitehorse,YK: Department of Health and Social Services, Government of Yukon.

Greenfield, S. F., Manwani, S. G., & Nargiso, J. E. (2003). Epidemiology of substance use disorders in women. *Obstet.Gynecol.Clin.North Am., 30,* 413-446.

Griffin, K. W., Scheier, L. M., Botvin, G. J., & Diaz, T. (2000). Ethnic and gender differences in psychosocial risk, protection, and adolescent alcohol use. *Prevention Science, 1,* 199-212.

Health Canada (1999). *Statistical Report on the Health of Canadians.* Ottawa: Health Canada.

Health Canada (2003). Canadian Drug Strategy Renewal. http://www.hc-sc.gc.ca/ahc-asc/minist/health-sante/speeches-discours/2003_05_27a_e.html [On-line].

Hill, K. G., White, H. R., Chung, I. J., Hawkins, J. D., & Catalano, R. F. (2000). Early adult outcomes of adolescent binge drinking: Person- and variable-centered analyses of binge drinking trajectories. *Alcoholism: Clinical and Experimental Research, 24,* 892-901.

Holdcraft, L. C. & Iacono, W. G. (2004). Cross-generational effects on gender differences in psychoactive drug abuse and dependence. *Drug Alcohol Depend., 74,* 147-158.

Ialomiteanu, A. & Adlaf, E. M. (2006). *CAMH Monitor 2005: Technical Guide.* Toronto: Centre for Addition and Mental Health.

Igra, V. & Irwin, C. E. (1996). Theories of adolescent risk-taking behaviour. In R.J.DiClemente, W. B. Hansen, & L. E. Ponton (Eds.), *Handbook of Adolescent Risk Behavior* (pp. 35-51). New York: Plenum Press.

Johnston, L. D., O'Malley, P. M., & Bachman, J. G. (2003). *Monitoring the Future national survey results on drug use, 1975-2002. Volume I: Secondary school students.* Bethesda, MD: National Institute on Drug Abuse.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2005a). *Monitoring the Future national survey results on drug use, 1975-2004. Volume I: Secondary school students.* Bethesda, MD: National Institute on Drug Abuse.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2005b). *Monitoring the Future national survey results on drug use, 1975-2004. Volume II: College students and adults.* Bethesda, MD: National Institute on Drug Abuse.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2006a). *Monitoring the Future national survey results on drug use, 1975-2005. Volume II: College students and adults ages 19-45.* Bethesda, MD: National Institute on Drug Abuse.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2006b). *Monitoring the Future: National survey results on drug use -- Overview of key findings, 2005.* Bethesda, MD: National Institute on Drug Abuse.

Kaminer, Y. (1999). Addictive disorders in adolescents. *Psychiatric Clinics of North America, 22,* 275-288.

Liu, J., Jones, B., Grobe, C., Balram, C., & Poulin, C. (2002). *New Brunswick Student Drug Use Survey 2002: Highlights Report.*

Lucas, K. & Lloyd, B. (1999). Starting smoking: Girls' explanations of the influence of peers. *Journal of Adolescence, 22,* 647-655.

MacNeil, P. & Webster, I. (1997). *Canada's Alcohol and Other Drugs Survey 1994: A Discussion of the Findings.* Ottawa: Minister of Public Works and Government Services Canada.

Mojtabai, R., Olfson, M., & Mechanic, D. (2002). Perceived need and help-seeking in adults with mood, anxiety, or substance use disorders. *Archives of General Psychiatry, 59,* 77-84.

Nolin, P. C. & Kenny, C. (2002). *Cannabis: Our position for a Canadian public policy: Report of the Senate Special Committee on Illegal Drugs, Vol. II, Part III* Ottawa: Senate of Canada.

Observatoire Français des Drogues et des Toxicomanies (2006). *Drugs and Dependence: Indicators and Trends in 2002.* Paris: Observatoire Français des Drogues et des Toxicomanies.

Patton, D., MacKay, T. L., & Broszeit, B. (2005). *Alcohol and Other Drug Use by Manitoba Students.* Addictions Foundation of Manitoba.

Pedersen, W. & Skrondal, A. (1999). Ecstasy and new patterns of drug use: A normal population study. *Addiction, 94,* 1695-1706.

Pernanen, K., Cousineau, M. M., Brochu, S., & Sun, F. (2002). *Proportion of crimes associated with alcohol and other drugs in Canada* Ottawa,ON: Canadian Centre on Substance Abuse.

Poulin, C. (2002). *Nova Scotia Student Drug Use 2002: Technical Report.* Dalhousie University.

Rehm, J., Ashley, M. J., Room, R., Single, E., Bondy, S., Ferrence, R. et al. (1996). On the emerging paradigm of drinking patterns and their social and health consequences. *Addiction, 91,* 1615-1621.

Rehm, J., Ballunas, D., Brochu, S., Fischer, B., Gnam, W., Patra, J. et al. (2006). *The Costs of Substance Abuse in Canada 2002: Highlights.* Ottawa: Canadian Centre on Substance Abuse.

Rutter, M., Caspi, A., & Moffitt, T. E. (2003). Using sex differences in psychopathology to study causal mechanisms: Unifying issues and research strategies. *Journal of Child Psychology and Psychiatry and Allied Disciplines, 44,* 1092-1115.

Simoni-Wastila, L. (2000). The use of abusable prescription drugs: The role of gender. *J.Womens Health Gend.Based.Med., 9,* 289-297.

Substance Abuse and Mental Health Services Administration (2003). *Results from the 2002 National Survey on Drug Use and Health: National Findings.* Rockville, MD: Office of Applied Studies.

Substance Abuse and Mental Health Services Administration (2005a). *Overview of Findings from the 2004 National Survey on Drug Use and Health.* Rockville,MD: Office of Applied Studies.

Substance Abuse and Mental Health Services Administration (2005b). *Results from the 2004 National Survey on Drug Use and Health: National Findings.* Rockville, MD: SAMHSA.

Substance Abuse and Mental Health Services Administration (2006). *Results from the 2005 National Survey on Drug Use and Health: National Findings.* Rockville, MD: SAMHSA.

The Global Youth Tobacco Survey Collaborative Group (2003). Differences in worldwide tobacco use by gender: Findings from the global youth tobacco survey. *Journal of School Health, 73,* 207-215.

The McCreary Centre Society (2004). *Healthy Youth Development: Highlights from the 2003 Adolescent Health Survey III.* Vancourver, BC: The McCreary Centre Society.

Thomas, B. S. (1996). A path analysis of gender differences in adolescent onset of alcohol, tobacco and other drug use (ATOD), reported ATOD use and adverse consequences of ATOD use. *J.Addict.Dis., 15,* 33-52.

Tjepkema, M. (2004). Use of cannabis and other illicit drugs. *Health Rep, 15,* 41-47.

Toumbourou, J. W., Williams, I. R., Snow, P. C., & White, V. M. (2003). Adolescent alcohol-use trajectories in the transition from high school. *Drug and Alcohol Review, 22,* 111-116.

U.S.Department of Health and Human Services (2000). *Healthy People 2010: Understanding and Improving Health.* Washington, DC.: U.S. Government Printing Office.

United Nations Office on Drugs and Crime (2005). *2005 World Drug Report: Volume 1, Analysis.* Vienna: United Nations Office on Drugs and Crime.

Van Til, L. & Poulin, C. (2002). *2002 PEI Student Drug Survey: Highlights Report.* Charlottetown: Department of Health and Social Services.

Warren, C. W., Jones, N. R., Eriksen, M. P., & Asma, S. (2006). Patterns of global tobacco use in young people and implications for future chronic dissease burden in adults. *Lancet, 367,* 749-753.

Wechsler, H., Dowdall, G. W., Davenport, A., & Rimm, E. B. (1995). A gender-specific measure of binge drinking among college-students. *American Journal of Public Health, 85,* 982-985.

White, H. R., Pandina, R. J., & Chen, P. H. (2002). Developmental trajectories of cigarette use from early adolescence into young adulthood. *Drug and Alcohol Dependence, 65,* 167-178.

Young, S. E., Corley, R. P., Stallings, M. C., Rhee, S. H., Crowley, T. J., & Hewitt, J. K. (2002). Substance use, abuse and dependence in adolescence: Prevalence, symptom profiles and correlates. *Drug Alcohol Depend., 68,* 309-322.

Zilberman, M., Tavares, H., & el Guebaly, N. (2003). Gender similarities and differences: The prevalence and course of alcohol- and other substance-related disorders. *J.Addict.Dis., 22,* 61-74.

Project Objectives and Research Questions

Project #1: Trajectories of Substance Use Among Adolescents

Objective

To describe the trajectories of substance use (tobacco, alcohol, marijuana, other drugs) by adolescents and to examine gender differences in the patterns of use.

Research Questions

1. What are the developmental trajectories for the initiation and current use of four substance types (tobacco, alcohol, marijuana, other drugs) among Canadian and American adolescents?
2. Are there gender-specific patterns of substance initiation or frequency of use?
3. How are the trajectory models similar or different for Canadian and American samples?

As delineated in the above research questions, project #1 was originally conceived of as a cross-national comparison study, drawing upon data collected in both Canada (National Longitudinal Survey of Children and Youth) and the United States (National Longitudinal Survey of Youth 1979 – Children and Young Adults data). Analyses to address the above research questions were conducted, including an examination of the differences and similarities in the trajectories developed based on both the Canadian and

American samples. However, the quantity of resultant models was simply too great to be synthesized into a reasonable manuscript for publication in the academic literature. For example, using data from both countries resulted in the development of 48 trajectory models: four substance categories (alcohol, tobacco, marijuana, and other drugs); two behaviour types (initiation and current frequency of use); three gender breakdowns (overall, and males and females separately); and two countries (Canada, United States).

After multiple iterations of the manuscript for project #1, for the purposes of publication it was decided to concentrate on a presentation of the analyses of tobacco and marijuana use based on the NLSCY only (i.e. the Canadian data). Even so, trajectories have been developed for the initiation and frequency of use of four substance categories in both the Canadian and the American samples: tobacco, alcohol, marijuana and other drugs. As such, the manuscript included in this thesis reflects only a portion of the work undertaken for this project. Time did not permit preparation of further articles based on the remaining models from project #1. However, these models and results may be written up in the future.

Project #2: Joint Trajectories of Childhood Behaviour Problems and Adolescent Substance Use Onset

Objective

To define and examine trajectories of behaviour problems during childhood as reported by mothers, and to determine how such behaviours are related to trajectories of substance

use initiation during adolescence. Gender differences in these joint trajectories will also be examined.

Research Questions

1. What are the trajectories of externalizing and internalizing problems among children ages 6 to 12?
2. What are the trajectories of smoking and marijuana initiation among youth ages 10 to 19?
3. Does the probability of membership in a particularly substance initiation trajectory vary by level of childhood behaviour problems?
4. Does the probability of membership vary by type of behaviour (external versus internal)?
5. Does the probability of membership vary by gender?

Project #2 uses data from a U.S. longitudinal survey of children and youth: the National Longitudinal Survey of Youth 1979 – Children and Young Adults (NLSY79-C). Described later in greater detail (see 'National Longitudinal Survey of Youth 1979 – Child and Young Adult Data (NLSY79-C)', p.51), the NLSY79-C has been conducted for nearly 20 years, which allows for an examination of behaviours that span a long developmental period for the same sample of individuals. Because the Canadian survey has only been conducted since 1994, it does not contain a sufficient number of time-points to allow for a similar examination of behaviour.

Project #3: Pubertal Timing and Risk for Substance Use

Objective

To model the relationship between pubertal timing and substance use behaviour.

Research Questions

1. Are there gender differences in the probability of substance use initiation at various ages?
2. What are the effects of pubertal timing (early or late vs. on-time) on the probability of initiating these behaviours?
3. Are the effects of pubertal timing stable across adolescence?

Whereas projects #1 and #2 use multiple trajectories to examine patterns of behaviour, project #3 uses survival analysis to examine the age at which youth first engage in substance using behaviours that are deemed problematic: daily smoking, drunkenness, weekly marijuana use, and initiation of other drug use. Project #3 also tests two hypotheses – the early maturation hypothesis and the maturational deviance hypothesis – that describe the relationship between pubertal maturation, timing and the onset of problem behaviours. Both hypotheses posit that youth who mature earlier than their peers will be at greater risk of initiating problematic drug use behaviours. Where the hypotheses diverge is in their characterization of youth who mature later than their peers: the early maturation hypothesis posits that late-maturing youth will be less or equally likely as youth who mature on-time to engage in risk behaviours, whereas the

maturational deviance hypothesis states that late-maturing youth will also incur greater risk.

Project #3 uses data from the National Longitudinal Survey of Children and Youth (NLSCY) only, as the American survey did not include questions that would allow for the examination of pubertal maturation of the sample.

Context and Relationship Between Studies

The over-arching theme of the three studies is the examination of substance use among adolescents. In addition, each of the three studies attempts to identify factors or individual characteristics that increase (or decrease) the likelihood of engaging in the various patterns of substance use behaviour. Each study explicitly addresses the influence of gender on substance use behaviours. Where the three studies differ is the perspective that each takes when describing the factors that are hypothesized to influence adolescent substance use.

The first project is primarily descriptive in nature. Project #1 describes the trajectories of substance use initiation and the frequency of use among youth ages 10 through 19. Furthermore, this project also examines gender differences in the trajectory paths and the proportion of youth who follow each trajectory. Lastly, project #1 examines the effect of various socio-demographic characteristics on the probability of engaging in the various trajectories of substance use. In essence, a sub-objective of the project was to develop a sociodemographic profile of substance use trajectories.

Project #2 builds upon the first by examining behaviour patterns that may be precursors to adolescent substance use: childhood behaviour problems. Whereas project #1 is based on an epidemiologic perspective of "risk factors" in its examination of individual characteristics, project #2 is rooted in the perspective of developmental psychology. Project #2 uses the concept of heterotypic continuity as it examines the overlap in trajectories of two distinct but related behaviours: externalizing and

internalizing behaviour problems in childhood and substance use initiation in adolescence. Heterotypic continuity refers to the manner by which a particular trait may be manifest over time through distinct but analogous behaviours. For example, a propensity for violence may be manifest in childhood as kicking and biting and as gang fighting during adolescence. Identifying a heterotypic relationship may aid in early identification of individuals who are at risk of adopting potentially detrimental behaviours.

Project #3 merges the epidemiologic (project #1) and developmental psychology (project #2) perspectives as it examines the influence of pubertal timing on the initiation of various substance use behaviours. Although puberty is a marker of physical development, important social and emotional changes also take place along with pubertal development. Early maturation has often been considered a risk factor for the initiation of deviant (i.e. socially non-desirable) behaviours. Through the use of non-proportional discrete survival analysis, project #3 examines two hypotheses linking pubertal timing to substance using behaviours: the early maturation hypothesis and the maturational deviance hypothesis.

Overview: Data Sources

Two longitudinal surveys have been used in the three thesis studies: the *National Longitudinal Survey of Children and Youth* (NLSCY) from Canada and the *National Longitudinal Survey of Youth 1979 – Child and Youth* (NLSY79-C) from the United States.

National Longitudinal Survey of Children and Youth (NLSCY)

The NLSCY is a long-term study that follows the development of Canadian children from birth to early adulthood. Conducted conjointly by Statistics Canada and Social Development Canada, the NLSCY began in 1994 and has been conducted biennially since. The most recent survey cycle for which data were available at the time of analysis was Cycle 5, conducted in 2002/2003. The survey covers a wide range of topics, including physical and emotional health and development, family environment, academic accomplishments and attitudes, and social behaviour. The NLSCY plans to follow children up to age 25.

There are two primary respondents in the NLSCY: the person most knowledgeable (PMK) of the child and the child or youth himself. PMKs provide information on family and parental characteristics, report on their and their spouse's (if applicable) health, and report on the health and behaviour of their children. Starting at age 10, children receive a self-administered questionnaire which elicits their own reports of health, behaviour, social relationships and academics. Of particular interest to the

studies included herein, the self-administered questionnaire asks youth to report on their lifetime and current use of various substances, including tobacco, alcohol, marijuana and other illicit substances.

The participants of interest to the following studies are those who were followed longitudinally and who were at least 10 years of age. Because longitudinal children enter the study at different ages, the size of the study population of interest increases every year as younger children become eligible to complete the self-administered questionnaire. Table 3 summarizes the approximate sample available for analysis from each cycle of the NLSCY.

Table 3 Number of NLSCY respondents by year of age for cycles 1 through 5

Age	Cycle 1 (1994-95)	Cycle 2 (1996-97)	Cycle 3 (1998-99)	Cycle 4 (2000-01)	Cycle 5 (2002-03)
10	1766	1186	1238	1285	1330
11	1668	1054	842	1183	1278
12		1195	1264	1090	1231
13		1063	875	1091	1151
14			1262	1151	1050
15			916	1101	1058
16				1173	1122
17				1081	1052
18					1172
19					1078
Total	3434	4498	6397	9155	11,522

Substance Use Questions in the NLSCY

Every cycle of the NLSCY has included questions regarding substance use in the self-administered questionnaire given to children aged 10 and up. Lifetime (ever) use of substances is asked in a relatively consistent manner across the five cycles of the

NLSCY. Frequency of substance use, however, has been asked in various ways since Cycle 1. Appendix A gives the question categories and new codes assigned to variables in order to maintain a consistent longitudinal measurement of substance use frequency.

In a series of questions, youth are first asked if they have ever used a particular substance. Those who indicate that they have used this substance at least once in their lifetime are subsequently asked about the frequency with which they currently use the particular substance. With regards to tobacco use, those who indicate that their experience with cigarettes was limited to a few puffs are still considered to have ever used tobacco, i.e. they are instructed to answer questions regarding the frequency with which they currently use tobacco. Conversely, with regard to alcohol use, those who report that their experience with alcohol is limited to just a few sips are not considered to be ever users of alcohol, i.e. they are instructed to skip questions regarding frequency of alcohol use.

Apart from tobacco and alcohol, youth are also asked about their use of other "harder" drugs. The drug categories covered depend on the age of respondents and the particular cycle of the NLSCY. As shown in Table 4, the composition and interpretation of the "other drugs" category differs depending on the drugs asked about prior to this question. Nevertheless, in the following thesis studies, use of any drug apart from tobacco, alcohol or marijuana was considered to be "other drug use", regardless of its specific nature.

Table 4 Substance categories included in each cycle of the NLSCY, by age group

Year	Ages	Mari-juana	Sniff glue or solvents	Hallucinogens (LSD/acid)	Crack/ cocaine	Drugs without prescription	Other drugs
1994	10-11	✓	✓				✓
1996	10-11	✓	✓				✓
	12-13	✓	✓	✓	✓		✓
1998	10-11						✓
	12-13	✓	✓				✓
	14-15	✓	✓	✓		✓	✓
2000	10-11						✓
	12-13	✓	✓	✓		✓	✓
	14-15	✓	✓	✓		✓	✓
	16-17	✓	✓	✓		✓	✓
2002	10-11						✓
	12-13	✓	✓	✓		✓	✓
	14-15	✓	✓	✓		✓	✓
	16-17	✓	✓	✓		✓	✓
	18-19	✓	✓	✓		✓	✓

In cycles 4 (2000) and 5 (2002) of the NLSCY, the use of marijuana is not distinguishable from the use of other substances for those aged 10 and 11. Consequently, analyses of the frequency of marijuana use are limited to those ages 12 and up.

Puberty Questions in NLSCY

Respondent ages 10 to 17 are asked about the degree to which their bodies are exhibiting the physical changes related to puberty. The questions are drawn from the shortened version of the *Pubertal Development Scale* (PDS) created by Petersen and colleagues, which has shown good reliability and validity in the literature (Brooks-Gunn, Warren, Rosso, & Gargiulo, 1987; Petersen, Crockett, Richards, & Boxer, 1988; Schmitz et al., 2004).

On a scale of 1 (has not yet started) to 4 (is complete), males and females are asked about physical change experienced in the following: the growth of body hair (boys and girls), breast development and menstruation (girls only), and voice change and the growth of facial hair (boys only). The wording of questions and categories used in the NLSCY are given in Table 5.

Table 5 Pubertal status questions included in the NLSCY

Gender	Body Change Question	Category	Code
Males and females	Would you say that your body hair ("body hair" means underarm and pubic hair) has begun to grow?	Has not yet started growing	1
		Has barely started growing	2
		Growth of body hair is definitely underway	3
		Growth of body hair seems completed	4
Females only	Have your breasts begun to grow?	Have not yet started growing	1
		Have barely started growing	2
		Breast growth is definitely underway	3
		Breast growth seems completed	4
	Have you begun to menstruate (your monthly periods)?	Yes	1
		No	4
Males only	Have you noticed a deepening of your voice?	Has not yet started changing	1
		Has barely started changing	2
		Voice is definitely changing	3
		Voice change seems completed	4
	Have you begun to grow hair on your face?	Has not yet started growing	1
		Has barely started growing	2
		Facial hair growth is definitely underway	3
		Facial hair growth seems completed	4

The responses for the three appropriate pubertal change questions for each gender are averaged to yield a PDS score between 1 and 4, with 4 representing completed puberty. Youth ages 18 and 19 are not asked about their pubertal status, presumably under the assumption that all individuals at this age will have completed pubertal

changes. These individuals are assigned a PDS score of 4. The methodology used to categorize individuals by their pubertal timing (e.g. early, on-time or late) is described in the study manuscript for project #3.

Changes in the NLSCY Over Time

There have been certain changes in sampling procedures over the course of the NLSCY that have affected the composition of the longitudinal sample. In 1994, the year that the NLSCY began, the National Population Health Survey (NPHS) was also being launched by Statistics Canada. Since both the NLSCY and the NPHS aimed to collect information on Canadian children, a portion of the survey content and sample composition was integrated for the two surveys: these children comprise what is called the *integrated component*. The integrated component, which included 3896 children, was dropped from later cycles of the NLSCY. Also in Cycle 1, up to four children per selected household were eligible for interview. In an effort to reduce response burden and cost, the number of eligible children was limited to two per household in Cycle 2. Furthermore, although it was unlikely to have had any effect on sample composition, the survey name in Cycle 1 – National Longitudinal Survey of Children – was changed to its current form in Cycle 2 – National Longitudinal Survey of Children and Youth (Statistics Canada, 1998).

Few significant sampling changes took place in Cycle 3. In Cycle 4 (2000-2001), however, changes were made to the sample selection procedure in order to render the process more efficient. Children who had been non-respondents in two cycles (n=519) were dropped from the selection procedure. A similar criterion in Cycle 5 resulted in a

further 243 children being excluded from selection. Also starting in Cycle 4, youth age 16 or over could continue to respond to the NLSCY even if they were no longer living in their parents' household.

With regards to the self-completed questionnaire, the method of administration was fairly consistent throughout the course of the NLSCY. The self-complete questionnaire has always been a paper and pencil format, completed by the youth in a private setting, and returned to the interviewer in a sealed envelope while the interviewer was present in the respondents' home. This process was altered slightly in Cycle 4, but only for youth aged 16 and 17, who received the self-complete questionnaire by mail prior to the interview. The oldest youth were encouraged to complete the questionnaire beforehand and to return it to the interviewer at the time of the household interview. Administration of the self-complete questionnaire returned to the initial methodology in Cycle 5.

National Longitudinal Survey of Youth 1979 – Child and Young Adult Data (NLSY79-C)

The *National Longitudinal Survey of Youth 1979* (NLSY79) is a nationally representative sample of 12,686 American men and women who were all 14 to 21 years of age on December 31, 1978. Starting in 1986, a survey of all children born to NLSY79 female respondents began collection: the *National Longitudinal Survey of Youth 1979 – Child and Young Adult Data* (NLSY79-C). In addition to the mother's information from

the NLSY79, the NLSCY79-C includes assessments of each child as well as additional demographic and development information collected from either the mother or child.

Beginning in 1988, children aged 10 and older have received self-administered questionnaires that elicit information regarding schooling, relationships, attitudes and behaviours, including questions regarding alcohol, tobacco, marijuana and other drug use. Starting in 1994, two forms of the self-administered questionnaire were conducted for children (ages 10-14) and youth (ages 15 and up). Both children and youth respond to questions regarding lifetime and current use of substances.

At the time that these thesis studies were conceived and developed, nine waves of data were available, representing biennial surveys conducted between 1986 and 2002. The number of children at each age interviewed at each cycle of the NLSY79-C is given in Table 6. All survey documentation and data (excluding geocode variables) are available free and online at http://www.bls.gov/nls/home.htm.

Table 6 Number of NLSY79-C respondents by age at interview, 1986-2002

Age	1986	1988	1990	1992	1994	1996	1998	2000	2002
0	607	588	505	364	290	223	189	113	49
1	634	552	562	435	367	258	196	123	72
2	614	598	585	470	367	314	212	180	115
3	619	656	553	469	436	355	271	178	112
4	618	585	588	495	456	342	301	211	187
5	511	618	673	481	476	429	346	252	176
6	471	603	585	504	484	453	351	269	189
7	350	555	615	547	463	453	426	352	237
8	297	503	612	501	510	465	444	322	271
9	214	360	543	502	550	467	457	405	324
10	168	309	514	517	495	503	474	434	330
11	90	233	359	456	499	545	474	433	380
12	39	194	315	423	506	462	487	431	410
13	17	120	253	307	451	514	513	440	414
14	4	55	192	261	419	481	460	440	436
15	1	25	124	188	323	427	515	518	423
16		7	56	156	251	407	484	453	458
17		2	28	96	187	288	418	470	461
18			7	46	162	250	394	461	441
19			2	23	93	183	283	414	458
20				3	44	147	245	401	440
21+				2	29	154	452	1022	1717
Total	5254	6563	7671	7246	7858	8120	8392	8322	8100

Substance Use Questions in the NLSY79-C

Lifetime and current use of substances is assessed starting at age 10 through a self-administered questionnaire. The types of drugs for which children and youth are asked to report their use are given in Table 7. Drug categories are fairly consistent from 1988 through 1992. Starting in 1994, when two versions of the self-administered questionnaire were designed (one for children ages 10-14 and one for youth ages 15 and up), the types of drugs reported on began to differ depending on age and the year of the survey.

Table 7 Substance categories asked in each cycle of the NLSY79-C, by age group

Year	Age group	Cigarettes	Alcohol	Marijuana	Inhalants	Halluci-nogens	Cocaine (not crack)	Crack	Any cocaine	Stimulants / sedatives	Drugs without a prescrip-tion	Other drugs
1988	10+	✓	✓	✓								✓
1990	10+	✓	✓	✓								✓
1992	10+	✓	✓	✓								✓
1994	10-14	✓	✓	✓	✓							✓
	15+	✓	✓	✓	✓		✓	✓			✓	✓
1996	10-14	✓	✓	✓	✓							✓
	15+	✓	✓	✓	✓		✓	✓			✓	✓
1998	10-14	✓	✓	✓	✓	✓			✓	✓		
	15+	✓	✓	✓	✓	✓	✓	✓		✓	✓	
2000	10-14	✓	✓	✓	✓	✓			✓	✓		
	15+	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓
2002	10-14	✓	✓	✓	✓	✓			✓	✓		
	14-15	✓	✓	✓	✓	✓	✓	✓		✓	✓	✓

Initially, an objective of project #1 was to compare trajectories of substance use based on the NLSCY with those based on NLSY79-C data. As mentioned previously (see 'Project #1: Trajectories of Substance Use Among Adolescents', p.37), the final manuscript did not include a description or discussion of the trajectory models for NLSY79-C respondents. Only project #2 – joint trajectories of behaviour problems and substance use – uses trajectories from the NLSY79-C, and then only trajectories of initiation, not frequency of use, are discussed. Nevertheless, at the outset of these projects it was necessary to develop a common set of indicators in order for the models to be comparable. As such, reports of substance use between the two datasets were rendered as similar as possible.

Lifetime use of substances is a binary measure: a substance has been used at least once in a lifetime or it hasn't. There was no difficulty in creating similar measures of substance use initiation between the NLSCY and the NLSY79-C. In addition to lifetime use (or initiation), the NLSCY assessed frequency of substance use using one question, whereas the NLSY79-C addresses two aspects of this behaviour: the recentness of use, and the past month frequency of use. Recentness and past month use were combined to create a measure of substance use frequency that was as similar as possible to that in the NLSCY. The manner in which recentness and past month use of substance were combined to yield a measure of substance use frequency are given in Appendix B.

As with the NLSCY, substance use is assessed through a series of questions. Children and youth are first asked if they have ever used a particular substance. Respondents are then asked about their most recent use of the particular substance and

how frequently they have used that substance. Unlike the NLSCY, the skip patterns in the NLSY79-C's self-completed questionnaire do not direct never-users to skip questions regarding the recentness and frequency of use. This means that, in certain cases, an individual may indicate that they have never used a substance in their life, but go on to indicate that they used a particular substance within the past year. In order to maintain consistency between the NLSCY and the NLSY79-C, those who first indicated that they had never used a particular substance were coded as missing for their frequency of use.

Behaviour Problem Index

Beginning with the first NLSY79-C cycle in 1986, mothers of children ages 4 to 14 were asked an extensive series of structured questions regarding behaviours exhibited by their child. These questions comprise the Behaviour Problems Index (BPI), created by Petersen and Zill (1986) and based primarily on Achenbach's Child Behaviour Checklist (Achenbach & Edelbrock, 1983). For each of a series of 28 items, mothers are asked to rate the extent to which each item is true of their child's behaviour in the past two months: (0) never true, (1) sometimes true, or (2) often true. Items from the BPI can be summed to create a total behaviour problems score, or can be subdivided into two subscales that measure a child's tendency to externalize or internalize behaviours. The externalizing scale is comprised of 20 items and the internalizing scale of 10 items. The trichotomously coded items are summed for each subscale, yield externalizing scores that range from 0 to 40, and internalizing scores that range from 0 to 20. Each item from the BPI, as well as its pertinence to measuring externalizing and internalizing problems, are

given in Table 8. Because two items from the BPI concern school-related behaviours – 'is disobedient at school' and 'has trouble getting along with teachers' – and thus are only pertinent to children who are or who have ever attended school, the analysis of BPI data from the NLSY79-C was restricted to children ages 6 and up.

Table 8 Items from the Behaviour Problem Index (BPI) and their inclusion in the externalizing and internalizing subscales

BPI Items	External	Internal
Has sudden changes in mood or feeling	✓	
Feels or complains that no one loves him/her		✓
Is rather high strung, tense and nervous	✓	
Cheats or tells lies	✓	
Is too fearful or anxious	✓	✓
Argues too much	✓	
Has difficulty concentrating, cannot pay attention for long	✓	
Is easily confused, seems to be in a fog	✓	✓
Bullies or is cruel or mean to others	✓	
Is disobedient at home	✓	
Does not feel sorry for misbehaving		
Has trouble getting along with other children	✓	
Is impulsive, or acts without thinking	✓	
Feels worthless or inferior		✓
Is not liked by other children	✓	
Has a lot of difficulty getting his/her mind off certain thoughts (has obsessions)	✓	
Is restless or overly active, cannot sit still	✓	
Is stubborn, sullen, or irritable	✓	
Has a very strong temper and loses it easily	✓	
Is unhappy, sad, or depressed	✓	✓
Is withdrawn, does not get involved with others		✓
Breaks things on purpose or deliberately destroys his/her own or another's things	✓	
Clings to adults		✓
Cries too much		✓
Demands a lot of attention		✓
Is too dependent on others		✓
Is disobedient at school	✓	
Has trouble getting along with teachers	✓	

Changes in the NLSY79-C Over Time

There have been a few changes to the sampling and administration of the NLSY79-C over time. Some of these are discussed in the manuscript for project #2: a summary of the relevant changes to the NLSY79-C is given below.

The NLSY79-C is a survey of children born to female respondents from the NLSY79. Therefore, sampling changes in the NLSY79 also affect the composition of the NLSY79-C sample. The NLSY79 originally included substantial over-samples of African-American, Hispanic, economically disadvantaged Caucasian, and military youth. Due to budget constraints, the military youth over-sample was dropped following the 1984 NLSY79 interview, and the economically disadvantaged Caucasian over-sample was dropped following the 1990 survey. Only the latter shifts the composition of the NLSY79-C sample over time. In 2000, a random sample of approximately 38% of the African American and Hispanic over-samples was excluded from interview. These individuals were reintroduced to the interview rolls for the 2002 interview (Center for Human Resource Research, 2004).

All interviews through 1992 were conducted primarily in person at the respondent's home using paper and pencil instruments. Beginning in 1994, the child supplement and the young adult self-administered questionnaire were conducted via Computer Assisted Personal Interview (CAPI). In 2000, all interview components were assessed using CAPI. From 1994 to 1998, the young adult questionnaires were conducted via in-person interviews. Beginning in 2000, the primary interview mode was changed to the telephone rather than in-home visits. Furthermore, up through 2000, all

young adult interviews coincided with other interview components. However, in 2002, the young adult phone interviews were conducted substantially prior to other interview components.

References

Achenbach, T. M. & Edelbrock, C. S. (1983). *Manual for the Child Behavior Checklist and Revised Child Behavior Profile*. Burlington, Vermont: University of Vermont, Department of Psychology.

Brooks-Gunn, J., Warren, M. P., Rosso, J., & Gargiulo, J. (1987). Validity of self-report measures of girls' pubertal status. *Child Development, 58,* 829-841.

Center for Human Resource Research (2004). *NLSY79 Child and Young Adult Data Users Guide: A guide to the 1986-2002 child data and 1994-2002 young adult data* Columbus, OH: The Ohio State University.

Petersen, A. C., Crockett, L., Richards, M., & Boxer, A. (1988). A self-report measure of pubertal status: Reliability, validity and initial norms. *Journal of Youth and Adolescence, 17,* 117-133.

Petersen, J. L. & Zill, N. (1986). Marital disruption, parent-child relationships, and behavior problems in children. *Journal of Marriage and the Family, 48,* 295-307.

Schmitz, K. E., Hovell, M. F., Nichols, J. F., Irvin, V. L., Keating, K., Simon, G. M. et al. (2004). A validation study of early adolescents' pubertal self-assessments. *Journal of Early Adolescence, 24,* 357-384.

Statistics Canada (1998). *Microdata User Guide, National Longitudinal Survey of Children and Youth, Cycle 1.* Ottawa: Statistics Canada.

Overview: Analysis

In addition to simple descriptive statistics, the three thesis projects make use of two other analytic techniques. Two of the three studies – projects #1 and #2 – make use of an analytic technique referred to as group-based developmental trajectory modelling. The third study, project #3, uses discrete-time survival analysis to examine the effect of pubertal maturation and timing on the initiation of various substance using behaviours. Although described in each of the study manuscripts, greater details of these analytic techniques are given below.

Group-Based Developmental Trajectories

Traditionally, hierarchical modelling (e.g. growth curves) and latent curve analysis techniques are used to analyze and model longitudinal data. Group-based developmental trajectory modelling is similar to these techniques in several ways. For instance, hierarchical, latent growth and group-based developmental models each have as their goal the measurement and explanation of individual-level change and the variation that exists between individuals in their developmental trajectories. Both growth curves and group-based trajectories model the shape of an outcome according to a polynomial of time. Where the methods diverge is in their assumptions (and consequent modelling) regarding the distribution of individual trajectories within the population. Growth curve methods assume that the parameters describing the polynomial function model the mean

population trajectory (e.g. normative trajectory) and that individuals' trajectories vary continuously about this mean according to a continuous distribution, usually the multivariate normal distribution. Alternately, group-based trajectory modelling assumes that individual differences can be summarized by a finite set of different polynomial functions of age (or time). Each set of polynomial functions corresponds to a trajectory group.

Developmental trajectory groups are not literal categories of individuals in a population: groups cannot be observed. Rather, trajectory groups can be thought of as latent strata in longitudinal data that describe clusters of individuals who share similar and distinctive developmental paths (Haviland & Nagin, 2005; Nagin & Tremblay, 2005). Group-based models explicitly acknowledge the uncertainty in group membership by assigning to individuals posterior probabilities of belonging to any one of the identified groups.

Derivation of the Likelihood Function

Trajectory modelling involves the construction of likelihood functions that aggregate a series of conditional likelihoods. For instance, $P(Y_i)$, the unconditional probability of observing individual i's set of longitudinal outcomes Y_i is equal to

$$P(Y_i) = \sum_{j=1}^{J} \pi_j P(Y_i \mid j)$$

where π_j is the probability that individual i belongs to trajectory j, and $P(Y_i|j)$ is the probability of obtaining the set of outcomes Y_i given i's membership in group j. The

likelihood of the entire sample is given by the product of all individual likelihood functions across all members of the sample, N.

$$L = \prod^{N} P(Y_i)$$

The likelihood functions can be modelled according to three distributions: the censored normal, the zero-inflated Poisson, and the logistic. The censored normal distribution, also called the tobit model, is used with psychometric or scale data, where the distribution of the outcome has a minimum and maximum. The zero-inflated Poisson is used for count data, and the logistic is used for binary outcomes. For further discussion regarding the mathematical theory that underlies the development of trajectories, refer to (Nagin, 2005). The group-based trajectory approach is undertaken using a macro called *Proc Traj* in the statistical software package SAS©.

Trajectory Model Development and Selection

Once the appropriate form of the likelihood function is decided upon, i.e. censored normal, zero-inflated Poisson or logistic, model development and selection follows a two-stage process. In the first stage, the optimal number of groups (trajectories) that will be used to describe the distribution of outcome data is determined. This is accomplished by maintaining a common shape (polynomial) for the function of time (age) across all trajectories and comparing overall fit across models with an increasing number of groups. Model fit is assessed by the Bayesian Information Criterion (BIC), which is calculated as $\text{BIC} = -2\log(L) - 0.5k\log(N)$, where L is the model's maximum log likelihood, k is the number of parameters in the model, and N is

the sample size. The model with the maximum BIC score, i.e. least negative number, is selected as the optimum model. This determines the number of trajectory groups to include in the model.

The second stage of model selection involves adjusting the shape of each trajectory group in the model. Trajectories can follow any polynomial function of time (age) up to a sixth-order polynomial curve. The statistical significance of each trajectory group's polynomial slope parameters helps determine trajectory shape, as does the change in BIC. A strength and advantage of the group-based methodology is that it allows each trajectory group to follow its own developmental path, meaning that trajectories can have quite different shapes.

Dual Trajectory Analysis: An Extension of Group-Based Techniques

Conventionally, the association between two variables is expressed through the use of a single summary statistic, usually a correlation or an odds ratio. Often, such summary statistics are interpreted such that the magnitude of the statistic applies equally to all members of the population. The reality, however, is that such summary statistics are averaged over the population, and that the association may exist for certain members of the population and not exist for others (Nagin, 2005).

Nagin and Tremblay (2001) describe an analytic procedure for comparing the developmental trajectories of distinct but related behaviours. The strength of this technique over conventional methods is that it communicates both average associations between outcomes as well as deviations from these averages. The dual trajectory

procedure provides three key outputs: the developmental trajectories of each behavioural outcome, the probability of membership in each trajectory, and the probabilities that link membership in trajectory groups across the two related behaviours.

The modelling of developmental trajectories and the probability of membership in each trajectory has already been outlined. The link between two developmental behaviours is represented in the dual trajectory procedure by three alternative probabilities: the conditional probability of membership in each trajectory for behaviour B conditional upon membership in each trajectory for behaviour A; the conditional probability of membership in each trajectory for behaviour A conditional upon membership in each trajectory for behaviour B; and the joint probability of belonging to each trajectory combination for behaviours A and B. In project #2 which uses the dual trajectory approach, behaviour A is the expression of externalizing and internalizing behaviours during childhood, and behaviour B is the initiation of substance use during adolescence.

The Proc Traj macro provides the estimates for the probability of membership in each trajectory for outcome A (π_A), the probability of membership in each trajectory for outcome B (π_B), and the joint probabilities for each combination of trajectories for A and B (π_{AB}). Based on these values, one can calculate the conditional probabilities of group membership. From probability theory, the probability of B given that A has occurred ($\pi_{B|A}$) is calculated by

$$\pi_{B|A} = \frac{\pi_{AB}}{\pi_A}$$

Similarly, one can calculate the probability of A given B ($\pi_{A|B}$):

$$\pi_{A|B} = \pi_{B|A} \frac{\pi_A}{\pi_B}$$

Given the temporal sequencing of behaviours in the project #2, i.e. behaviours during childhood are observed prior to those in adolescence, the interpretation of $\pi_{A|B}$ is not reasonable. Therefore, the conditional probabilities of behaviour problems in childhood conditional on substance initiation during adolescence are not presented.

Discrete-Time Survival Analysis

Whereas the group-based development trajectories described above seek to answer the question "how to behaviours change over time?", another question that may be asked is "when does a particular event take place"? Project #3 asks whether and when adolescents engage in particular substance use behaviours (e.g. regular smoking, drunkenness, weekly marijuana use, other drug use), and whether the age at which youth first engage in such behaviours differs by pubertal timing. Answering these types of questions is best done through the use of survival analysis.

The framework used for conducting the discrete-time survival analyses is based primarily on the techniques described by Judith Singer and John Willett in their textbook *Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence* (Singer & Willet, 2003). The metric of time utilized in these analyses is year of age. Although substance initiation can occur at any point, and the underlying measure of time is truly

continuous, due to the manner in which individuals answer these questions, i.e. in whole years, analyses are constrained to be discrete. However, to compensate for this, all analyses use a complementary log-log (clog log) transformation, which better accommodates the discrete measurement of a continuous outcome than other link functions (Hosmer & Lemeshow, 1999; Singer & Willet, 2003).

In survival analysis, the sample of respondents who are at risk of experiencing the event of interest is referred to as the *risk set*. The number of individuals who comprise this risk set decreases over time as individuals either experience the event or are dropped from analysis. The latter type of loss is referred to as right-censoring, where an event time is not observed either because the individual is lost to follow-up, or the study period ends.

Two statistical summaries of event occurrence are used in survival analysis: the hazard function and the survival function. In discrete-time survival analysis, the hazard function refers to the conditional probability that an individual i will experience an event during time period j given that they have not experienced the event in any prior time period. This is expressed algebraically as:

$$h(t_{ij}) = \Pr[T_i = j | T_i \geq j]$$

According to this representation, each individual in the sample has their own hazard function. However, in practical terms, the subscript i can be dropped because many individuals will experience an event at the same time, i.e. at the same age. Therefore, we can discuss the overall hazard of event occurrence for each time period, which is estimated by:

$$h(t_j) = \frac{\text{n events}_j}{\text{n at risk}_j}$$

Whereas the hazard function describes the unique probability of event occurrence for a given time period, the survival function provides a cumulative estimate of risk by expressing the probability that an individual *will not* experience an event. At time 0, the probability of survival is 1, given that no one has yet to experience the event. As time passes and individuals experience the event, the survival function can be expressed as:

$$S(t_j) = S(t_{j-1})[1 - h(t_j)]$$
$$S(t_j) = [1 - h(t_j)][1 - h(t_{j-1})][1 - h(t_{j-2})]\ldots[1 - h(t_1)]$$

Building the Model

To conduct discrete-time survival analysis, a variant of the logistic regression model is used. The first step is to generate a flexible, general model of the hazard function which uses a series of dichotomous dummy variables to represent each time period. As shown in Table 9, each time indicator dummy is set to 1 in the time period that it represents, and set to 0 for every other time period.

Table 9 Time indicator dummy variables in discrete-time survival analysis

Period	D_1	D_2	...	D_{j-1}	D_j
1	1	0	0	0	0
2	0	1	0	0	0
...	0	0	...	0	0
j-1	0	0	0	1	0
j	0	0	0	0	1

Source. Singer & Willett. 2003. Applied Longitudinal Data Analysis: Modeling Change and Event Occurrence. New York: Wiley. p. 370.

When substituted into a logistic model (using the clog log function), the hazard function is represented by:

$$c\log\log h(t_j) = \alpha_1 D_1 + \alpha_2 D_2 + \ldots + \alpha_j D_j$$

$$h(t_j) = \frac{1}{1 - e^{-e^{(\alpha_1 D_1 + \alpha_2 D_2 + \ldots + \alpha_j D_j)}}}$$

where each α represents the value of the log odds of event occurrence in that particular time period.

As mentioned in the manuscript for project #3, alternate specifications of time in the hazard function were also examined: linear, quadratic and cubic.

$$c\log\log h(t_j) = \alpha_0 + \alpha_1 (TIME)$$
$$c\log\log h(t_j) = \alpha_0 + \alpha_1 (TIME) + \alpha_2 (TIME)^2$$
$$c\log\log h(t_j) = \alpha_0 + \alpha_1 (TIME) + \alpha_2 (TIME)^2 + \alpha_3 (TIME)^3$$

In each case, the change in the model's fit, as assessed by -2log likelihood and the BIC, from that of the general hazard function was assessed. In all cases, the general hazard function provided a better fit to the data, and the general, dummy variable hazard model was retained.

Next, the impact of pubertal timing on hazard was assessed by the inclusion of time-independent dummy variables in the model:

$$c\log\log h(t_j) = \{\alpha_1 D_1 + \alpha_2 D_2 + \ldots + \alpha_j D_j\} + \beta_1 (early) + \beta_2 (late)$$

where β_1 and β_2 refer to the impact of early and late pubertal timing in relation to on-time maturation, respectively. In this model form, the effect of pubertal timing is forced to be proportional across all time periods. This means that the effect of being an early maturer

is constrained to have the same effect on the probability of initiation at age 10 as it does on the probability of initiation at age 17.

However, to investigate whether the effect of pubertal timing is in fact nonproportional, interactions between the time indicators and the pubertal timing variables were included in the model:

$$\text{cloglog}\, h(t_j) = \{\alpha_1 D_1 + \alpha_2 D_2 + \ldots + \alpha_j D_j\} + \{\beta_{11}(early)D_1 + \beta_{12}(early)D_2 + \ldots + \beta_{1j}(early)D_j\} + \{\beta_{21}(late)D_1 + \beta_{22}(late)D_2 + \ldots + \beta_{2j}(late)D_j\}$$

Although the above equation seems very complex, in fact, for each time period it simplifies remarkably to:

$$\text{In time period 1}: \text{cloglog}\, h(t_1) = \alpha_1 + \beta_{11}(early) + \beta_{21}(late)$$
$$\text{In time period 2}: \text{cloglog}\, h(t_2) = \alpha_2 + \beta_{12}(early) + \beta_{22}(late)$$

If the fit of the model containing the interaction terms is superior to that of the model containing the fixed, proportional effects of pubertal timing, then the nonproportional model is retained. This was the case for all discrete-time survival models examined in project #3.

Gender Differences or Sex Differences?

A primary purpose of this thesis work was to identify gender differences in adolescent substance use. Some may argue that what are really being examined in this work are *sex* differences in use. Though the words may be used interchangeably in common parlance, they refer to distinct concepts. Sex refers to the division of living

things into male and female based on biology and reproductive functions. Gender refers to "the characteristics or traits [that are] determined socially as a result of one's sex" (Canadian Oxford Dictionary, 2004).

Indeed, individuals in the following studies are identified and compared on the basis of their sex, i.e. whether they are male or female. However, the following studies hypothesize that the differences between male and female substance using behaviour is generated on the basis of socialization and social convention (e.g. gender differences), not on the basis of biology (e.g. sex differences). Even for project #3 which examines the relationship between substance use and pubertal developmental, which is primarily a function of biology, it is my contention that the differences in exhibited behaviour are due to the social influences acting upon the individual, and not necessarily due to biological causes.

The use of the term 'gender' will be retained in this document, which is consistent with the terminology used by various other organizations and government agencies, including Health Canada (Health Canada, 2005), the Canadian Institutes of Health Research (CIHR Institute of Gender and Health, 2004), and the Status of Women in Canada (Status of Women Canada, 1998).

References

Canadian Oxford Dictionary (2004). Toronto: Oxford University Press Canada.

CIHR Institute of Gender and Health (2004). *What's Sex and Gender Got to Do With It? Integrating Sex and Gender into Health Research* Ottawa: Canadian Institutes of Health Research.

Haviland, A. M. & Nagin, D. S. (2005). Causal inferences with group based trajectory models. *Psychometrika, 70,* 1-22.

Health Canada (2005). What is Gender-Based Analysis? http://www.hc-sc.gc.ca/hl-vs/women-femmes/gender-sexe/gender-sexes_e.html [On-line].

Hosmer, D. W. & Lemeshow, S. (1999). *Applied survival analysis: Regression modeling of time to event data.* New York: Wiley.

Nagin, D. S. (2005). *Group-Based Modeling of Development.* Cambridge: Harvard University Press.

Nagin, D. S. & Tremblay, R. E. (2001). Analyzing developmental trajectories of distinct but related behaviors: A group-based method. *Psychol.Methods, 6,* 18-34.

Nagin, D. S. & Tremblay, R. E. (2005). What has been learned from group-based trajectory modeling? Examples from physical aggression and other problem behaviors. *Annals of the American Academy of Political and Social Science, 602,* 82-117.

Singer, J. D. & Willet, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence.* New York, NY: Oxford University Press.

Status of Women Canada (1998). *Gender-based analysis: A guide for policy-making* Ottawa: Status of Women Canada.

Project #1: Gender differences in the developmental trajectories of smoking and marijuana use among Canadian adolescents

Gender differences in the developmental trajectories of smoking and marijuana use among Canadian adolescents

Rochelle E. Garner* and Michael H. Boyle*+

*McMaster University, Health Research Methodology Programme, Hamilton, Ontario

+Offord Centre for Child Studies, Hamilton, Ontario

Mailing address and phone number of lead author:

Rochelle Garner

565 Kirkwood Ave.

Ottawa, ON

K1Z 5X3

613-715-9733

Send off-prints to lead author at above address

Short title: Gender differences in substance use trajectories

Abstract

The goal of the present study was to identify developmental trajectories of smoking and marijuana use during adolescence, and to determine whether patterns of substance use differed by gender. Data from the first five cycles of the National Longitudinal Survey of Children and Youth (NLSCY) were analyzed to identify trajectories of smoking initiation, frequency of smoking, marijuana use initiation and frequency of marijuana use from a national sample of Canadian youth ages 10 through 19. Sociodemographic characteristics were added to models to determine their effect on predicting trajectory membership. Results yielded four trajectories of smoking initiation, three trajectories of smoking frequency, and three trajectories of marijuana use initiation. Although these patterns of behaviour were similar for males and females, the proportion of individuals belonging to the various trajectories differed significantly by gender. Gender-specific trajectories describing the frequency of marijuana use were identified. Youth who came from non-intact families were more likely to follow trajectories with earlier ages at initiation and an increasing frequency of use over time. Youth from low-income families were more likely to follow early-initiating smoking trajectories. Low-income status protected males from engaging in increasing use of marijuana.

Keywords: gender, adolescents, smoking, marijuana, trajectories, Canada

Acknowledgements: The authors would like to thank Statistics Canada for providing stipend funding and data access to the lead author of this paper. The comments of Tracy Vaillancourt and Paul Contoyannis, both of McMaster University, were very helpful in preparing this manuscript for publication.

Background

Tobacco and marijuana are two substances commonly used by adolescents. According to a recent Canadian survey, 28% of 15-19 year-olds smoked cigarettes in 1998-99 (Perez, 1999). In 2003, 14% of Ontario students reported smoking on a daily basis (Adlaf, Begin, & Sawka, 2005). In some surveys, marijuana use is more common than cigarette use, reported by 29% of 15-17 year-olds and 47% of 18-19 year-olds in 2003 (Adlaf et al., 2005). A U.S. survey found that 22% of students currently smoked cigarettes, and 22% reported using marijuana in the past 30 days (Grunbaum et al., 2004).

Rates of adolescent substance use have changed over time, declining throughout the 1980s into the early 1990s, but increasing thereafter to the current day (Boggess, Duberstein Lindberg, & Porter, 2000). A study of Ontario students showed that, between 1993 and 1999, alcohol use rose from 57% to 66%, cigarette smoking increased from 24% to 28%, and cannabis use rose alarmingly from 13% to 29% (Adlaf, Paglia, & Ivis, 1999). Other student surveys show similar trends (Liu et al., 2002; Patton, Brown, Broszeit, & Dhaliwal, 2001; Poulin, 2002; Van Til & Poulin, 2002). Additionally, while not all youth are involved in substance consumption, the proportion of non-users is in decline (Adlaf et al., 1999).

Prevalence of substance use is highest during the teen years (Health Canada, 1999), causing some to regard it as a teenage phenomenon. To a certain extent, experimentation with substances may be regarded as a normal part of adolescence (Igra & Irwin, 1996). There are indications that "normative" users, i.e. those whose

experimentation does not progress to regular use, have better long-term outcomes than heavy users or abstainers (Kaminer, 1999). Nevertheless, substance use practices begun during adolescence are strong precursors to use later in life.

Adolescent substance use, particularly use that goes beyond experimentation, can lead to serious consequences, both in the short- and long-term. Early age of substance use initiation increases the likelihood of developing substance use problems in adulthood (Hawkins, Catalano, & Miller, 1992; Hawkins, Graham, Maguin, Abbott, Hill, & Catalano, 1997; Kandel, Simchafagan, & Davies, 1986). Early initiation has also been linked with increased risk of other health conditions, such as decreased lung function (Apostol et al., 2002), lung cancer (Hegmann et al., 1993), and breast cancer (Marcus, Newman, Millikan, Moorman, Baird, & Qaqish, 2000). Other risk behaviours correlated with drug use include unprotected sexual intercourse and sexual precocity (Brener & Collins, 1998; Hovell et al., 1994; Langer & Tubman, 1997; Rosenbaum & Kandel, 1990), injury-related behaviours (Apostol et al., 2002), and other forms of delinquency (Porter & Lindberg, 2000). There are indications that the adverse consequences of alcohol, tobacco and other drug use differ by gender among adolescents (Thomas, 1996).

Historically, males have been more likely to use substances, and to use them more frequently, than females. However, the gender gap in use has narrowed, and in certain cases females out-use males, particularly at younger ages (Brady & Randall, 1999; Crosnoe, 2002; Kaminer, 1999; Waldon, 1991). Johnson and Gerstein (1998) examined the changing rates of substance use initiation in nine birth cohorts and found that, while the proportion of individuals using substances has increased in more recent birth cohorts,

there has also been a convergence in the ratio of males to females who initiated drug use prior to age 21. While convergence in cigarette use occurred in cohorts born just before or shortly after World War II, convergence in initiation of illicit drug use is a more recent phenomenon (Johnson & Gerstein, 1998).

Not only are the rates of substance use different between males and females, but there is evidence that there are also gender differences in the risk factors for substance use. For example, frequent residential relocation is associated with earlier age of marijuana, hallucinogen and cocaine initiation among males but not among females (DeWit, 1998). Parental educational attainment, family structure, and having a family member who uses substances have all been shown to increase a youth's risk of initiating substance use, although these risk factors are more strongly predictive among young women than men (Blackson, Butler, Belsky, Ammerman, Shaw, & Tarter, 1999; Rohde, Lewinsohn, Brown, Gau, & Kahler, 2003; Ellickson, Tucker, & Klein, 2001). Furthermore, girls are more likely to achieve ongoing smoking cessation than boys once they make an attempt (Burt & Peterson, Jr., 1998).

Although the *prevalence* of substance use may differ by gender, this does not necessarily indicate that the *patterns* of use also differ by gender. Prevalence indicates use at a point in time, whereas patterns of use describe when use is initiated and how frequency of use changes across time. Examining developmental patterns of use, both overall and by gender, may help target intervention efforts by identifying points in the life-course when primary prevention would be most effective, or groups that are at high risk of engaging in detrimental use.

Previously, research on patterns of substance use has focussed on variable-centred approaches that describe the average behaviour of a population, but not necessarily patterns that deviate from the norm. Such an approach may be inappropriate for behaviours that display significant heterogeneity in a population, such as substance use. Recently, attention has been paid to more sophisticated techniques, such as growth mixture modelling, to describe longitudinal patterns (i.e. trajectories) of intra-individual change in behaviour.

The focus of the present study was to model the trajectories of smoking and marijuana use in a sample of Canadian adolescents aged 10-19, and to examine gender differences in the patterns of use. A secondary objective was to examine the influence of demographic characteristics on the patterns of substance use.

Methods

Participants

The National Longitudinal Survey of Children and Youth (NLSCY) is a longitudinal study of Canadian children conducted biennially since 1994. Beginning at age 10, children completed a self-administered questionnaire that included questions regarding substance use. Surveyed children were 0-11 years-old in 1994/1995 and were 8-19 years-old in 2002/2003. Between 1994 and 2003, 12,225 children aged 10-19 were interviewed in the NLSCY.

Measures

Substance use

Respondents who reported ever smoking cigarettes, even just a few puffs, were considered to have initiated smoking. Those who reported ever trying marijuana, even just once, were considered to have initiated marijuana use. For 10 and 11-year-olds, the use of marijuana was combined in a list with use of other illicit drugs and was therefore impossible to study on its own at these ages. As such, ever use of marijuana was analyzed only for those aged 12 and up.

Only those who reported ever using cigarettes or marijuana were surveyed regarding the frequency with which they presently smoked cigarettes or used marijuana. Smoking frequency was asked of all ever smokers. Frequency of marijuana use was asked only of those aged 12-19. Frequency of cigarette and marijuana use were each coded on a 5-point scale: 0 (discontinued use), 1 (use a few times a year), 2 (monthly use), 3 (weekly use), and 4 (daily use).

Covariates

Factors other than age may affect the pattern of substance use behaviour exhibited during adolescence. In order to examine and control for the effect of such factors, trajectories were adjusted for the effect of several covariates.

Maternal age has been associated with developmental and behavioural outcomes in children. Specifically, children of teenaged mothers tend to have poorer outcomes than children born to older mothers (Furstenberg, Jr., Brooks-Gunn, & Morgan, 1987).

Therefore, to evaluate the effect of maternal age on the substance use behaviours in this sample, *mother's age at the birth of the respondent child* was dichotomized to reflect children who were born to teenaged (i.e. less than 20 years old) and adult (i.e. 20 years and older) mothers.

Relative income was measured as family income relative to Canada's low income cut-off (LICO). When a family's income fell below the LICO for its family size and community, the family was considered "low income" (Statistics Canada, 2004). For each survey cycle, family income was divided by the LICO, yielding a measure of relative income. This measure was averaged over the multiple survey periods for each respondent child, resulting in a measure of mean relative income. Families whose mean relative income fell below one were considered *low-income*.

Family structure has been consistently associated with adolescents' substance use, with youth in lone-parent and blended families at greater risk of substance use than youth living in traditional two-parent families (Ellickson, Tucker, Klein, & McGuigan, 2001; Hoffmann & Johnson, 1998; Hoffmann, 2002; Ledoux, Miller, Choquet, & Plant, 2002; McArdle et al., 2002; Nurco, Kinlock, Ogrady, & Hanlon, 1996; Nurco, Kinlock, O'Grady, & Hanlon, 1998; Sutherland & Shepherd, 2001; Simantov, Schoen, & Klein, 2000). To examine the effect of family structure on the trajectories of cigarette smoking and marijuana use, the respondent child's family structure was coded as either intact or non-intact. A child's family was considered *intact* if the child lived with both biological parents at each survey period. Children who lived in two-parent families not comprised of both biological parents or children of single-parent families were considered *non-*

intact. Also, children whose families experience divorce or other parental loss over the course of the survey were considered to be in non-intact families.

Analysis

This study used a growth mixture model approach to developing trajectories of cigarette and marijuana use among Canadian adolescents. Developed and described elsewhere (Jones, Nagin, & Roeder, 2001; Nagin, 1999; Nagin & Tremblay, 2001), this method conceptualizes a population as being comprised of distinct groups of individuals who share patterns of behaviour. The number of groups and the shape of their trajectories are tested empirically rather than being assumed a priori. The modeling approach is implemented using a SAS macro known as Proc Traj, developed and described by Jones et al. (2001).

As described by Nagin (2005, p. 66), trajectory development followed a two-stage model selection process. The first stage involved the selection of the number of groups to be included in the optimal trajectory model. Based on a finite mixture modelling framework, a series of models with increasing number of groups were fit. Substantive differences in goodness of fit between models with increasing numbers of groups were determined using the Bayesian information criterion (BIC) and the Bayes factor, as approximated by $e^{BIC_i - BIC_j}$ (Nagin, 2005), where i and j refer to the number of groups present in the model. Improvement in model fit by the addition of one group was considered strong if the Bayes factor was 10 or greater (Nagin, 2005). A maximum of six

groups were considered. This technique selects a model with a higher number of trajectory groups only when the additional group adds sufficient descriptive value. In this stage, the only independent variable considered was age.

Once the number of groups was selected, the second stage involved determining the shape of the trajectories. Trajectories may be flat (constant), linear with age, or follow higher order age curves such as quadratic, cubic or quartic. An asset of this modelling technique is that each trajectory group may have its own shape. The selection of final model shape was based on model fit improvement as measured by the BIC and other fit indicators. When the change in BIC was small, i.e. less than 6 points, the more parsimonious model was chosen.

In order to model behaviour change, at least two response points were needed, though these needed not be contiguous time points. Therefore, only those individuals who provided responses in at least two survey periods were included in these models. Models were fit for the overall sample and then separately by gender.

Following final model selection, covariates were added to the trajectory models to assess the degree to which certain demographic characteristics affected trajectory group membership. Using the Proc Traj procedure, the effect of covariates on trajectory group membership were assessed using multinomial logit analysis. The effect of each covariate was controlled for the presence of all other predictors, including age, in the model. Coefficients are interpreted as the increased probability (odds) that an individual will follow a particular trajectory relative to a contrast group given the presence of a covariate characteristic. To determine whether the effect of covariates differed by gender,

interaction terms were added to the models. In those cases where interactions were significant, the effects of covariates on group membership were given overall and by gender. Addition of covariates did not significantly alter trajectory shapes.

Logistic trajectory models were fit to smoking or marijuana use initiation, while censored normal models were fit to the frequency of smoking and marijuana use. All analyses were unweighted and were conducted using the statistical software SAS version 9.0.

Results

In the first five cycles of the NLSCY, 10,045 children were eligible to contribute information regarding their cigarette and marijuana use. Those who were 10- or 11-years-old in 2002/2003 were not eligible because two survey points are required for analysis. Of those eligible, 6855 (68.24%) provided substance use information in two or more cycles of the survey, and were thus included in the present analyses. Children excluded from analysis were more likely to be male, born to teenaged mothers, and from low-income families than included children (Table 10). There was no statistically significant difference in early smoking (reports of ever smoking by age 11) or early marijuana use (reports of trying marijuana by age 13) between excluded and included respondents.

Smoking Initiation

At age 10, 6.19% of respondents reported that they had ever smoked a cigarette. The proportion of 10-year-olds who reported ever smoking cigarettes was significantly higher among males (7.20%) than among females (5.24%, p=.02). At age 14, nearly half (49.65%) of respondents reported ever smoking a cigarette. At this age, significantly more females (54.18%) than males (45.06%) reported ever smoking (p<.0001).

The optimal trajectory model of respondents' smoking initiation contained four distinct groups: non-smokers, middle-onset smokers, early-onset smokers, and early smokers (Figure 9). Non-smokers have a near-zero probability of ever smoking cigarettes. Although the probability of ever smoking increased slightly by age 18 or 19, it remained less than 20%. Middle-onset and early-onset trajectories describe groups with an increasing probability of smoking initiation as the individual ages. Early-onset adolescents initiated smoking earlier than middle-onset adolescents, and have nearly all initiated smoking by age 14. The fourth trajectory, early smokers, describes those who have already initiated cigarette smoking by age 10 or 11. The proportions of respondents belonging to these trajectories are given in Table 11.

Upon fitting gender-specific trajectory models, males and females did not differ significantly in their patterns of smoking initiation from the overall model. However, the proportion of individuals in each trajectory group did differ significantly by gender (Table 11). Males were more likely to be non-smokers or early smokers, whereas females were more likely to be early-onset smokers.

Frequency of Smoking

Among respondents who reported ever smoking cigarettes, 24.72% reported smoking 6-7 days a week at some point in the study period. This proportion did not differ significantly by gender.

The optimal trajectory model describing the frequency of smoking contained three groups: ex-smokers and experimenters, moderate smokers, and heavy smokers (Figure 10). Ex-smokers and smoking experimenters (horizontal line in Figure 10) are those who try smoking cigarettes but who never report occasional or regular use. Moderate smokers are those whose smoking increases over time from experimentation to monthly use of cigarettes. Heavy smokers were those respondents whose smoking became more frequent at earlier ages, and peaks at or nears daily cigarette use by age 16. Table 11 shows the proportion of individuals belonging to each trajectory group.

Males and females did not differ in their patterns of behaviour from the overall model. Though the shape of trajectories was similar by gender among respondents, the proportion of males and females belonging to each of the three smoking frequency trajectories differed significantly (Table 11). While the proportion of heavy smokers was similar for males and females, males were more likely to be ex-smokers/experimenters whereas females were more likely to be moderate smokers.

Marijuana Use Initiation

At age 16, 48.65% of the respondents reported having tried marijuana at least

once. At this age, there was no statistically significant difference in the proportion of males and females who had tried marijuana (50.00% and 47.16%, respectively).

The optimal model of marijuana use initiation among respondents contained three groups (see Figure 11). Trajectories model non-use of marijuana (with slight increase in probability of use in later teen years), a group of middle-onset marijuana initiators, and an early-onset group of marijuana use initiators. The proportion of respondents per trajectory group is given in Table 12.

The gender-specific models differed slightly from the overall model, but not in interpretively-important ways. The primary difference was that the male-specific model identified a flat non-user trajectory whereas the overall and female-specific models did not; overall and female models had a trajectory that mixed non-users with late onset users (i.e. 20% probability of reporting use at age 19). As such, the overall model was retained in subsequent analyses.

Males were more likely to follow early- and middle-onset marijuana initiation trajectories than females (Table 12). Resultantly, females were more likely than males to be non-users of marijuana.

Frequency of Marijuana Use

Among respondents who reported ever trying marijuana, 7.03% of females and 14.38% of males reported using marijuana 6-7 days a week at some point in the study period. This difference is statistically significant.

Three trajectories best described the frequency of marijuana use in this sample: infrequent users, increasers, and desisters (Figure 12). Infrequent users report using marijuana only once or twice a year across the studied period. Increasers gradually increase their use from low to high levels (e.g. weekly use of marijuana) over this same period. Finally, desisters report decreasing their use of marijuana over time, to the point of achieving non-use by age 19. Table 12 shows the proportion of respondents belonging to each trajectory group.

Gender-specific models differed in important ways from the overall model. Like the overall model, the male-specific model (Figure 14) contained a trajectory of consistently infrequent users. Although the intercept for the male trajectory was lower than that in the overall model, both trajectories describe those whose use of marijuana tended to be limited to a few times a year. However, whereas the overall model included a trajectory of increasingly frequent use of marijuana, the male-specific model contained two such trajectories. One male-specific trajectory, male increasers, lies slightly lower than the overall increasing trajectory, and describes marijuana use that increases from a few times a year to using marijuana a couple of times a week by age 19. The male early increasers trajectory lies higher than in the overall model, and describes marijuana use that changes from low levels at age 12, increasing sharply to near-daily use by age 15. Importantly, the male-specific model did not contain a trajectory of desisting marijuana use.

The female-specific model of respondents' frequency of marijuana use contained three trajectories that are similar in interpretation to the three overall trajectories (Figure

13). The female infrequent marijuana users trajectory is similar to that in the overall model. Female increasers had significantly higher initial levels of use than in the overall model, but the increase among females was more gradual than that in the overall model. Among desisters, the rate of decreased use with age was greater among females than in the overall model.

The early-increasing trajectory among males and the desisting trajectory among females seemed to be gender-specific patterns of the frequency of marijuana use. Infrequent users of marijuana were more common among female than male respondents (Table 12), and males were more likely to be increasing users of marijuana than females.

Effect of Covariates on Trajectory Membership

Tables 13 through 16 present the odds ratios of group membership associated with the demographic covariates in each trajectory model. The effect of covariates is given for the overall models of smoking initiation, frequency of smoking, and marijuana use initiation, and separately for males and females for frequency of marijuana use. Also calculated are the predicted membership probabilities for an array of risk factor scenarios. In each case, the 'no risk' scenario refers to individuals who are born to non-teenaged mothers, who are not in low-income families, and whose families are intact.

Examining the effect of covariates on smoking behaviour patterns, being born to a teenaged mother did not significantly affect the smoking trajectory followed, whether initiation or frequency of ongoing use. The exception was the early-onset smoking trajectory. Those whose mothers were under age 20 when they were born were

significantly more likely to initiate smoking early (early-onset group) than they were to be non-smokers (Table 13). This effect did not differ by gender, i.e. there was no statistically significant interaction with gender.

Low-income status was a significant predictor of smoking group membership. Regarding smoking initiation, youth from low-income families were significantly more likely to follow the early-onset or early smoking trajectories than they were to be non-smokers (Table 13). Also, once they initiated smoking, low-income youth were significantly more likely to be heavy smokers (Table 14). The impact of low-income family status did not differ significantly by gender.

Non-intact family status has a significant impact on smoking trajectory group membership. Regarding smoking initiation, non-intact family status significantly increased the odds of belonging to all smoking initiation trajectories relative to the non-smokers. There was a significant gender interaction with non-intact family status among early-onset smokers (Table 13). Whereas 16.38% of males and 21.94% of females with no risk factors were predicted to be early-onset smokers, these proportions jumped to 24.76% and 38.36% among males and females from non-intact families (Table 13). Among smoking initiators, non-intact family status significantly increased the odds of following the heavy smoker trajectory.

The influence of covariates on marijuana use behaviours was similar in many ways to that on smoking behaviours, with one notable exception. There were indications that low-income status may be protective among young males. The odds of early-onset marijuana initiation were lower among low-income males than their higher income

counterparts. This is seen in the middle panel of Table 15. Relative to the no risk scenario, low-income males had a higher probability of being non-users (41.88%) and a lower probability of early-onset marijuana use (17.99%). Furthermore, among male marijuana initiators, the probability of following the early increasers trajectory was significantly lower among low-income respondents (1.98%) than among higher income respondents (no risk scenario, 4.38%; Table 16). Although the protective effect of low-income status was not seen among females, it should be noted that the odds of trajectory group membership remain unchanged by low-income status.

Discussion

The present study sought to identify developmental trajectories of Canadian adolescents' smoking and marijuana use, and to determine whether these differed by gender. Gender differences, when they existed, tended to be a matter of differential distribution between trajectories of behaviour rather than gender-specific patterns of behaviour. Exceptions were the gender-specific patterns of marijuana use frequency, in which an early increasing trajectory was identified for males only, while a desisting trajectory was found exclusively for females.

In the model for the frequency of smoking behaviour, no identified trajectory depicted a decrease in the frequency of smoking over time. Other studies modelling smoking behaviour trajectories among adolescents found similar results (Audrain-McGovern, Rodriguez, Tercyak, Cuevas, Rodgers, & Patterson, 2004; Colder et al.,

2001; Stanton, Flay, Colder, & Mehta, 2004). Lack of a decreasing smoking trajectory may be due to the fact that respondents were not followed into young adulthood when quit attempts are more common and relapse is less common (Pallonen, Murray, Schmid, Pirie, & Luepker, 1990; Shields, 2005).

Few studies have modelled trajectories of substance use separately by gender. An exception is the work of Flory et al. (2004) who modelled both alcohol and marijuana use from age 11-12 to age 19-21. Modelling mean marijuana use, Flory and colleagues found that three trajectories best described the behaviour of both males and females: non-users, early-onset and late-onset users. In that study, although early-onset males had higher mean marijuana use at every age than early-onset females, females were more likely to be classified as early-onset users than males (Flory, Lynam, Milich, Leukefeld, & Clayton, 2004).

The gender difference reported for marijuana use behaviours in the Flory et al. study is the reverse of that found in the present study, wherein females are less likely than males to be early-onset marijuana users. This may be a result of separately modelling initiation and frequency of use in the current study. The varying gender difference may also be due to significant sample or historical differences between surveys.

Although low-income status and non-intact family status both had significant effects on trajectory membership, they were not fully predictive. No tested characteristic yielded a predicted probability of group membership greater than 71%, and most were considerably lower. Although it may be desirable for prevention purposes to create a sociodemographic profile of individuals who are likely to engage in early initiation and

heavy substance use behaviours, the covariates examined in the present study did not provide much accuracy. The use of sociodemographic characteristics, however, is justifiable given their ease of measurement and their use in identifying high risk groups.

It is likely that other measures may be better able to predict trajectory membership. For example, Resnick et al. (1997) found that individual characteristics such as self-esteem and academic performance explained more variance in adolescents' substance use than demographic variables alone. Addition of family and school contact variables explained further variation (Resnick et al., 1997). As such, future research using the NSLCY may wish to examine domains beyond demography in developing profiles of substance use risk among Canadian adolescents.

In this study, low-income status had a protective effect on males' marijuana use. Other studies have found that, unlike cigarette smoking, individuals' use of marijuana increased with income status (Adlaf et al., 2005). In their study of predictors of marijuana initiation, Miller and Miller (1997) found that socioeconomic status (SES) was associated with an inverse U-shaped pattern with past year marijuana use among males but not females. They found that male adolescents in the third quartile (second highest SES) had the highest odds of marijuana use, whereas those of lower (first and second quartile) or higher (fourth quartile) SES had significantly lower use (Miller & Miller, 1997). This relationship persisted even after controlling for other substance use risk factors, whereas it did not among young females. A U-shaped SES-gradient has also been found between parental education status and adolescent marijuana use (Goodman & Huang, 2002). In the present study, middle-income respondents were grouped together

with high-income respondents, making identification of this U-shaped pattern not possible. The result among males in the present study may indicate that adolescents from higher income families have greater financial ability to obtain marijuana relative to low-income youth. The lack of a commensurate association among females indicates the need for further investigation into the role of SES on marijuana use.

This study has certain limitations. Firstly, the findings presented here were based on a single sample of Canadian youth. Due to concerns regarding the wide range of sample weights assigned to individuals in the NLSCY (minimum=15.85, maximum=4919.06) and the potential for observations with disproportionately large sample weights to unduly influence the outcomes of analysis (Macnab, Koval, Speechly, & Campbell, 2005), the models were not weighted and should not be interpreted as being representative of the Canadian adolescent population.

Secondly, nearly 30% of the eligible sample was not included in this study's analyses due to missing data, i.e. response only available in one cycle of the NLSCY. Some individuals (n=635) were dropped from the survey following cycle 1 due to design changes. Others refused either to participate in particular cycles of the NLSCY, or did not provide answers to the relevant questions. Results showed that children who were male, born to teenaged mothers or from low-income families were over-represented among those excluded from analysis. Since certain of these characteristics were found to be predictive of trajectory group membership, particularly low-income family status, it is possible that the profiles of individuals in these trajectories would differ had it been possible to follow excluded individuals. Furthermore, if the substance using behaviours

of excluded individuals vary significantly from those of included individuals, additional trajectories might have been identified, or the proportion of individuals accounted for by each trajectory group might be found to differ. Nevertheless, no difference in early smoking or marijuana use was found in the present study, indicating that differences in trajectory patterns would likely occur later in the period of adolescence.

Thirdly, the reliance on self-reported substance use may also limit the validity of the findings. Although researchers have found adolescents' self-reports of substances to be generally reliable (Smith, McCarthy, & Goldman, 1995), there was no way in the present study to validate respondents' reports of substance use. However, compared to other modes of administration, self-administered questionnaires like those used in the NLSCY are the preferred survey method as they guarantee more privacy in responding to sensitive questions, thereby encouraging greater respondent candour (Kraus & Augustin, 2001). Furthermore, studies show that accuracy of reports may vary with age and respondent characteristics (Johnson & Mott, 2001). However, given the size of the sample surveyed, and the burden associated with other methods of data collection, reliance on self-reports is best in this context.

A fourth limitation in this study is the age range under investigation. Marijuana use behaviours could not be assessed for youth less than 12 years old. Given the increasing prevalence of marijuana use among youth, it could prove important to delineate early use of marijuana and to identify characteristics of those who are likely to engage in this behaviour. Further, trajectories of substance use could not be drawn beyond age 19. As many substance use behaviours decline as individuals move into early

adulthood, it will be important to repeat the analyses outlined in this paper as future cycles of the NLSCY become available.

In interpreting developmental trajectories of behaviour, one should be clear as to the meaning of such models. Trajectories are used as an analytic tool to simplify the description of complex patterns of behaviour. Individuals assigned to a particular trajectory group do not follow exactly the patterns of behaviour described by each trajectory. Furthermore, members of a trajectory group are not homogenous in their patterns of behaviour. Instead, trajectories are an approximation of behaviour patterns. In addition, although a particular trajectory model is deemed statistically optimal, there will inevitably be patterns of behaviour that are not captured by the final trajectory model. For instance, though no desisting trajectory was found in the male-specific model of marijuana use, there were undoubtedly males in the sample who decreased their use of marijuana over time. Despite these shortcomings, the greater value of the developmental trajectory approach is its ability to summarize and communicate complex patterns in longitudinal data that are often lost in other analytic methods.

The present study indicates that males and females followed similar patterns of smoking behaviour across the period of adolescence, whereas the frequency of marijuana use among initiators did show gender-specific patterns. The fact that multiple trajectories were empirically identified highlights the heterogeneity of adolescents' substance use behaviours, and provides a strong argument for the use of analytic procedures, such as developmental trajectory modelling, that allow examination of group behaviours outside of the population norm. The sociodemographic characteristics examined in this study,

although significant in affecting the probability of substance use trajectory membership, were not fully predictive of the behaviours in which these youth engaged. Further research is necessary to address the manner in which other characteristics, whether at the individual-, family- or peer-group level, are associated with patterns of substance use behaviour among adolescents.

References

Adlaf, E. M., 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: Detailed Report* Ottawa: Canadian Centre on Substance Abuse.

Adlaf, E. M., Paglia, A., & Ivis, F. (1999). Drug use among Ontario students 1977-1999: Findings from the OSDUS. Toronto, ON, Centre for Addiction and Mental Health. CAMH Research Document Series No. 5.

Apostol, G. G., Jacobs, D. R., Tsai, A. W., Crow, R. S., Williams, O. D., Townsend, M. C. et al. (2002). Early life factors contribute to the decrease in lung function between ages 18 and 40 - The coronary artery risk development in young adults study. *American Journal of Respiratory and Critical Care Medicine, 166,* 166-172.

Audrain-McGovern, J., Rodriguez, D., Tercyak, K. P., Cuevas, J., Rodgers, K., & Patterson, F. (2004). Identifying and characterizing adolescent smoking trajectories. *Cancer Epidemiology Biomarkers & Prevention, 13,* 2023-2034.

Blackson, T. C., Butler, T., Belsky, J., Ammerman, R. T., Shaw, D. S., & Tarter, R. E. (1999). Individual traits and family contexts predict sons' externalizing behavior and preliminary relative risk ratios for conduct disorder and substance use disorder outcomes. *Drug & Alcohol Dependence, 56,* 115-131.

Boggess, S., Duberstein Lindberg, L., & Porter, L. (2000). *Changes in risk-taking among high school students, 1991-1997: Evidence from the Youth Risk Behavior Surveys.* The Urban Institute.

Brady, K. T. & Randall, C. L. (1999). Gender differences in substance use disorders. *Psychiatric Clinics of North America, 22,* 241-252.

Brener, N. D. & Collins, J. L. (1998). Co-occurrence of health-risk behaviors among adolescents in the United States. *Journal of Adolescent Health, 22,* 209-213.

Burt, R. D. & Peterson, A. V., Jr. (1998). Smoking cessation among high school seniors. *Preventive Medicine, 27,* 319-327.

Colder, C. R., Mehta, P., Balanda, K., Campbell, R. T., Mayhew, K. P., Stanton, W. R. et al. (2001). Identifying trajectories of adolescent smoking: an application of latent growth mixture modeling. *Health Psychology, 20,* 127-135.

Crosnoe, R. (2002). Academic and health-related trajectories in adolescence: The intersection of gender and athletics. *Journal of Health and Social Behavior, 43,* 317-335.

DeWit, D. J. (1998). Frequent childhood geographic relocation: its impact on drug use initiation and the development of alcohol and other drug-related problems among adolescents and young adults. *Addictive Behaviors, 23,* 623-634.

Ellickson, P. L., Tucker, J. S., & Klein, D. J. (2001). Sex differences in predictors of adolescent smoking cessation. *Health Psychology, 20,* 186-195.

Ellickson, S. L., Tucker, J. S., Klein, D. J., & McGuigan, K. A. (2001). Prospective risk factors for alcohol misuse in late adolescence. *Journal of Studies in Alcohol, 62,* 773-782.

Flory, K., Lynam, D., Milich, R., Leukefeld, C., & Clayton, R. (2004). Early adolescent through young adult alcohol and marijuana use trajectories: early predictors, young adult outcomes, and predictive utility. *Developmental Psychopathology, 16,* 193-213.

Furstenberg, F. F., Jr., Brooks-Gunn, J., & Morgan, S. P. (1987). Adolescent mothers and their children in later life. *Family Planning Perspectives, 19,* 142-151.

Goodman, E. & Huang, B. (2002). Socioeconomic status, depressive symptoms, and adolescent substance use. *Archives of Pediatric & Adolescent Medicine, 156,* 448-453.

Grunbaum, J. A., Kann, L., Kinchen, S., Ross, J., Hawkins, J., Lowry, R. et al. (2004). Youth risk behavior surveillance--United States, 2003. *MMWR Surveill Summ., 53,* 1-96.

Hawkins, J. D., Catalano, R. F., & Miller, J. Y. (1992). Risk and protective factors for alcohol and other drug problems in adolescence and early adulthood: Implications for substance abuse prevention. *Psychological Bulletin, 112,* 64-105.

Hawkins, J. D., Graham, J. W., Maguin, E., Abbott, R., Hill, K. G., & Catalano, R. F. (1997). Exploring the effects of age of alcohol use initiation and psychosocial risk factors on subsequent alcohol misuse. *Journal of Studies in Alcohol, 58,* 280-290.

Health Canada (1999). *Statistical Report on the Health of Canadians* Ottawa: Health Canada.

Hegmann, K. T., Fraser, A. M., Keaney, R. P., Moser, S. E., Nilasena, D. S., Sedlars, M. et al. (1993). The effect of age at smoking initiation on lung-cancer risk. *Epidemiology, 4,* 444-448.

Hoffmann, J. P. (2002). The community context of family structure and adolescent drug use. *Journal of Marriage and the Family, 64,* 314-330.

Hoffmann, J. P. & Johnson, R. A. (1998). A national portrait of family structure and adolescent drug use. *Journal of Marriage and the Family, 60,* 633-645.

Hovell, M. F., Hillman, E. R., Blumberg, E., Sipan, C., Atkins, C., Hofstetter, C. R. et al. (1994). A behavioral-ecological model of adolescent sexual development - A template for AIDS-prevention. *Journal of Sex Research, 31,* 267-281.

Igra, V. & Irwin, C. E. (1996). Theories of adolescent risk-taking behaviour. In R.J. DiClemente, W. B. Hansen, & L. E. Ponton (Eds.), *Handbook of Adolescent Risk Behavior* (pp. 35-51). New York: Plenum Press.

Johnson, R. A. & Gerstein, D. R. (1998). Initiation of use of alcohol, cigarettes, marijuana, cocaine, and other substances in US birth cohorts since 1919. *American Journal of Public Health, 88,* 27-33.

Johnson, T. P. & Mott, J. A. (2001). The reliability of self-reported age of onset of tobacco, alcohol and illicit drug use. *Addiction, 96,* 1187-1198.

Jones, B. L., Nagin, D. S., & Roeder, K. (2001). A SAS procedure based on mixture models for estimating developmental trajectories. *Sociological Methods & Research, 29,* 374-393.

Kaminer, Y. (1999). Addictive disorders in adolescents. *Psychiatric Clinics of North America, 22,* 275-288.

Kandel, D., Simchafagan, O., & Davies, M. (1986). Risk-factors for delinquency and illicit drug-use from adolescence to young adulthood. *Journal of Drug Issues, 16,* 67-90.

Kraus, L. & Augustin, R. (2001). Measuring alcohol consumption and alcohol-related problems: comparison of responses from self-administered questionnaires and telephone interviews. *Addiction, 96,* 459-471.

Langer, L. M. & Tubman, J. G. (1997). Risky sexual behavior among substance-abusing adolescents: Psychosocial and contextual factors. *American Journal of Orthopsychiatry, 67,* 315-322.

Ledoux, S., Miller, P., Choquet, M., & Plant, M. (2002). Family structure, parent-child relationships, and alcohol and other drug use among teenagers in France and the United Kingdom. *Alcohol & Alcoholism, 37,* 52-60.

Liu, J., Jones, B., Grobe, C., Balram, C., & Poulin, C. (2002). *New Brunswick Student Drug Use Survey 2002: Highlights Report.*

Macnab, J. J., Koval, J. J., Speechly, K. N., & Campbell, M. K. (2005). Influential observations in weighted analyses: Examples from the National Longitudinal Survey of Children and Youth (NLSCY). *Chronic Diseases in Canada, 26,* 1-8.

Marcus, P. M., Newman, B., Millikan, R. C., Moorman, P. G., Baird, D. D., & Qaqish, B. (2000). The associations of adolescent cigarette smoking, alcoholic beverage consumption, environmental tobacco smoke, and ionizing radiation with subsequent breast cancer risk (United States). *Cancer Causes & Control, 11,* 271-278.

McArdle, P., Wiegersma, A., Gilvarry, E., Kolte, B., McCarthy, S., Fitzgerald, M. et al. (2002). European adolescent substance use: the roles of family structure, function and gender. *Addiction, 97,* 329-336.

Miller, D. S. & Miller, T. Q. (1997). A test of socioeconomic status as a predictor of initial marijuana use. *Addictive Behaviors, 22,* 479-489.

Nagin, D. S. (1999). Analyzing developmental trajectories: A semiparametric, group-based approach. *Psychological Methods, 4,* 139-157.

Nagin, D. S. (2005). *Group-Based Modeling of Development.* Cambridge: Harvard University Press.

Nagin, D. S. & Tremblay, R. E. (2001). Analyzing developmental trajectories of distinct but related behaviors: a group-based method. *Psychological Methods, 6,* 18-34.

Nurco, D. N., Kinlock, T. W., O'Grady, K. E., & Hanlon, T. E. (1998). Differential contributions of family and peer factors to the etiology of narcotic addiction. *Drug and Alcohol Dependence, 51,* 229-237.

Nurco, D. N., Kinlock, T. W., Ogrady, K. E., & Hanlon, T. E. (1996). Early family adversity as a precursor to narcotic addiction. *Drug and Alcohol Dependence, 43,* 103-113.

Pallonen, U. E., Murray, D. M., Schmid, L., Pirie, P., & Luepker, R. V. (1990). Patterns of self-initiated smoking cessation among young adults. *Health Psychology, 9,* 418-426.

Patton, D., Brown, D., Broszeit, B., & Dhaliwal, J. (2001). *Substance Use Among Manitoba High School Students* Addictions Foundation of Manitoba.

Perez, C. (1999). Personal health practices: Smoking, drinking, physical activity and weight. *Health Reports, 11,* 83-90.

Porter, L. & Lindberg, D. (2000). Reaching out to multiple risk adolescents. The Urban Institute.

Poulin, C. (2002). *Nova Scotia Student Drug Use 2002: Technical Report* Dalhousie University.

Resnick, M. D., Bearman, P. S., Blum, R. W., Bauman, K. E., Harris, K. M., Jones, J. et al. (1997). Protecting adolescents from harm. Findings from the National Longitudinal Study on Adolescent Health. *JAMA, 278,* 823-832.

Rohde, P., Lewinsohn, P. M., Brown, R. A., Gau, J. M., & Kahler, C. W. (2003). Psychiatric disorders, familial factors and cigarette smoking: I. Associations with smoking initiation. *Nicotine & Tobacco Research, 5,* 85-98.

Rosenbaum, E. & Kandel, D. B. (1990). Early Onset of Adolescent Sexual-Behavior and Drug Involvement. *Journal of Marriage and the Family, 52,* 783-798.

Shields, M. (2005). Youth smoking. *Health Reports, 16,* 53-57.

Simantov, E., Schoen, C., & Klein, J. D. (2000). Health-compromising behaviors: why do adolescents smoke or drink?: identifying underlying risk and protective factors. *Archives of Pediatric & Adolescent Medicine, 154,* 1025-1033.

Smith, G. T., McCarthy, D. M., & Goldman, M. S. (1995). Self-reported drinking and alcohol-related problems among early adolescents: dimensionality and validity over 24 months. *Journal of Studies in Alcohol, 56,* 383-394.

Stanton, W. R., Flay, B. R., Colder, C. R., & Mehta, P. (2004). Identifying and predicting adolescent smokers' developmental trajectories. *Nicotine & Tobacco Research, 6,* 843-852.

Statistics Canada, I. S. D. (2004). Low income cutoffs from 1994-2003 and low income measures from 1992-2001. 75F0002MIE-002. Income Research Paper Series.

Sutherland, I. & Shepherd, J. P. (2001). Social dimensions of adolescent substance use. *Addiction, 96,* 445-458.

Thomas, B. S. (1996). A path analysis of gender differences in adolescent onset of alcohol, tobacco and other drug use (ATOD), reported ATOD use and adverse consequences of ATOD use. *Journal of Addictive Diseases, 15,* 33-52.

Van Til, L. & Poulin, C. (2002). *2002 PEI Student Drug Survey: Highlights Report* Charlottetown: Department of Health and Social Services.

Waldon, I. (1991). Patterns and causes of gender differences in smoking. *Social Science & Medicine, 32,* 989-1005.

Table 10 Characteristics of NLSCY children by inclusion status

Characteristic	NLSCY sample			
	Overall (n=10045)	Exclude (n=3190)	Include (n=6855)	p-value
Male (%)	50.28	52.92	49.06	.0003
Non-intact family structure (%)	33.48	32.45	33.96	ns
Born to teen mother (%)	5.74	6.86	5.23	.001
Low-income status (%)	13.48	20.09	10.42	<.0001
Early smoking behaviour (%)	8.49	8.80	8.40	ns
Early marijuana use (%)	6.93	7.85	6.86	ns

[a]Comparison of characteristics by inclusion status.

Table 11 Smoking trajectory groups, proportion per group, overall and by gender

Smoking initiation trajectory groups	Overall (n=6609)	Male (n=3234)	Female (n=3375)	Z-test p-value
Non-smoker	35.96	38.24	32.85	<.001
Middle-onset	35.71	36.37	35.35	ns
Early-onset	23.52	19.56	27.96	<.001
Early smokers	4.81	5.83	3.83	<.001
Frequency of smoking trajectory groups	Overall (n=2214)	Male (n=1020)	Female (n=1194)	Z-test p-value
Ex-smoker/Experimenters	37.23	41.53	30.99	<.001
Moderate smokers	42.44	36.72	47.63	<.001
Heavy (daily) smokers	20.33	21.76	21.38	ns

Note. Trajectory groups are adjusted for age, being born to a teenaged mother, non-intact family status, and low-income family status.

Table 12 Marijuana use trajectory groups, proportion per group, overall and by gender

Marijuana use initiation trajectory groups	Overall (n=4468)	Male (n=2180)	Female (n=2288)	Z-test p-value
Non-users	43.82	30.68	46.41	<.001
Middle-onset	36.66	40.74	34.01	<.001
Early-onset	19.52	28.58	19.58	<.001
Frequency of marijuana use trajectory groups	Overall (n=1079)	Male (n=501)	Female (n=578)	Z-test p-value
Infrequent users	59.41	45.99	62.52	<.001
Desisters	13.06	0	16.87	n/a
Increasing users	27.53	47.98	20.61	<.001
Early increasing users	0	6.03	0	n/a

Note. Trajectory groups are adjusted for age, being born to a teenaged mother, non-intact family status, and low-income family status.

Table 13 Odds ratios (95% CIs) and predicted membership probabilities for different risk scenarios for initiation of smoking trajectories

Covariate/Risk scenario	Non-smoker	Middle-onset	Early-onset	Early smoker
Odds ratios (95% CIs) relative to non-smokers				
Male	...	0.84	0.61	1.54
		(0.69, 1.04)	(0.51, 0.73)	(1.00, 2.37)
Born to teen mother	...	1.27	1.68	1.18
		(0.78, 2.08)	(1.15, 2.46)	(0.56, 2.46)
Low-income family	...	1.40	1.47	2.00
		(0.97, 2.04)	(1.09, 1.98)	(1.26, 3.20)
Non-intact family	...	1.28	2.50[a]	4.03
		(1.01, 1.62)	(2.04, 3.06)	(2.78, 5.84)
Male	...	1.07	1.93	4.08
		(0.76, 1.50)	(1.40, 2.67)	(2.44, 6.81)
Female	...	1.57	3.04	4.61
		(1.12, 2.21)	(2.33, 3.95)	(2.59, 8.20)
Predicted membership probabilities (males)				
Population rate	38.24	36.37	19.56	5.83
No risk	42.26	38.07	16.38	3.29
Born to teen mother only	33.53	39.98	23.50	2.99
Low-income family only	35.17	41.87	18.05	4.92
Non-intact family only	33.03	31.72	24.76	10.49
All risks	19.51	32.78	34.99	12.73
Predicted membership probabilities (females)				
Population rate	32.85	35.35	27.96	3.83
No risk	39.47	36.28	21.94	2.30
Born to teen mother only	32.38	35.82	29.46	2.34
Low-income family only	27.81	42.23	25.87	4.08
Non-intact family only	22.73	32.81	38.36	6.10
All risks	10.72	30.76	49.54	8.94

[a]Interaction between gender and covariate significant in overall model, therefore separate odds ratios reported from gender-specific models.

Table 14 Odds ratios (95% CIs) and predicted membership probabilities for different risk scenarios for frequency of smoking trajectories

Covariate/Risk scenario	Ex-smoker/ Experimenter	Moderate smoker	Heavy smoker
Odds ratios (95% CIs) relative to ex-smokers/experimenters			
Male	...	0.84 (0.61, 1.16)	0.82 (0.61, 1.09)
Born to teen mother	...	1.09 (0.55, 2.16)	1.35 (0.78, 2.33)
Low-income family	...	0.87 (0.51, 1.47)	1.54 (1.03, 2.30)
Non-intact family	...	1.05 (0.74, 1.49)	2.67 (1.961, 3.64)
Predicted membership probabilities (males)			
Population rate	41.53	36.72	21.76
No risk	45.66	39.84	14.50
Born to teen mother only	35.95	40.95	23.09
Low-income family only	49.38	31.29	19.33
Non-intact family only	36.12	34.59	29.29
All risks	25.46	23.11	51.43
Predicted membership probabilities (females)			
Population rate	30.99	47.63	21.38
No risk	33.64	52.75	13.62
Born to teen mother only	36.23	51.43	12.34
Low-income family only	29.17	48.21	22.62
Non-intact family only	28.59	42.47	28.94
All risks	24.70	35.01	40.29

Table 15 Odds ratios (95% CIs) and predicted membership probabilities for different risk scenarios for initiation of marijuana use trajectories

Covariate/Risk scenario	Non-user	Middle-onset user	Early-onset user
Odds ratios (95% CIs) relative to non-users			
Male	...	1.19	0.99
		(0.97, 1.47)	(0.80, 1.21)
Born to teen mother	...	0.89	0.58
		(0.79, 1.38)	(0.36, 0.94)
Low-income family	...	0.73	0.87[a]
		(0.50, 1.07)	(0.63, 1.18)
Males	...	0.72	0.58
		(0.41, 1.29)	(0.37, 0.91)
Females	...	0.88	1.20
		(0.53, 1.47)	(0.79, 1.81)
Non-intact family	...	1.50	3.37
		(1.16, 1.93)	(2.67, 4.26)
Predicted membership probabilities (males)			
Population rate	30.68	40.74	28.58
No risk	32.60	43.23	24.17
Born to teen mother only	28.21	59.28	12.51
Low-income family only	41.88	40.13	17.99
Non-intact family only	23.84	32.56	43.60
All risks	31.26	48.92	19.82
Predicted membership probabilities (females)			
Population rate	46.41	34.01	19.58
No risk	52.04	35.68	12.28
Born to teen mother only	61.63	27.50	10.87
Low-income family only	52.99	32.04	14.96
Non-intact family only	33.98	33.05	32.97
All risks	41.22	23.01	35.78

[a]Interaction between gender and covariate significant in overall model, therefore separate odds ratios reported from gender-specific models

Table 16 Odds ratios (95% CIs) and predicted membership probabilities for different risk scenarios for frequency of marijuana use trajectories

Covariate/Risk scenario	Males			Females		
	Infrequent	Increasers	Early increasers	Infrequent	Desisters	Increasers
	Odds ratios (95% CIs) relative to infrequent users					
Born to teen mother	...	1.29	1.90	...	1.45	0.59
		(0.65, 2.55)	(0.91, 3.94)		(0.21, 9.91)	(0.08, 4.37)
Low-income family	...	1.32	0.51	...	0.90	1.06
		(0.74, 2.36)	(0.32, 0.81)		(0.27, 2.94)	(0.46, 2.48)
Non-intact family	...	1.21	2.49	...	1.81	2.48
		(0.77, 1.90)	(1.82, 3.42)		(0.78, 4.19)	(1.36, 4.49)
Predicted membership probabilities based on multinomial logit model coefficient estimates						
Population rate	45.99	47.98	6.03	62.52	16.87	20.61
No risk	49.39	46.24	4.38	70.32	14.53	15.15
Born to teen mother only	42.06	50.86	7.08	70.13	21.00	8.86
Low-income family only	43.82	54.19	1.98	70.72	13.11	16.18
Non-intact family only	42.56	48.04	9.40	52.42	19.62	27.97
All risks	31.84	61.33	6.82	54.99	26.76	18.26

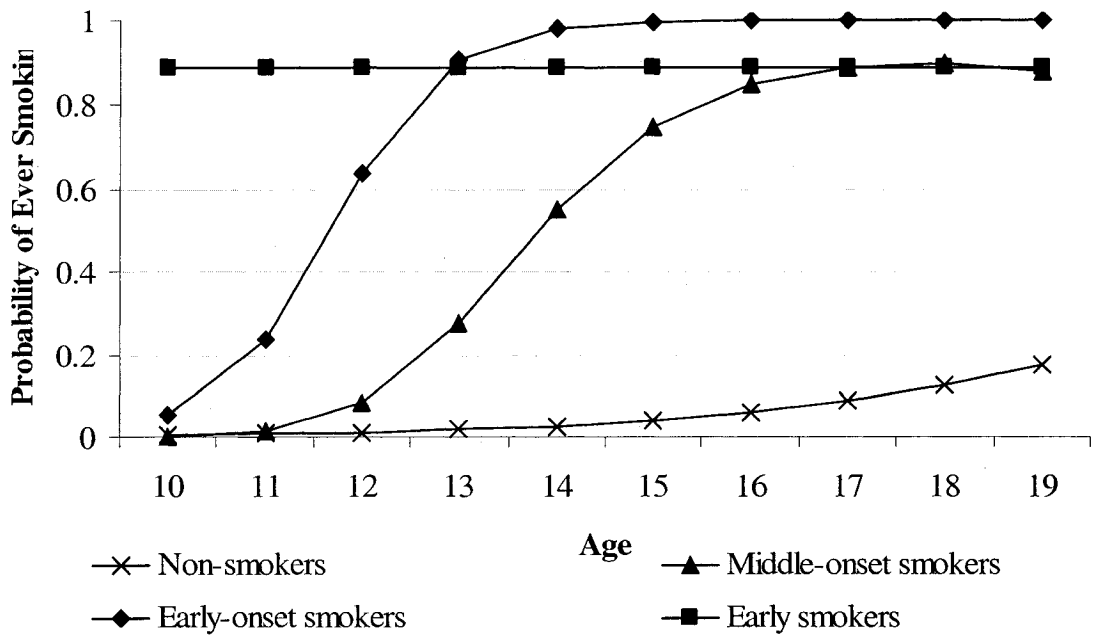

Figure 9 Smoking initiation trajectories, overall sample (n=6609)

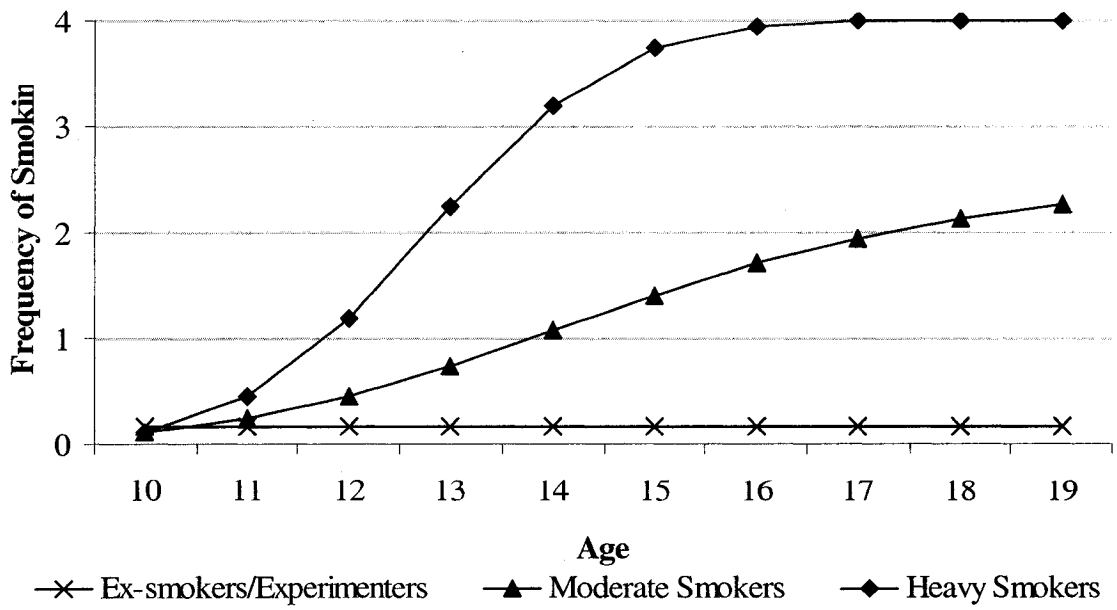

Figure 10 Frequency of smoking trajectories, overall sample (n=2214). Frequency scale: 0=No current smoking, 1=Smoke a few times a year, 2=Smoke monthly, 3=Smoke weekly, 4=Smoke daily

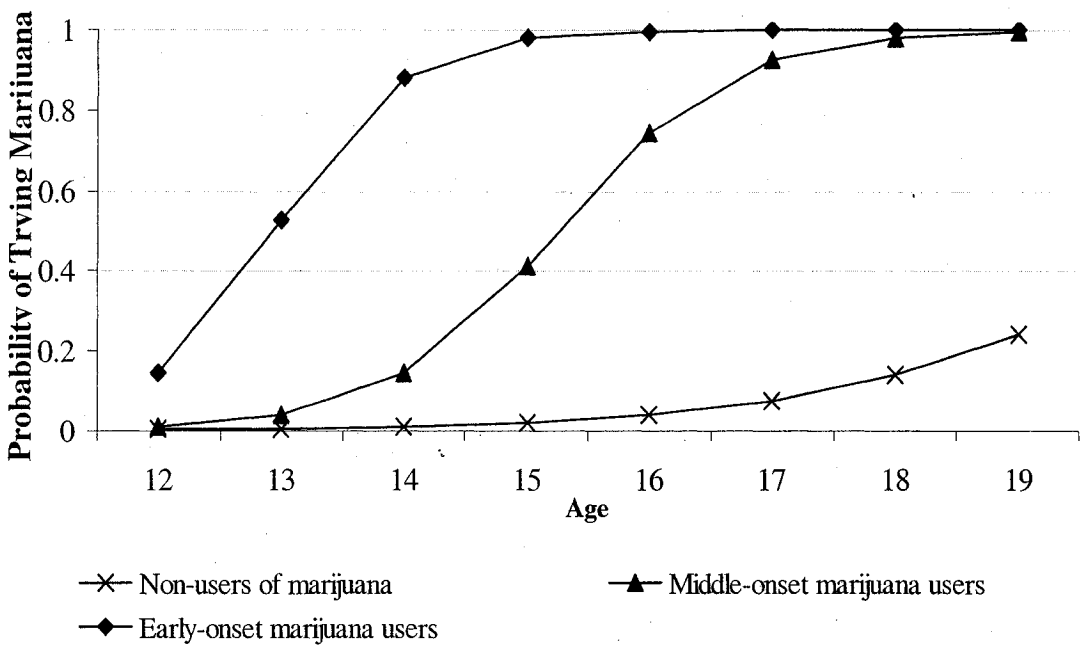

Figure 11 Marijuana use initiation trajectories, overall sample (n=4468)

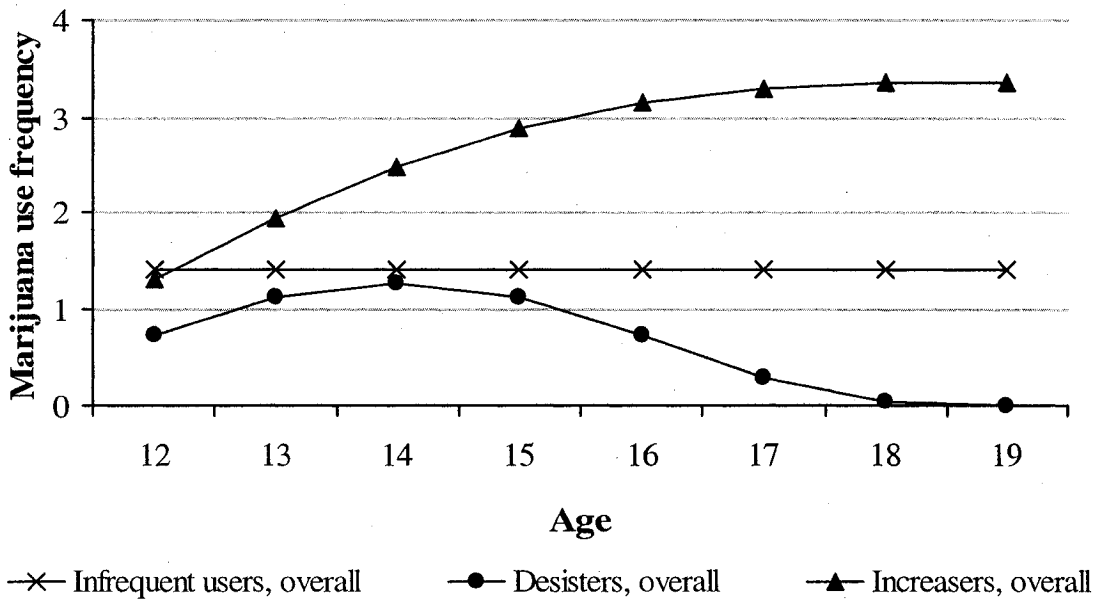

Figure 12 Trajectories of marijuana use frequency, overall sample (n=1079)
Frequency scale: 0=No current use, 1=Use a few times a year, 2=Monthly use, 3=Weekly use, 4=Daily use

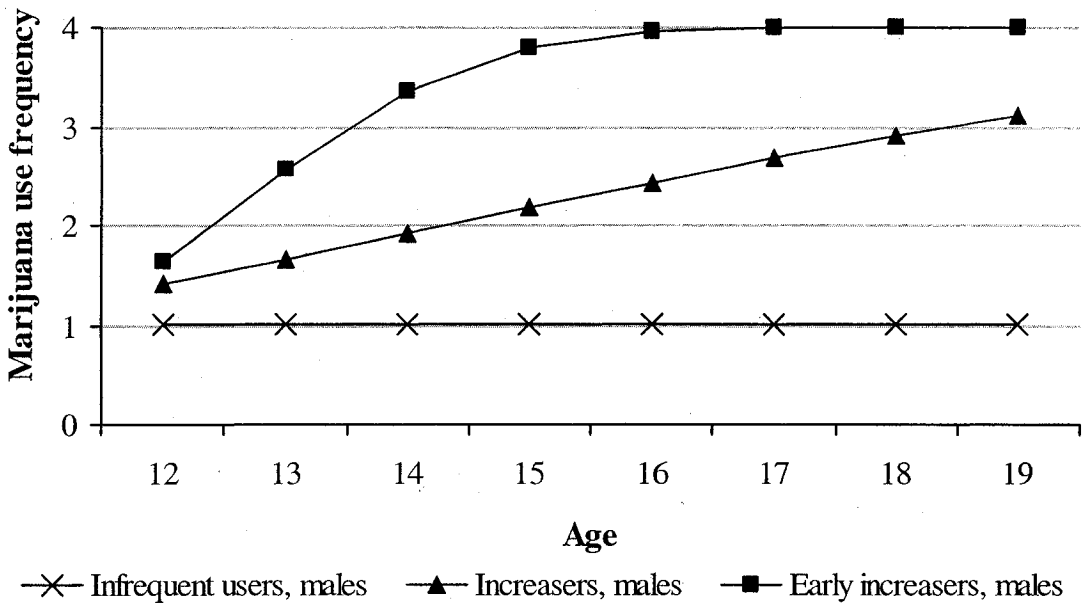

Figure 14 Trajectories of marijuana use frequency, males (n=501)

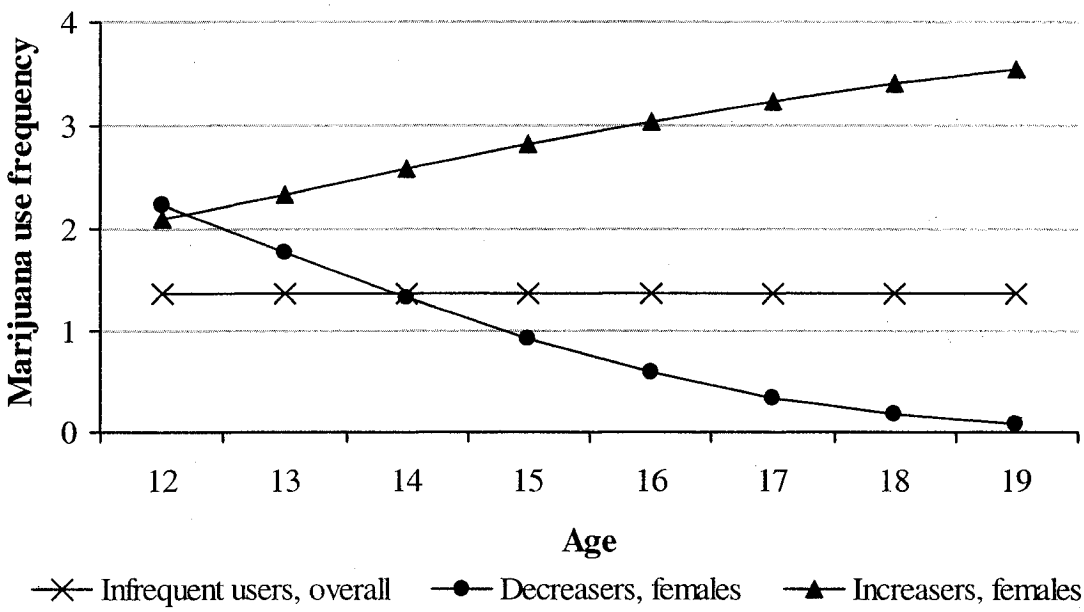

Figure 13 Trajectories of marijuana use frequency, females (n=578)

Project #2: Joint Trajectories of Childhood Behaviour Problems and Adolescent Substance Use Onset

Background

Many youth exhibit behaviours, both overt and covert, that defy social conventions. *Externalizing problems* are characterized by behaviours that are disruptive and harmful to others, such as fighting and bullying. Diagnoses of conduct disorder, attention-deficit hyperactivity disorder (ADHD) and antisocial behaviours fall into this category. Conversely, *internalizing problems* reflect emotions and moods that are most punitive to the individual, such as worry and anxiety, as well as efforts to control and suppress these negative emotions.

Considerable work has been done to describe patterns of behaviour problems from childhood through adolescence. Normative trajectories have been described for aggressive behaviours (Bongers, Koot, van der, & Verhulst, 2003; Bongers, Koot, van der, & Verhulst, 2004; Brame, Nagin, & Tremblay, 2001; Broidy et al., 2003; Côté, Zoccolillo, Tremblay, Nagin, & Vitaro, 2001; Côté, Vaillancourt, Farhat, LeBlanc, Nagin, & Tremblay, 2006; Côté, Vaillancourt, Barker, Nagin, & Tremblay, 2006; Lahey et al., 2000; Nagin & Tremblay, 1999; Stanger, Achenbach, & Verhulst, 1997), delinquency (Bongers et al., 2003), hyperactivity (Bongers et al., 2003; Nagin & Tremblay, 1999; Stanger et al., 1997), property and status violations (Bongers et al., 2004; Lahey et al., 2000), anxiety and depression (Beyers & Loeber, 2003; Bongers et al., 2003), withdrawal (Bongers et al., 2003), and patterns of externalizing and internalizing problems more generally (Bongers et al., 2003; Galambos, Barker, & Almeida, 2003; Gilliom & Shaw, 2004; Keiley, Bates, Dodge, & Pettit, 2000; Kowaleski-Jones &

Duncan, 1999). During childhood, externalizing behaviours are significantly more prevalent in boys than girls, and internalizing behaviours show little or no gender differences (McCulloch, Wiggins, Joshi, & Sachdev, 2000). As children move into late childhood and their early teens, externalizing behaviours such as aggression and antisocial behaviour become less prevalent among both genders, reaching near equivalence in late adolescence. Conversely, internalizing behaviours such as anxiety and depression increase significantly into adolescence for girls, whereas this increase is less dramatic for boys (Garber, Keiley, & Martin, 2002). Through adolescence, being female becomes the strongest risk factor for internalizing problems (Zahn-Waxler, Klimes-Dougan, & Slattery, 2000; Keiley, Lofthouse, Bates, Dodge, & Pettit, 2003).

Among theories of maladaptive behaviour, Jessor's *problem behaviour theory* is most commonly cited (Steinberg & Morris, 2001). This theory posits that problem behaviours, i.e. behaviours that are not socially desirable or normative, tend to co-occur within individuals, leading to a syndrome of problem behaviours (Costa, 2006; Jessor & Jessor, 1977; Jessor, Van den Bos, Vanderryn, Costa, & Turbin, 1995). Accordingly, children who exhibit non-normative, problematic behaviours are more likely to engage in undesirable behaviours when they are adolescents, such as early substance use initiation.

Empirical studies have shown that the presence of problem behaviours during childhood is linked with problems later in adolescence. Externalizing problems in childhood, such as physical aggression, have been associated with higher rates of delinquency (Broidy et al., 2003; Beyers & Loeber, 2003; Nagin & Tremblay, 1999; Dishion, 2000), violence (Nagin & Tremblay, 1999), and sexual promiscuity (Dishion,

2000) in adolescence. Internalizing problems, such as depressed mood, have also been associated with adolescent delinquency (Beyers & Loeber, 2003).

Specifically, substance use has been linked with problematic behaviour, particularly externalizing problems. Conduct disorder (Boyle, Offord, Racine, Szatmari, Fleming, & Links, 1992; Disney, Elkins, McGue, & Iacono, 1999; Flory, Milich, Lynam, Leukefeld, & Clayton, 2003; Ruchkin, Koposov, Vermeiren, & Schwab-Stone, 2003), ADHD (Burke, Loeber, & Lahey, 2001; Molina, Smith, & Pelham, 1999; Flory et al., 2003; Ruchkin et al., 2003), and antisocial behaviour (Adalbjarnardottir & Rafnsson, 2002; Fergusson, Horwood, & Lynskey, 1994) have all been found to be significantly and positively associated with lifetime and current use of substances in adolescence. Furthermore, those exhibiting more than one behaviour problem are significantly more likely to engage in substance use and abuse than those with one behaviour problem alone (Molina, Bukstein, & Lynch, 2002; Flory et al., 2003; Molina et al., 1999; Barkley, Fischer, Smallish, & Fletcher, 2004).

The association between externalizing problems and substance use persists beyond adolescence into adulthood. In a 14-year prospective follow-up survey, reports of property- and person-related offences in adolescence significantly predicted alcohol dependence and abuse in adulthood, even after controlling for other demographic and behavioural factors, including substance use during adolescence (Harford & Muthen, 2000). Another study found that the presence of conduct disorder during adolescence was significantly predictive of higher alcohol, marijuana and other hard drug use in early adulthood (Steele, Forehand, Armistead, & Brody, 1995). In contrast, others have failed

to find significant associations between measures of mental health and behaviour problems in adolescence and substance use in adulthood (Brook, Cohen, & Brook, 1998).

The literature shows a consistent relationship between the presence of externalizing problems and greater likelihood of substance involvement among youth. As per problem behaviour theory, externalizing behaviour problems during childhood can be viewed as an early point on a continuum, with substance initiation and ongoing use in adolescence representing a later point on that continuum (Jessor & Jessor, 1977; Steele, Forehand, Armistead, & Brody, 1995). Conversely, internalizing behaviours have not shown a consistent association with substance use. Some studies have found that adolescents with internalizing problems are at greater risk of drug initiation than adolescents without such symptoms (Patton, Hibbert, Rosier, Carlin, Caust, & Bowes, 1996; Riggs, Baker, Mikulich, Young, & Crowley, 1995; Whitmore, Mikulich, Thompson, Riggs, Aarons, & Crowley, 1997). Such findings would be consistent with the self-medication hypothesis, which suggests that youth engage in substance use to dull feelings of low self-worth or anxiety. Conversely, others have found that the presence of internalizing problems reduces the likelihood of engaging in substance use (Raine, Venables, & Williams, 1995; Steele, Forehand, Armistead, & Brody, 1995). These results support a risk-reducing hypothesis, which posits that youth who are anxious or shy are less likely to engage with deviant peers or enter into high risk situations, thereby reducing their involvement with substances. Still others have failed to show any association between substance use and internalizing problems (Helstrom, Bryan, Hutchison, Riggs, & Blechman, 2004; Dishion, 2000; Boyle et al., 1992).

There are also inconsistent findings in the literature regarding the effect of gender on the association between problem behaviours and substance use. Whereas consistent associations have been shown among boys, the relationship is less clear among girls (Broidy et al., 2003; McCulloch et al., 2000). For example, some studies have found no difference in effect (Adalbjarnardottir & Rafnsson, 2002; Disney et al., 1999; Flory et al., 2003; Windle, 1990), while others have found that the association exists only for males (Fothergill & Ensminger, 2006; Mason & Windle, 2002; Steele, Forehand, Armistead, & Brody, 1995). Still others have found that the effect is greater among females with problem behaviours than among males (Fergusson et al., 1994). The major difference may be the effect of externalizing versus internalizing problems. While the former may be more predictive of later substance use for males, the latter may be more predictive for females (Helstrom et al., 2004; Lillehoj, Trudeau, Spoth, & Wickrama, 2004). This may be due to the fact that studies of problem behaviour tend to focus on boys (Gilliom & Shaw, 2004), or fail to include sufficient numbers of girls to draw important gender comparisons.

Methodological differences also reduce the comparability of studies and contribute to our uncertainty. A number of studies examine the cross-sectional or concurrent presence of behaviour problems and substance use (Brook et al., 1998; Disney et al., 1999; Kandel et al., 1997; Pedersen, Mastekaasa, & Wichstrom, 2001), while others reply on retrospective reports of behaviour problems, which may be subject to recall bias (Disney et al., 1999; Flory et al., 2003; Ohannessian, Stabenau, & Hesselbrock, 1995).

The purpose of this study is to examine the relationship between levels of externalizing and internalizing behaviours in childhood and substance use initiation in adolescence. This purpose is achieved by defining trajectories of externalizing and internalizing behaviours among children ages 6-12 and trajectories of smoking and marijuana initiation among youth ages 10-19 and examining the overlap between these trajectories. In doing so, three questions are addressed: (1) Does the probability of membership in a particularly substance initiation trajectory vary by level of childhood behaviour problems (e.g. low versus high)?; (2) Does the probability of membership vary by type of behaviour (externalizing versus internalizing)?; and (3) Does the probability of membership vary by gender?

Methods

Data Source

The National Longitudinal Survey of Youth (NLSY79) is a nationally representative sample of 12,686 U.S. men and women who were between the ages of 14 and 21 on December 31, 1978. First conducted in 1979, respondents were interviewed annually until 1994, and have been interviewed biennially since.

Starting in 1986, the children of NLSY79 female respondents have been interviewed every two years. These children form the sample for the National Longitudinal Survey of Youth – Children and Young Adult (NLSY79-C) component. Starting in 1988, children who were aged 10 and up completed self-administered questionnaires that elicit information regarding schooling, family and peer relationships,

and attitudes and behaviours. Further information regarding the NLSY79-C sample and survey are given elsewhere (Center for Human Resource Research, 2002).

Certain changes have taken place over time in the way that the NLSY79-C has been conducted. In the first cycle of the NLSY79-C, all children born to NLSY79 mothers were eligible for interview. In 1988, children whose usual residence was outside of their mother's home were not eligible for interview. However, beginning at age 15, all children born to NLSY79 mothers are eligible, regardless of their usual place of residence. Following the 1990 NLSY79 interview, the supplemental sample of economically disadvantaged Caucasian youth was dropped from the sample. For the 2000 interview, a random sample of approximately 38 percent of the African American and Hispanic over-samples was excluded from interview. The eligibility of these individuals was reinstated in 2002.

Participants

To be included in this study, respondents must have been assessed on at least two occasions with the Behaviour Problem Index (BPI) between the ages of 6 and 12 and also have completed the self-administered questionnaire items pertaining to cigarette or marijuana use initiation between the ages of 10 and 19. As such, respondents must have been born prior to 1991. Of all interviewed children born to NLSY79 mothers, 8752 were born prior to 1991.

Compared to those excluded from analysis, included children were older (i.e. born in earlier years) and to younger mothers, were more likely to be African American and to have been born to single mothers (data not shown). There was no difference in child

gender or the family's poverty status (as measured in 1985) by inclusion status. Due to the change in NLSY79-C sampling, none of the included children were born to mothers in the supplemental economically disadvantaged Caucasian sample.

Measures

Measures used in this study are based on maternal reports of behaviour and the child/youth's own reports of substance use.

Externalizing and Internalizing Behaviour. The BPI was developed by Nicholas Zill and James Peterson to measure the types and range of behaviour problems exhibited by children aged 4 and over (Peterson & Zill, 1986). The BPI consists of 28 questions which are asked of the mother in the NLSY79-C. Mothers are asked to report on specific behaviours exhibited by their child in the past three months, indicating whether the behaviour is not true (0), sometimes true (1) or often true (2) for their child. Responses can be summarized by two subscales to describe the degree to which children externalize or internalize their behaviours. The externalizing subscale consists of 20 items and measures aggressive behaviour problems such as bullying and cheating. The internalizing subscale consists of 10 items and measures the extent to which the child feels anxious, unhappy or depressed. Three items are included in both the externalizing and the internalizing subscales.

The trichotomous responses to items for each subscale are summed to create a summary score. For individuals missing responses on two or fewer items for the externalizing behaviours, or on one item for the internalizing behaviours, the mean of other reported items was imputed for the missing items on the scale. Individuals with

three or more items missing for the externalizing behaviour questions, or with two or more items missing for the internalizing behaviour questions, were excluded from analyses. Values for the externalizing subscale range from 0 to 40, and on the internalizing subscale range from 0 to 20, with higher scores reflecting higher levels of problem behaviour.

Smoking and Marijuana Initiation. Children aged 10 and up self-report their lifetime use of cigarettes and marijuana. Smoking initiation is based on the response to the question "Have you ever smoked a cigarette?", and marijuana initiation is based on the response to the question "Have you ever used marijuana?".

Analysis

This study uses a growth mixture model approach to developing trajectories of behaviour problems and substance use initiation among NLSY79-C respondents. Described elsewhere (Jones et al., 2001; Nagin, 1999; Nagin & Tremblay, 2001; Nagin, 2005), this method conceptualizes a population as being comprised of distinct groups of individuals who share patterns of behaviour. The number of groups and the shape of their trajectories are tested empirically rather than being assumed a priori. The modeling approach is implemented using a SAS macro known as Proc Traj, developed and described by Jones et al. (2001).

As described by Nagin (2005, p. 66), trajectory development follows a two-stage model selection process. The first stage involves the selection of the number of groups to be included in the optimal trajectory model. Based on a finite mixture modelling framework, a series of models with increasing number of groups were fit. Selection of an

optimal trajectory model was based on two criteria: the Bayesian information criterion (BIC) and the Bayes factor. The BIC is calculated as $BIC = \log(L) - 0.5k\log(N)$, where L is the model's maximum log likelihood, k is the number of parameters in the model, and N is the sample size. As suggested by others, a model with the largest BIC score is selected (Raftery, 1995). The Bayes factor is a means of determining the substantive importance in BIC scores between models. Calculated as $e^{BIC_i - BIC_j}$, where i and j refer to the number of groups present in the two models, the addition of one group was considered strong if the Bayes factor was 10 or greater (Nagin, 2005). A maximum of six groups were considered. This technique selects a model with a higher number of trajectory groups only when the additional group adds sufficient descriptive value. In this stage, the only independent variable considered is age.

Once the number of groups is selected, the second stage involves determining the shape of the trajectories: flat (constant), linear with age, or a higher order polynomial curve. An asset of this technique is that each trajectory group may have its own shape. The selection of final model shape is based on model fit improvement as measured by the BIC, other fit indicators, and interpretive meaningfulness of groups. When the change in BIC is small, the more parsimonious model is chosen.

Developmental trajectories of behaviour problems were modeled based on mothers' response to the BPI for children aged 6 through 12. Censored normal models were used to fit the bounded nature of the externalizing and internalizing behaviour subscales. Trajectories of smoking and marijuana initiation were modeled based on children and youth's responses to the self-administered questionnaire for respondents

aged 10 through 19. Logistic trajectory models were used to fit models to substance use initiation.

A further feature of the Proc Traj program is the ability to model developmental trajectories of two distinct but related outcomes. First described in Nagin and Tremlay (2001), such dual models may be used to analyze the connection between outcomes that occur contemporaneously or at separate points in the lifecourse. In the present analysis, dual models were developed to examine the relationship between externalizing and internalizing behaviours during childhood and smoking and marijuana initiation during adolescence. Four dual models were developed for each gender: externalizing behaviour with smoking initiation, internalizing behaviour with smoking initiation, externalizing behaviour with marijuana initiation, and internalizing behaviour with marijuana initiation.

The key outputs of the dual trajectory models are the probabilities linking membership in the two behaviours. Joint probabilities reflect the probability of belonging to a specific combination of the two modeled behaviour groups. Conditional probabilities reflect the likelihood of belonging to a particular substance use initiation trajectory given an individual's membership in a particular behaviour problem trajectory. Conditional probabilities were compared in three ways. First, within each gender, conditional probabilities of substance initiation were compared across different levels of behaviour problems to determine if there was any indication of heterotypic continuity. Second, within each gender and substance use category, comparisons were made to determine if there was a difference in conditional probabilities between externalizing and

internalizing behaviour trajectories. Third, within each behaviour type, conditional probabilities of substance use initiation were compared between males and females to determine if there was a significant gender difference. Dual model conditional probabilities were compared using a standard Z-test.

In order to model behaviour change, at least two response points are needed, though these need not be contiguous time points. Therefore, only those individuals who provide responses in at least two survey periods are included in these models. Models were fit separately by gender. As per the NLSY79-C users guide, since this analysis used responses across multiple waves of the survey, the analyses are unweighted (Center for Human Resource Research, 2002; p. 26). All analyses were conducted using the statistical software SAS version 9.1.

Results

Externalizing and Internalizing Problems in Childhood

Mean externalizing and internalizing scores for males and females ages 6 through 12 are shown in Table 17. Externalizing scores are consistently and significantly higher among males than females (all $p < .0001$), whereas mean internalizing scores were similar for males and females at every age (all $p \geq .05$). Cronbach's alpha for externalizing scores is 0.93 for males and 0.90 for females. Cronbach's alpha for internalizing scores is slightly lower, at 0.90 for males and 0.88 for females.

In fitting trajectories to mothers' reports of their child's behaviour problems, although the BIC for the models indicated that four or five trajectory groups provided the best fit to the data, the additional groups were either too small (less than 5% per group) to be analyzed separately, or were interpretively similar to other groups in the model. As such, we opted for more parsimonious models. As shown in top panel of Figure 15, three groups represent the trajectories of externalizing behaviour: externalizing-low (48.68% males, 53.56% females), externalizing-mid (40.39% males, 36.34% females), and externalizing-high (10.93% males, 10.10% females). Females were statistically significantly more likely to follow an externalizing-low trajectory ($p = .0008$), while males were statistically significantly more likely to follow an externalizing-mid trajectory ($p = .004$). Males and females are equally likely to follow an externalizing-high trajectory.

As shown in the bottom panel of Figure 15, three groups also represent trajectories of internalizing behaviour: internalizing-low (39.64% males, 36.42% females), internalizing-mid (50.01% males, 51.53% females), and internalizing-high (10.34% males, 12.04% females). Males were statistically significantly more likely to follow an internalizing-low trajectory ($p = .02$), while males and females were similarly likely to follow the mid or high internalizing trajectories.

Mean scores for those in the externalizing-high and internalizing-high trajectories were above the 90th percentile for this sample. The 90th percentile has been used by others as a marker of clinically significant behaviour problems (Lumeng, Gannon, Cabral, Frank, & Zuckerman, 2003).

Smoking and Marijuana Initiation

The proportions of males and females who report ever using tobacco or marijuana from ages 10 through 19 are given in Table 18. In general, males and females report similar rates of lifetime use of either tobacco or marijuana at every age.

Trajectory models were built separately for males and females for each of smoking and marijuana initiation. Three groups optimally described the trajectories of smoking initiation for both males and females (Figure 16, top panel): smoking abstainers (47.36% males, 51.42% females), middle initiators (27.63% males, 32.63% females), and early initiators (25.01% males, 15.95% females). Females were statistically significantly more likely to be smoking abstainers ($p = .005$) or be middle initiators ($p = .0002$), while males were statistically significantly more likely to follow the early initiator trajectory ($p < .0001$).

Three groups also optimally described the trajectories of marijuana initiation among both males and females (Figure 16, bottom panel): marijuana abstainers (41.17% males, 48.73% females), late initiators (46.78% males, 36.03% females), and middle initiators (12.05% males, 15.24% females). Female middle initiators show a much sharper increase in the probability of initiation than males, and reach a probability of 1.0 earlier than do males. Males were statistically significantly more likely to follow the late initiator trajectory ($p < .0001$), while females were statistically significantly more likely to follow either the marijuana abstainer ($p < .0001$) or middle initiator trajectories ($p = .004$).

Behaviour Problems in Childhood and Substance Initiation in Adolescence

Table 19 gives the joint and conditional probabilities of smoking initiation based on externalizing behaviour (top panel) and internalizing behaviour (bottom panel). The most common joint trajectory of externalizing behaviour and smoking is the externalizing-low/smoking abstainer group (27.21% of males, 31.10% of females). This is expected, given that the externalizing-low and smoking abstainer trajectories were the most common groups for the respective behaviours. An additional one in six respondents was accounted for by the externalizing-low/smoking middle initiator and externalizing-mid/smoking abstainer joint trajectories.

Conditional probabilities of smoking initiation are also given in Table 19. For example, for those in the externalizing-low trajectory during childhood, 55.69% of males and 58.58% of females followed the smoking abstainer trajectory: very few (9.71% of males and 8.27% of females) low externalizers followed the early smoking initiator trajectory. Comparisons across levels of externalizing behaviour reveal that, as the trajectory levels increase from low to middle to high, the probability of following the smoking abstainer trajectory drops significantly for both males and females. Conversely, the probability of following the early smoking initiator trajectory increases significantly with higher levels of externalizing behaviour for both genders. The probability of following the smoking middle initiator trajectory does not change with different levels of externalizing behaviour among males, while the probabilities only differ for females between externalizing-mid and externalizing-high members.

With regards to internalizing behaviour (Table 19 bottom panel), similar proportions of males fall into the internalizing-low/smoking abstainer (21.92%) and internalizing-mid/smoking abstainer (21.75%) joint trajectories. Among females, the largest joint group is the internalizing-mid/smoking abstainer (25.26%), followed by similar proportions falling into the internalizing-low/smoking abstainer (19.67%) and internalizing-mid/smoking middle initiator (19.94%) joint trajectories. Conditional probabilities reveal that nearly a third of males (32.10%) and a fifth of females (20.38%) in the internalizing-high trajectory are expected to following the early trajectory of smoking initiation. As the trajectories of internalizing behaviour increase from low to mid, the probability of abstaining from smoking decreases significantly for males, while the decrease in probability for females does not reach significance ($p = .06$). Concomitantly, there is a significant increase in the probability of following the early initiator trajectory for both males and females. As the trajectories of internalizing behaviour increase from mid to high, the probability of following the early initiator trajectory increases significantly for both males and females.

Table 20 gives the joint and conditional probabilities of marijuana initiation based on externalizing behaviour (top panel) and internalizing behaviour (bottom panel). The most common joint trajectory of externalizing behaviour and marijuana initiation is the externalizing-low/marijuana abstainer group (22.76% of males, 28.89% of females). Examining the conditional probabilities, 47.51% of males and 54.09% of females in the externalizing-low trajectory are expected to following the marijuana abstainer trajectory.

The probability of following the abstainer trajectory among externalizing-high children is significantly lower (27.76% males, 36.49% females; $p < .0001$).

All conditional probabilities change significantly as the level of externalizing behaviour increases. The exception is that females in the externalizing-low and externalizing-mid trajectories exhibit similar probabilities of following the marijuana late initiator trajectory ($p = .92$). In general, the probability of following the abstainer trajectory decreases as the level of externalizing behaviour increases. The probability of following the late initiator trajectory for marijuana initiation is highest in the externalizing-mid group and lower for those in the externalizing-low and externalizing-high trajectories. Among males, the probability of following the middle initiator trajectory of marijuana use increases with higher levels of externalizing behaviour, while the probability is highest for females among those in the externalizing-mid group.

The most common joint trajectories of internalizing behaviour and marijuana initiation among males is the internalizing-mid/marijuana late initiator group (22.44%), followed by similar proportions following the internalizing-low/marijuana abstainer (18.10%) and internalizing-mid/marijuana abstainer (18.28%) groups ($p = .94$). Among females, the most common joint trajectory was the internalizing-mid/marijuana abstainer (24.76%), followed by similar proportions in the internalizing-low/marijuana abstainer (19.12%) and internalizing-mid/marijuana late initiator groups (18.29%, $p = .52$). The conditional probabilities are nearly all significantly different for males between the levels of internalizing behaviour, while few conditional probabilities differ by level of internalizing behaviour among females.

Do conditional probabilities differ by type of behaviour (external vs. internal)?

The probabilities of smoking initiation conditional on externalizing behaviour compared with those conditional on internalizing behaviour trajectories showed no difference among males, and only a few statistically significant differences among females (Table 21). For example, the probability of early smoking initiation was significantly higher when conditional on externalizing rather than internalizing behaviour, whether the levels of behaviour were mid (19.17 vs. 11.79, $p < .0001$) or high (35.64 vs. 20.38, $p = .0001$).

Comparing the probabilities of marijuana initiation, there were few differences by behaviour type (Table 21). Exceptions occurred among males only, where the probability of abstaining from marijuana use was higher among internalizing-high than externalizing-high male trajectory members, and the probability of initiating marijuana use in middle adolescence was greater among externalizing-high members than among internalizing-high members.

Do the conditional probabilities of substance use initiation pattern differ by gender?

As shown in Table 22, the probabilities of following a particular smoking initiation trajectory conditional on level of externalizing behaviour did not differ significantly by gender, except that male externalizing-mid children had a significantly higher probability of following the early smoking initiation trajectory as compared to female externalizing-mid children (24.34 vs. 19.17, $p = .008$). Conversely, nearly all conditional probabilities of smoking initiation based on internalizing behaviour problems

showed significant gender differences. In general, where differences were significant, females in a given internalizing behaviour trajectory had higher probabilities of abstaining or initiating smoking in mid-adolescence while males had higher probabilities of early smoking initiation.

The conditional probabilities of marijuana initiation, whether based on externalizing or internalizing behaviour trajectories, showed many significant gender differences. In general, where differences were significant, females in a given behaviour trajectory were significantly more likely to be abstainers, whereas males were significantly more likely to be mid-initiators. For those in the middle behaviour trajectories, males were more likely to be late initiators.

Discussion

Several findings are drawn from this study. First, although males are reported to exhibit higher mean levels of externalizing behaviour during childhood than females, individuals maintain relatively stable levels of behaviour from age 6 through 12. Reports of internalizing behaviour are similarly stable over this period. This is consistent with other studies based on the NLSY79-C children (Kowaleski-Jones & Duncan, 1999).

Most studies examining the patterns of behaviour problems across childhood and adolescence present normative trajectories that describe the average pattern of change. However, behaviour theories all hypothesize that there are different clusters of children, some of whom exhibit few problems, while another smaller group exhibits a large

number of problematic behaviours. The use of multiple trajectories, as exemplified in this study, tests for the presence of such clusters of children and examines the developmental trajectories of such groups.

Few studies have used multiple trajectory methods to describe patterns of childhood behaviour problems. Bongers and colleagues (2004) describe both the normative and multiple trajectories of four externalizing behaviours from age 4 through 18. In their study, males and females were found to share similar patterns of behaviour but that they were differentially represented in the trajectories: males were over-represented in the high-problem trajectories, whereas females were over-represented in the low-level, non-problematic trajectories (Bongers et al., 2004).

The present study found that, while females were over-represented in the low-externalizing trajectory, males and females were similarly represented in the high-externalizing group. This may be because the externalizing-high trajectory for females represented slightly lower scores than that for males. If males and females were modeled together, the proportion of females in the externalizing-high trajectory may be significantly lower than that of males. There is disagreement among researchers using the Proc Traj methodology regarding whether it is appropriate to model groups (e.g. males and females) separately. Arguments in favour of maintaining a single model posit that separate models create artificial between-group differences and do not allow for meaningful comparison across groups. However, analyses that model males and females together allow only for a comparison of proportions within a trajectory and do not permit the identification of group-specific patterns of behaviour. Furthermore, modelling males

and females, particularly with respect to behaviour problems, acknowledges that the interpretation of behaviour is often gender-specific. That is to say, the behaviour of boys is often compared to that of other boys their age, and similarly for girls. For this reason, it was deemed appropriate to maintain separate models for males and females in this study.

The high proportion of externalizing-high females may also reflect the non-representativeness of the NLSY79-C sample, who have been found to have BPI scores above national norms (Center for Human Resource Research, 2002). Evaluations of the NLSY79-C have suggested that earlier cycles of the survey over-represent children born to younger and less-educated mothers (Mott, 1998), but that more recent surveys show greater heterogeneity (Center for Human Resource Research, 2002) and are becoming more like the general population. Due to the age and data requirements of this study, i.e. participants must have information both during childhood and adolescence, the participants in this study are those who were interviewed at earlier cycles of the NLSY79-C.

Three trajectories of initiation behaviour were described for cigarette smoking and marijuana use from age 10 through 19. The smoking abstainer trajectory showed a slight increase in the probability of initiation in late adolescence, indicating that a small contingent of youth initiate at later ages. If followed for longer, a separate trajectory of late initiators may emerge from these data.

The results of this study provide some evidence in favour of Jessor's problem behaviour theory (Jessor & Jessor, 1977). Children who exhibit high levels of behaviour

problems are more likely to engage in non-normative substance using behaviours, such as early initiation, than children exhibiting low or normative levels of these behaviours. This relationship is seen for both externalizing and internalizing problems, smoking initiation as well as marijuana initiation.

The probability of initiating smoking or marijuana use differed significantly by gender. In most cases, the probability of early initiation (i.e. following either the early smoking initiation or the middle marijuana initiation trajectories) was greater for males than females, regardless of whether the pattern of behaviour problems in childhood was externalized or internalized, low or high. These differences are not driven entirely by the higher prevalence of early drug use among males, as females were more likely than males to initiate marijuana use in middle adolescence.

That this analysis failed to find many significant differences in the probability of substance initiation by behaviour type was unexpected. The lack of difference in impact of behaviour type may be accounted for by the high comorbidity between levels of externalizing and internalizing behaviour in this sample. For example, all externalizing-low males and females were also classified as internalizing-low, nearly 98% of males and 97% of females in the externalizing-mid trajectory were also internalizing-mid members, and 76% of males and 91% of females in the externalizing-high trajectory also followed the internalizing-high path.

The presence of behaviour problems in this study was assessed using maternal reports. There is some evidence in the literature that different informants report behaviour problems differently, resulting in low correlations between reports

(Achenbach, McConaughy, & Howell, 1987; Curtis, Dooley, & Phipps, 2002; Rowe & Kandel, 1997; Seiffge-Krenke & Kollmar, 1998). Furthermore, correlation is found to be lowest in reporting internalized rather than externalized problems (Achenbach et al., 1987; Rowe & Kandel, 1997). Such comparisons, however, are often made against the child's own reports, which may be an inappropriate gold standard against which to validate the reports of others, particularly at younger ages. For instance, Rowe and Kandel (1997) found that parental ratings of child problem behaviours were more informative than those of children themselves in predicting clinical disorders. Therefore, it was preferable in the present study to use mothers' reports of behaviour problems, even in the absence of self-reported behaviour problems during childhood. However, it should be noted that maternal reports of internalizing problems may not fully reflect the levels of these problems, particularly as the children enter into early adolescence (e.g. ages 10 through 12).

The present study examined general patterns of behaviours, categorized by their outward (i.e. externalizing) or inward (i.e. internalizing) expression. It may be, however, that the relationship between childhood behaviour and adolescent substance use is more behaviour-specific. For instance, there is evidence that the association between ADHD and substance use is entirely mediated through conduct disorders (Boyle et al., 1992; Disney et al., 1999; Flory et al., 2003; Flory & Lynam, 2003; Burke et al., 2001; Molina et al., 1999). The results of the present study may underestimate the association between childhood behaviour problems and adolescence substance initiation by the grouping of behaviours that yield opposite effects. A next step would be to re-examine mothers'

reports of their child's behaviour problems as they describe more specific types of behaviour, e.g. antisocial behaviour, hyperactivity, social withdrawal.

Despite certain limitations, this study addresses gaps existing in the literature. First, by utilizing prospective, longitudinal data, this study is able to eliminate problems of reverse causation and correlation in behaviour. Second, because the data are drawn from nine cycles, the trajectories are likely to represent more accurate patterns of behaviour as opposed to temporal blips found in studies utilizing only two time points. Third, both externalizing and internalizing behaviour have been examined in relation to substance use. This is a significant contribution to the literature both because few studies consider the relationship between internalizing behaviour and substance use, and because few studies examine both behaviour types in the same sample of children. Fourth, both males and females were examined in sufficient number to address gender differences (or similarities) that have been lacking from other studies.

References

Achenbach, T. M., McConaughy, S. H., & Howell, C. T. (1987). Child/adolescent behavioral and emotional problems: implications of cross-informant correlations for situational specificity. *Psychol.Bull., 101,* 213-232.

Adalbjarnardottir, S. & Rafnsson, F. D. (2002). Adolescent antisocial behavior and substance use: Longitudinal analyses. *Addict.Behav., 27,* 227-240.

Barkley, R. A., Fischer, M., Smallish, L., & Fletcher, K. (2004). Young adult follow-up of hyperactive children: Antisocial activities and drug use. *J.Child Psychol.Psychiatry, 45,* 195-211.

Beyers, J. M. & Loeber, R. (2003). Untangling developmental relations between depressed mood and delinquency in male adolescents. *J.Abnorm.Child Psychol., 31,* 247-266.

Bongers, I. L., Koot, H. M., van der, E. J., & Verhulst, F. C. (2003). The normative development of child and adolescent problem behavior. *J.Abnorm.Psychol., 112,* 179-192.

Bongers, I. L., Koot, H. M., van der, E. J., & Verhulst, F. C. (2004). Developmental trajectories of externalizing behaviors in childhood and adolescence. *Child Dev., 75,* 1523-1537.

Boyle, M. H., Offord, D. R., Racine, Y. A., Szatmari, P., Fleming, J. E., & Links, P. S. (1992). Predicting substance use in late adolescence: Results from the Ontario Child Health Study follow-up. *Am.J.Psychiatry, 149,* 761-767.

Brame, B., Nagin, D. S., & Tremblay, R. E. (2001). Developmental trajectories of physical aggression from school entry to late adolescence. *J.Child Psychol.Psychiatry, 42,* 503-512.

Broidy, L. M., Nagin, D. S., Tremblay, R. E., Bates, J. E., Brame, B., Dodge, K. A. et al. (2003). Developmental trajectories of childhood disruptive behaviors and adolescent delinquency: A six-site, cross-national study. *Dev.Psychol., 39,* 222-245.

Brook, J. S., Cohen, P., & Brook, D. W. (1998). Longitudinal study of co-occurring psychiatric disorders and substance use. *J.Am.Acad.Child Adolesc.Psychiatry, 37,* 322-330.

Burke, J. D., Loeber, R., & Lahey, B. B. (2001). Which aspects of ADHD are associated with tobacco use in early adolescence? *J.Child Psychol.Psychiatry, 42,* 493-502.

Center for Human Resource Research (2002). *NLSY79 Child & Young Adult Data Users Guide: A Guide to the 1986-2000 Child Data, 1994-2000 Young Adult Data* Columbus, Ohio: Ohio State University.

Costa, F. M. (2006). Problem-behavior theory: A brief overview. http://www.colorado.edu/ibs/jessor/pb_theory.html [On-line].

Côté, S., Vaillancourt, T., Barker, T., Nagin, D., & Tremblay, R. E. The joint development of physical and indirect aggression: Predictors of continuity and change during childhood. *Development and Psychopathology,* (in press).

Côté, S., Vaillancourt, T., Farhat, A., LeBlanc, J. C., Nagin, D., & Tremblay, R. E. (2006). The development of physical aggression from toddlerhood to pre-adolescence: A nation wide longitudinal study of Canadian children. *J.Abnorm.Child Psychol., 34,* 74-85.

Côté, S., Zoccolillo, M., Tremblay, R. E., Nagin, D., & Vitaro, F. (2001). Predicting girls' conduct disorder in adolescence from childhood trajectories of disruptive behaviors. *J.Am.Acad.Child Adolesc.Psychiatry, 40,* 678-684.

Curtis, L., Dooley, M., & Phipps, S. (2002). Does parent of child know best? An assessment of parent/child agreement in the Canadian National Longitudinal Survey of Children and Youth. [181]. Ottawa, Statistics Canada. Analytical Studies Branch Research Paper Series.

Dishion, T. J. (2000). Cross-setting consistency in early adolescent psychopathology: deviant friendships and problem behavior sequelae. *J.Pers., 68,* 1109-1126.

Disney, E. R., Elkins, I. J., McGue, M., & Iacono, W. G. (1999). Effects of ADHD, conduct disorder, and gender on substance use and abuse in adolescence. *Am.J.Psychiatry, 156,* 1515-1521.

Fergusson, D. M., Horwood, L. J., & Lynskey, M. T. (1994). The comorbidities of adolescent problem behaviors: A latent class model. *J.Abnorm.Child Psychol., 22,* 339-354.

Flory, K. & Lynam, D. R. (2003). The relation between attention deficit hyperactivity disorder and substance abuse: What role does conduct disorder play? *Clin.Child Fam.Psych.Rev., 6,* 1-16.

Flory, K., Milich, R., Lynam, D. R., Leukefeld, C., & Clayton, R. (2003). Relation between childhood disruptive behavior disorders and substance use and dependence symptoms in young adulthood: individuals with symptoms of attention-deficit/hyperactivity disorder and conduct disorder are uniquely at risk. *Psychol.Addict.Behav., 17,* 151-158.

Fothergill, K. E. & Ensminger, M. E. (2006). Childhood and adolescent antecedents of drug and alcohol problems: A longitudinal study. *Drug and Alcohol Dependence, 82,* 61-76.

Galambos, N. L., Barker, E. T., & Almeida, D. M. (2003). Parents do matter: trajectories of change in externalizing and internalizing problems in early adolescence. *Child Dev., 74,* 578-594.

Garber, J., Keiley, M. K., & Martin, N. C. (2002). Developmental trajectories of adolescents' depressive symptoms: Predictors of change. *Journal of Consulting and Clinical Psychology, 70,* 79-95.

Gilliom, M. & Shaw, D. S. (2004). Codevelopment of externalizing and internalizing problems in early childhood. *Dev.Psychopathol., 16,* 313-333.

Harford, T. C. & Muthen, B. O. (2000). Adolescent and young adult antisocial behavior and adult alcohol use disorders: A fourteen-year prospective follow-up in a national survey. *J.Stud.Alcohol, 61,* 524-528.

Helstrom, A., Bryan, A., Hutchison, K. E., Riggs, P. D., & Blechman, E. A. (2004). Tobacco and alcohol use as an explanation for the association between externalizing behavior and illicit drug use among delinquent adolescents. *Prev.Sci., 5,* 267-277.

Jessor, R. & Jessor, S. C. (1977). *Problem behavior and psychological development: A longitudinal study of youth.* New York: Academic Press.

Jessor, R., Van den Bos, J., Vanderryn, J., Costa, F. M., & Turbin, M. S. (1995). Protective factors in adolescent problem behavior: Moderator effects and developmental change. *Dev.Psychol., 31,* 923-933.

Jones, B. L., Nagin, D. S., & Roeder, K. (2001). A SAS procedure based on mixture models for estimating developmental trajectories. *Sociological Methods & Research, 29,* 374-393.

Kandel, D. B., Johnson, J. G., Bird, H. R., Canino, G., Goodman, S. H., Lahey, B. B. et al. (1997). Psychiatric disorders associated with substance us among children and adolescents: Findings from the Methods for the Epidemiology of Child and Adolescent Mental Disorders (MECA) Study. *J.Abnorm.Child Psychol., 25,* 121-132.

Keiley, M. K., Bates, J. E., Dodge, K. A., & Pettit, G. S. (2000). A cross-domain growth analysis: Externalizing and internalizing behaviors during 8 years of childhood. *J.Abnorm.Child Psychol., 28,* 161-179.

Keiley, M. K., Lofthouse, N., Bates, J. E., Dodge, K. A., & Pettit, G. S. (2003). Differential risks of covarying and pure components in mother and teacher reports of externalizing and internalizing behavior across ages 5 to 14. *J.Abnorm.Child Psychol., 31,* 267-283.

Kowaleski-Jones, L. & Duncan, G. J. (1999). The structure of achievement and behavior across middle childhood. *Child Development, 70,* 930-943.

Lahey, B. B., Schwab-Stone, M., Goodman, S. H., Waldman, I. D., Canino, G., Rathouz, P. J. et al. (2000). Age and gender differences in oppositional behavior and conduct problems: A cross-sectional household study of middle childhood and adolescence. *J.Abnorm.Psychol., 109,* 488-503.

Lillehoj, C. J., Trudeau, L., Spoth, R., & Wickrama, K. A. S. (2004). Internalizing, social competence, and substance initiation: Influence of gender moderation and a preventive intervention. *Substance Use & Misuse, 39,* 963-991.

Lumeng, J. C., Gannon, K., Cabral, H. J., Frank, D. A., & Zuckerman, B. (2003). Association between clinically meaningful behaviour problems and overweight in children. *Pediatrics, 112,* 1138-1145.

Mason, W. A. & Windle, M. (2002). Reciprocal relations between adolescent substance use and delinquency: A longitudinal latent variable analysis. *J.Abnorm.Psychol., 111,* 63-76.

McCulloch, A., Wiggins, R. D., Joshi, H. E., & Sachdev, D. (2000). Internalising and externalising children's behaviour problems in Britain and the US: Relationships to family resources. *Children & Society, 14,* 368-383.

Molina, B. S., Bukstein, O. G., & Lynch, K. G. (2002). Attention-deficit/hyperactivity disorder and conduct disorder symptomatology in adolescents with alcohol use disorder. *Psychol.Addict.Behav., 16,* 161-164.

Molina, B. S. G., Smith, B. H., & Pelham, W. E. (1999). Interactive effects of attention deficit hyperactivity disorder and conduct disorder on early adolescent substance use. *Psychology of Addictive Behaviors, 13,* 348-358.

Mott, F. L. (1998). *Patterning of Child Assessment Completion Rates in the NLSY: 1986-1996* Columbus: The Ohio State University, Center for Human Resource Research.

Nagin, D. & Tremblay, R. E. (1999). Trajectories of boys' physical aggression, opposition, and hyperactivity on the path to physically violent and nonviolent juvenile delinquency. *Child Dev., 70,* 1181-1196.

Nagin, D. S. (1999). Analyzing developmental trajectories: A semiparametric, group-based approach. *Psychological Methods, 4,* 139-157.

Nagin, D. S. (2005). *Group-based modeling of development.* Cambridge: Harvard University Press.

Nagin, D. S. & Tremblay, R. E. (2001). Analyzing developmental trajectories of distinct but related behaviors: A group-based method. *Psychol.Methods, 6,* 18-34.

Ohannessian, C. M., Stabenau, J. R., & Hesselbrock, V. M. (1995). Childhood and adulthood temperament and problem behaviors and adulthood substance use. *Addict.Behav., 20,* 77-86.

Patton, G. C., Hibbert, M., Rosier, M. J., Carlin, J. B., Caust, J., & Bowes, G. (1996). Is smoking associated with depression and anxiety in teenagers? *Am.J.Public Health, 86,* 225-230.

Pedersen, W., Mastekaasa, A., & Wichstrom, L. (2001). Conduct problems and early cannabis initiation: A longitudinal study of gender differences. *Addiction, 96,* 415-431.

Peterson, J. L. & Zill, N. (1986). Marital disruption, parent-child relationships, and behavioural problems in children. *J.Marriage Fam., 48,* 295-307.

Raftery, A. E. (1995). Bayesian model selection in social research. *Sociological Methodology, 25,* 111-163.

Raine, A., Venables, P. H., & Williams, M. (1995). High autonomic arousal and electrodermal orienting at age 15 years as protective factors against criminal behavior at age 29 years. *Am.J.Psychiatry, 152,* 1595-1600.

Riggs, P. D., Baker, S., Mikulich, S. K., Young, S. E., & Crowley, T. J. (1995). Depression in substance-dependent delinquents. *J.Am.Acad.Child Adolesc.Psychiatry, 34,* 764-771.

Rowe, D. C. & Kandel, D. (1997). In the eye of the beholder? Parental ratings of externalizing and internalizing symptoms. *J.Abnorm.Child Psychol., 25,* 265-275.

Ruchkin, V., Koposov, R., Vermeiren, R., & Schwab-Stone, M. (2003). Psychopathology and age at onset of conduct problems in juvenile delinquents. *J.Clin.Psychiatry, 64,* 913-920.

Seiffge-Krenke, I. & Kollmar, F. (1998). Discrepancies between mothers' and fathers' perceptions of sons' and daughters' problem behaviour: a longitudinal analysis of parent-adolescent agreement on internalising and externalising problem behaviour. *J.Child Psychol.Psychiatry, 39,* 687-697.

Stanger, C., Achenbach, T. M., & Verhulst, F. C. (1997). Accelerated longitudinal comparisons of aggressive versus delinquent syndromes. *Dev.Psychopathol., 9,* 43-58.

Steele, R. G., Forehand, R., Armistead, L., & Brody, G. (1995). Predicting alcohol and drug use in early adulthood: The role of internalizing and externalizing behavior problems in early adolescence. *Am.J.Orthopsychiatry, 65,* 380-388.

Steinberg, L. & Morris, A. S. (2001). Adolescent development. *Annu.Rev.Psychol., 52,* 83-110.

Whitmore, E. A., Mikulich, S. K., Thompson, L. L., Riggs, P. D., Aarons, G. A., & Crowley, T. J. (1997). Influences on adolescent substance dependence: conduct disorder, depression, attention deficit hyperactivity disorder, and gender. *Drug Alcohol Depend., 47,* 87-97.

Windle, M. (1990). A longitudinal study of antisocial behaviors in early adolescence as predictors of late adolescent substance use: gender and ethnic group differences. *J.Abnorm.Psychol., 99,* 86-91.

Zahn-Waxler, C., Klimes-Dougan, B., & Slattery, M. J. (2000). Internalizing problems of childhood and adolescence: prospects, pitfalls, and progress in understanding the development of anxiety and depression. *Dev.Psychopathol., 12,* 443-466.

Table 17 Mean (standard deviation) externalizing and internalizing scores by year of age, by gender

	Age						
	6	7	8	9	10	11	12
	Externalizing score						
Males	8.62**	9.08**	9.24**	9.29**	9.06**	9.00**	9.05**
	(6.26)	(6.26)	(6.75)	(6.93)	(6.95)	(6.89)	(6.94)
Females	6.98	7.59	7.45	7.33	7.18	7.48	7.61
	(5.49)	(5.71)	(5.93)	(5.76)	(5.76)	(5.97)	(6.31)
	Internalizing score						
Males	3.04	3.22	3.18	3.16	2.94	3.00	2.81
	(2.93)	(3.02)	(3.03)	(3.19)	(3.06)	(3.22)	(3.11)
Females	3.14	3.40	3.16	3.16	2.98	2.98	2.81
	(2.84)	(3.04)	(2.95)	(2.93)	(9.94)	(2.98)	(3.01)

Note. T test comparisons made at every age between males and females; ** $p < .01$; * $p < .05$

Table 18 Proportion of respondents reporting ever smoking or ever using marijuana by age at interview, by gender

	Age (years)									
	10	11	12	13	14	15	16	17	18	19
	Smoking initiation									
Males	7.30**	9.11	13.86	18.83**	28.33	36.87	47.25	54.25	59.79*	63.51
Females	3.82	6.86	12.36	23.66	30.07	38.83	45.39	54.34	53.83	62.90
	Marijuana initiation									
Males	2.50**	0.99	2.42	4.66	9.76	22.69	29.33	37.77	44.11*	50.61*
Females	...[a]	...	...	2.41	10.25	21.01	26.91	34.40	37.40	43.36

Note. Chi-square test comparisons made at every age between males and females; ** $p < .01$; * $p < .05$

[a] Number of respondents too small ($n < 5$) to report proportions

Table 19 Joint and conditional probabilities of externalizing behaviour problems (top panel) and internalizing problems (bottom panel) with smoking initiation, by gender

	Smoking initiation trajectories					
	Males			Females		
	Abstainer	Middle initiator	Early initiator	Abstainer	Middle initiator	Early initiator
Externalizing Behaviour Trajectories						
Joint trajectory probabilities (cells total 100):						
Low (EL)	27.21	16.90	4.74	31.10	17.59	4.39
Mid (EM)	17.33	13.19	9.82	16.92	12.71	7.03
High (EH)	3.36	3.22	4.23	3.86	2.74	3.66
Probability of smoking initiation conditional on externalizing behaviour (rows total 100):						
Low (EL)	55.69	34.60	9.71	58.58	33.15	8.27
Mid (EM)	42.97	32.69	24.34	46.16	34.67	19.17
High (EH)	31.08	29.79	39.13	37.68	26.68	35.64
Comparison across levels of externalizing behaviour (p-values):						
EL vs. EM	< .0001	.35	< .0001	< .0001	.47	< .0001
EM vs. EH	.0001	.37	< .0001	.02	.02	< .0001
Internalizing Behaviour Trajectories						
Joint trajectory probabilities (cells total 100):						
Low (IL)	21.92	13.36	4.95	19.67	14.86	2.24
Mid (IM)	21.75	17.19	10.55	25.26	19.94	6.04
High (IH)	3.99	2.99	3.30	5.42	4.13	2.44
Probability of smoking initiation conditional on internalizing behaviour (rows total 100):						
Low (IL)	54.48	33.21	12.31	53.48	40.43	6.09
Mid (IM)	43.95	34.74	21.31	49.29	38.92	11.79
High (IH)	38.87	29.03	32.10	45.20	34.42	20.38
Comparison across levels of internalizing behaviour (p-values)						
IL vs. IM	< .0001	.46	< .0001	.06	.48	< .0001
IM vs. IH	.14	.08	.0009	.23	.18	.0002

Note. All comparisons are made on conditional probabilities.

Table 20 Joint and conditional probabilities of externalizing behaviour problems (top panel) and internalizing problems (bottom panel) with marijuana initiation, by gender

	Marijuana initiation trajectories					
	Males			Females		
	Abstainer	Late initiator	Middle initiator	Abstainer	Late initiator	Middle initiator
Externalizing Behaviour Trajectories						
Joint trajectory probabilities (cells total 100):						
Low (EL)	22.76	16.97	8.18	28.89	18.70	5.82
Mid (EM)	14.05	17.37	8.56	15.99	12.45	7.37
High (EH)	3.36	4.19	4.56	3.93	5.18	1.67
Probability of marijuana initiation conditional on externalizing behaviour (rows total 100):						
Low (EL)	47.51	35.43	17.06	54.09	35.01	10.90
Mid (EM)	35.14	43.44	21.42	44.65	34.76	20.59
High (EH)	27.76	34.60	37.64	36.49	48.01	15.50
Comparison across levels of behaviour problems (p-values)						
EL vs. EM	< .0001	.0008	.02	.0002	.92	< .0001
EM vs. EH	.04	.02	< .0001	.04	.0008	.01
Internalizing Behaviour Trajectories						
Joint trajectory probabilities (cells total 100):						
Low (IL)	18.10	14.95	5.66	19.12	13.69	4.26
Mid (IM)	18.28	22.44	9.20	24.76	18.29	8.80
High (IH)	4.29	4.02	3.06	5.09	4.40	1.59
Probability of marijuana initiation conditional on internalizing behaviour (rows total 100):						
Low (IL)	46.75	38.63	14.62	51.58	36.93	11.49
Mid (IM)	36.62	44.95	18.43	47.75	35.27	16.98
High (IH)	37.74	35.35	26.91	45.99	39.76	14.25
Comparison across levels of behaviour problems (p-values):						
IL vs. IM	< .0001	.009	.04	.12	.49	.002
IM vs. IH	.76	.01	.005	.65	.23	.34

Note. All comparisons are made on conditional probabilities

Table 21 Comparison of conditional probabilities of substance initiation across type of behaviour problem, by gender

	EL versus IL		EM versus IM		EH versus IH	
	Males	Females	Males	Females	Males	Females
			Smoking initiation			
Abstainer (SA)	=	EL > IL*	=	=	=	=
Middle initiator (SM)	=	EL < IL**	=	=	=	=
Early initiator (SE)	=	=	=	EM > IM**	=	EH > IH**
			Marijuana initiation			
Abstainer (MA)	=	=	=	=	EH < IH*	=
Late initiator (ML)	=	=	=	=	=	=
Middle initiator (MM)	=	=	=	=	EH > IH*	=

*p < .05; **p < .01; = indicates non-significant difference
EL=externalizing-low; EM=externalizing-mid; EH=externalizing-high; IL=internalizing-low; IM=internalizing-mid; IH=internalizing-high

Table 22 Comparison of conditional probabilities of substance initiation between males and females, by behaviour trajectory

	Externalizing behaviour			Internalizing behaviour		
	Low	Mid	High	Low	Mid	High
			Smoking initiation			
Abstainer (SA)	=	=	=	=	M < F*	=
Mid initiator (SM)	=	=	=	M < F**	M < F*	=
Early initiator (SE)	=	M > F**	=	M > F**	M > F**	M > F**
			Marijuana initiation			
Abstainer (MA)	M < F**	M < F**	=	=	M < F**	=
Late initiator (ML)	=	M > F**	M < F**	=	M > F**	=
Mid initiator (MM)	M > F**	=	M > F**	=	=	M > F**

*p < .05; **p < .01; = indicates non-significant difference
M=male; F=female

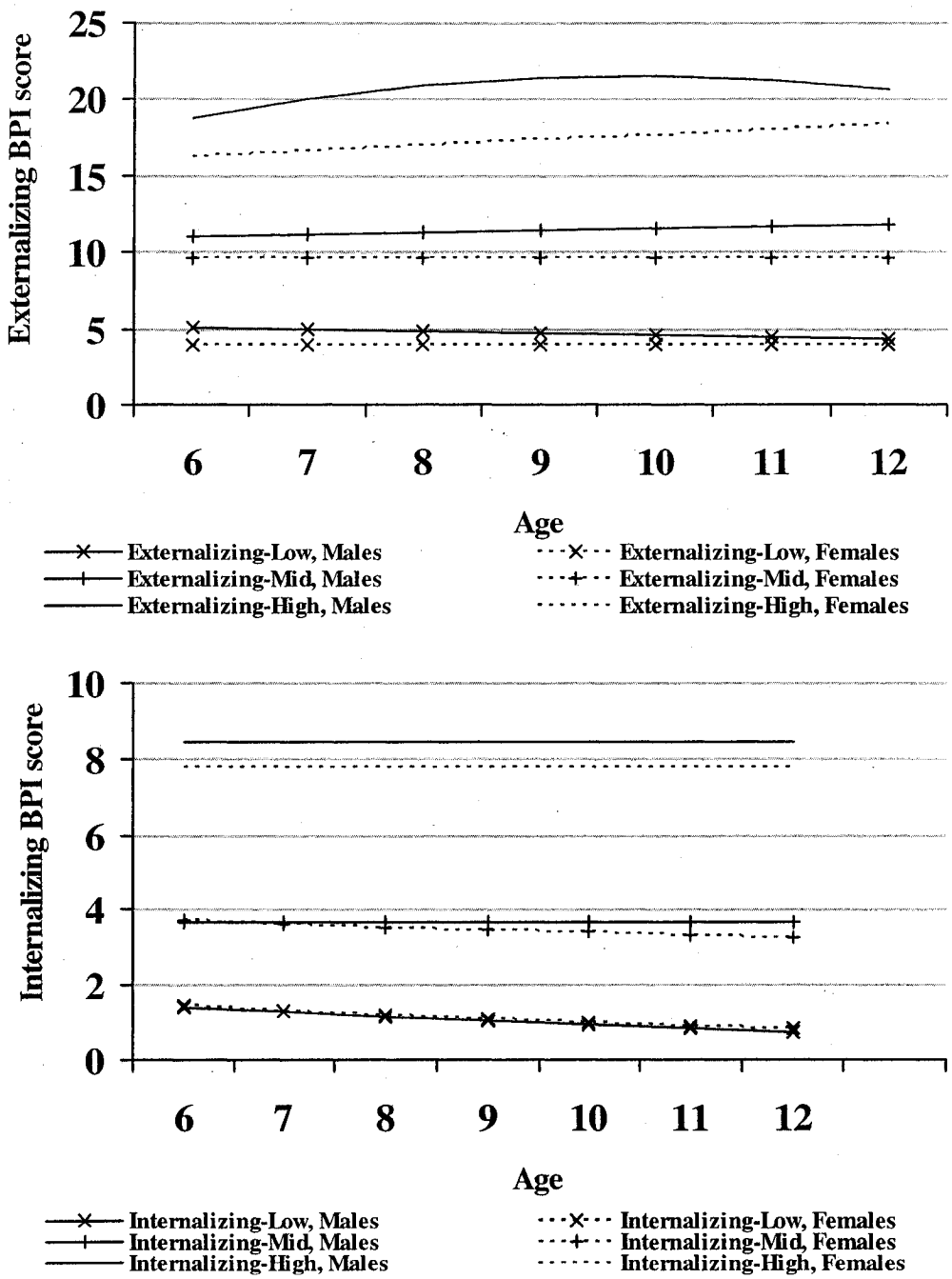

Figure 15 Trajectories of externalizing behaviour (top panel) and internalizing behaviour (bottom panel), by gender

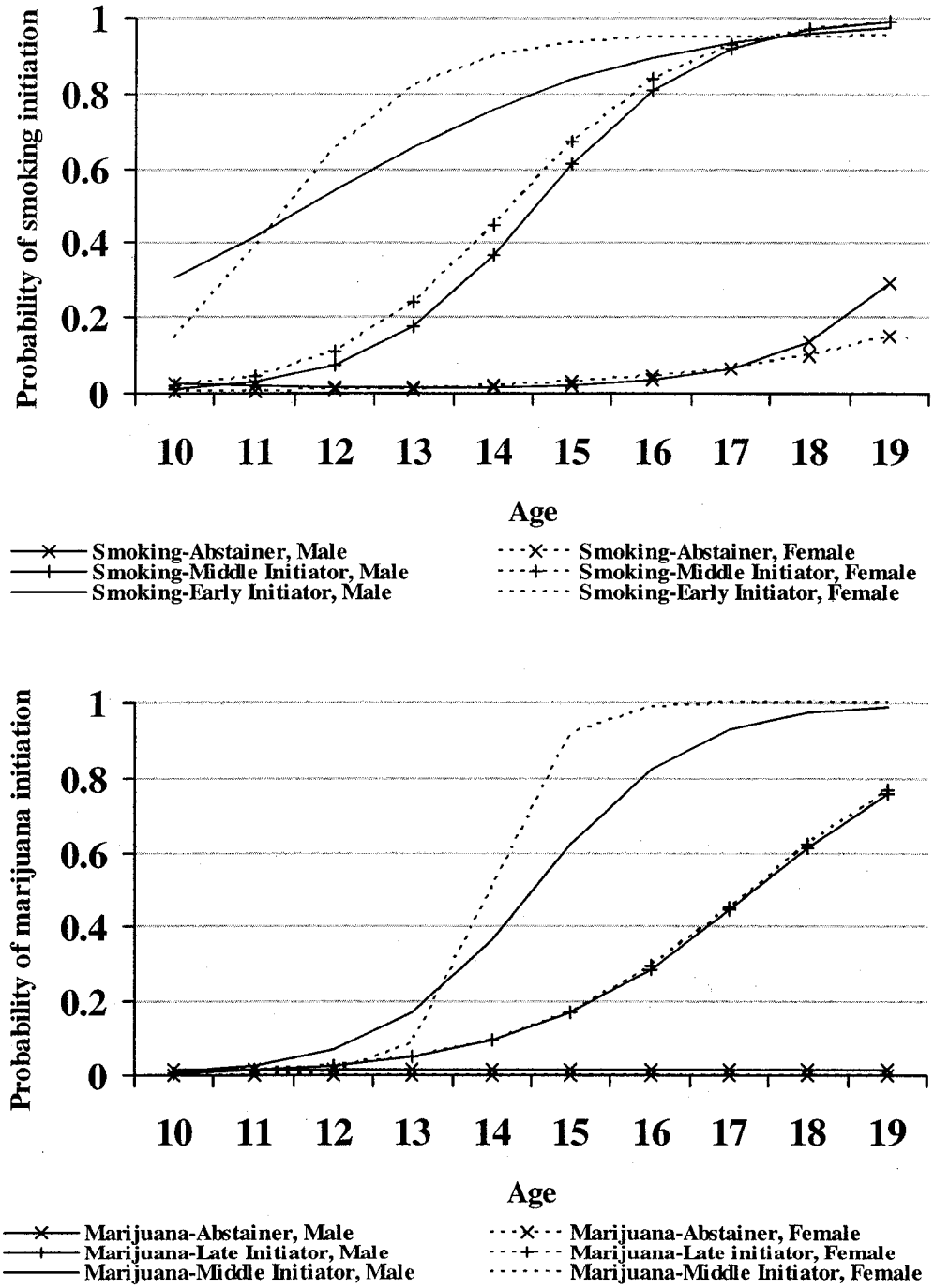

Figure 16 Trajectories of smoking initiation (top panel) and marijuana initiation (bottom panel), by gender

Project #3: Pubertal timing and risk for substance use

Running head: PUBERTAL TIMING AND RISK FOR SUBSTANCE USE

Pubertal timing and nonproportional risk for substance use: A discrete survival analysis of daily smoking, drunkenness, weekly marijuana use and other drug initiation among adolescents

Rochelle E. Garner
McMaster University
Statistics Canada

Tracy Vaillancourt
McMaster University

Michael H. Boyle
McMaster University
Offord Centre for Child Studies

Abstract

Pubertal timing is associated with substance use behaviours. Theorists agree that early maturers are at increased risk of early substance use initiation, while there is disagreement regarding the impact of late maturation. The present study uses a nationally representative sample of Canadian youth to assess the relationship between pubertal timing and substance use behaviour. Results indicate that early maturers have a greater hazard of initiating substance use during early adolescence, but this increased risk subsides or reverses in mid-adolescence. Late maturers exhibit a lower risk of drug initiation than on-time maturers, or show no difference at all. The magnitude of the relationship between pubertal timing and substance initiation differs by age and by gender.

Keywords: pubertal timing, early maturation, substance use, nonproportional hazard

Background

Substance use is a developmental phenomenon that shows a nearly linear increase in prevalence from early through to late adolescence (Young, Corley, Stallings, Rhee, Crowley, & Hewitt, 2002). According to the 2005 American *Monitoring the Future* study, 58% of grade 12 students had ever been drunk, 50% had ever smoked cigarettes, and 45% had ever tried marijuana (Johnston, O'Malley, Bachman, & Schulenberg, 2006).

Those who engage in frequent substance use experience detrimental consequences both during adolescence and in adulthood. Youth who use marijuana frequently have been shown to have higher levels of delinquency, poorer academic performance, and to be associated with more drug-using peers (Windle & Wiesner, 2004). In comparison to abstainers and experimenters, adolescents who use marijuana frequently have been shown to have lower overall mental health scores at age 29 (Ellickson, Martino, & Collins, 2004). Early age of substance use initiation has been found to increase the likelihood of developing substance use problems in later life (Hawkins et al., 1992; Hawkins et al., 1997; Kandel et al., 1986) and is significantly predictive of other risk behaviours, including unprotected sexual intercourse and sexual precocity (Brener & Collins, 1998; Hovell et al., 1994; Langer & Tubman, 1997), injury-related behaviours (Apostol et al., 2002), and other forms of delinquency (Porter & Lindberg, 2000). Early age of initiation has also been linked with increased risk of other health conditions, such as decreased lung function (Apostol et al., 2002), lung cancer (Hegmann et al., 1993), and breast cancer (Marcus et al., 2000).

The most obvious and significant developmental phenomenon during adolescence is pubertal maturation, which is associated with various hormonal, neurophysiological, physical and social changes. The most notable physical changes are the development of secondary sexual characteristics. Boys' pubertal development generally lags behind that of girls by one to two years (Graber, Petersen, & Brooks-Gunn, 1996). Despite the description of puberty as following ordered stages of change (Marshall & Tanner, 1969; Marshall & Tanner, 1970), there is great variation in the onset and pace of development. For example, it is not uncommon for young people to exhibit discordant maturation stages, such as breast development in girls that is nearer to completion than pubic hair development (Graber et al., 1996; Schubert, Chumlea, Kulin, Lee, Himes, & Sun, 2005). Furthermore, there are indications that the earlier the onset of puberty, the longer its duration (Marti-Henneberg & Vizmanos, 1997; Sun et al., 2005).

Pubertal timing has been linked to problem behaviours, substance use in particular (Beckdale, Ghezzo, & Ernst, 2005; Martin et al., 2002). Two major theories attempt to explain this link: the early maturation hypothesis and the maturational deviance hypothesis. The *early maturation hypothesis* is based on the work of Peskin (1973), and posits that those who undergo pubertal changes earlier than their peers will have higher rates of antisocial behaviour than others. Central to this theory is the sequence, timing and successful completion of developmental tasks. Adolescents who experience pubertal changes on-time are able to anticipate, prepare and learn how to cope with the physical and social changes associated with puberty. Early pubertal maturation increases the risk of problem behaviour by precipitating physical and social changes without the individual

first having acquired the necessary adaptive and coping skills. Compounding these lack of skills is the tendency for early maturers to associate with older teens and be exposed to additional behavioural risks (Stattin & Magnusson, 1990). Although not always stated explicitly, a corollary of the early maturation hypothesis is that late maturation exerts a protective effect. Unlike early maturers, late maturers have the opportunity to prepare for the changes of puberty by observing their peers and learning what to expect (Alsaker, 1996).

Several studies report findings that support the early maturation hypothesis. Tschann et al. (1994) found that early maturers reported significantly more substance use than on-time maturing adolescents for both males and females, whereas late maturation had no statistically significant association. In a study by Dick et al. (2000), early age at menarche was significantly related to a higher prevalence of weekly drinking and earlier age at initiation of alcohol and tobacco use. Similar results are found in other studies (Kaltiala-Heino, Kosunen, & Rimpela, 2003; Wiesner & Ittel, 2002; Harrell, Bangdiwala, Deng, Webb, & Bradley, 1998), including more general measures of antisocial behaviour (Caspi & Moffitt, 1991).

The second theory, the *maturational deviance* hypothesis, posits that youth who begin or complete puberty either earlier or later than their peers are more likely to engage in antisocial behaviours (Caspi & Moffitt, 1991; Tschann, Adler, Irwin, Jr., Millstein, Turner, & Kegeles, 1994). While early maturers may be unprepared to cope with their new status, late maturers may be vulnerable to peer exclusion and social comparison. This theory differs from the early maturation hypothesis in its expectations for late

maturers. There are some indications that delayed puberty may be more troublesome for boys than girls (Rosen & Foster, 2001). Williams and Dunlop (1999) report that young males who experienced puberty earlier or later than their peers reported significantly higher levels of crime-related delinquency and school opposition behaviours than their on-time peers. Graber and colleagues (2004) found that males who matured later than their peers had higher levels of disruptive behaviour and a greater prevalence of substance use disorders than other males, whereas young females who were late maturers did not differ from on-time maturing females. In a prospective cohort study of Swedish youth, Andersson and Magnusson (1990) found that both early and late maturing males had significantly higher prevalence rates of drunkenness at age 14 than on-time maturing males; one and a half years later, the significance of this difference disappeared. Followed into adulthood, late maturers (36%) were more likely than on-time maturers (14%) and early maturers (8%) to be registered in an alcohol abuse program. Another study found that both early and late maturing girls were significantly more likely than their on-time peers to report advanced drinking (Bratberg, Nilsen, Holmen, & Vatten, 2005). Conversely, late maturing males were significantly less likely to report advanced drinking than on-time maturing males.

Although existing studies generally support a link between early maturation and behavioural risk, no such consensus exists about the effects of late maturation. There are also methodological limitations. First, researchers have focussed primarily on girls, presumably because age at menstruation is an easily measured marker of pubertal timing (Caspi & Moffitt, 1991; Chung, Park, & Lanza, 2005; Dick, Rose, Viken, & Kaprio,

2000; Lanza & Collins, 2002). Second, most studies are cross-sectional (Kaltiala-Heino, Kosunen, & Rimpela, 2003; Williams & Dunlop, 1999; Graber, Lewinsohn, Seeley, & Brooks-Gunn, 1997) or only focus on a short-period of risk during adolescence (Lanza & Collins, 2002; Tschann, Adler, Irwin, Jr., Millstein, Turner, & Kegeles, 1994). Prospective longitudinal studies are needed to examine long term effects. Notable exceptions are longitudinal studies conducted by Ge and colleagues, who found that pubertal status in grade 7 was significantly predictive of externalized hostility and internalized distress in grade 10 (Ge, Conger, & Elder, 2001b). However, pubertal timing was entered as a continuous measure in regression models making it difficult to distinguish changes over time for those at the low versus high end of the pubertal status score (i.e. late versus early maturers). In another study, pubertal timing in grade 7 (i.e. early, on-time or late) was significantly predictive of depressive symptoms over time. There were also gender differences in the significance and magnitude of the effect of pubertal timing, as well as indications that the differences between timing groups changed over time (Ge, Conger, & Elder, 2001a). However, this study utilized only two waves of data during early adolescence (ages 11 through 14) which may be too short a period in which to observe the full and complex effects of pubertal timing.

The present study attempts to address the aforementioned limitations by (1) including males and females, (2) enlisting a large, nationally representative sample of 9785 Canadian children ages 10 to 11 at time 1, and (3) assessing these children on five occasions between 1994/95 and 2002/03. The overall objective is to model the relationship between pubertal timing and substance use behaviour. This objective is

achieved by: (1) estimating the age of onset of four substance use behaviours (regular smoking, drunkenness, weekly marijuana use, and use of other drugs); (2) looking for gender differences in the probability of substance use initiation at various ages; (3) testing the effects of pubertal timing on the probability of initiating these behaviours; and (4) determining whether the effects of pubertal timing are stable across adolescence.

Methods

Data were drawn from the National Longitudinal Survey of Children and Youth (NLSCY), a nationally-representative study of Canadian children conducted jointly by Statistics Canada and Social Development Canada. The NLSCY was first conducted in 1994 and has been conducted biennially since. Of interest to the current study is the longitudinal cohort who was 0-11 years old in 1994/95 and were ages 8-19 in 2002/2003.

The person most knowledgeable (PMK) of the child provides information on family and household characteristics, and also gives information about him/herself, as well as their spouse (if appropriate). In 78% of cases, the PMK is the child's biological mother. Beginning at age 10, children complete a self-administered questionnaire that includes reports of substance use as well as questions regarding physical maturation and pubertal development.

Participants

To be eligible for analysis, participants must provide reports of substance use in at least one cycle of the NLSCY and have complete pubertal status information at age 10 or 11. Between 1994 and 2003, 12,225 children ages 10 and up had been interviewed by the

NLSCY. Of those, 9785 (80.04%) provided pubertal status information at ages 10 or 11. The final sample size varies according to the substance use behaviour under consideration: 9778 for regular smoking; 9705 for drunkenness; 7479 for weekly marijuana use; and 9785 for other drug use.

Measures

Pubertal status. The NLSCY includes items from the Pubertal Development Scale (PDS) developed by Petersen et al. (1988). On a scale of 1 (not yet begun) to 4 (development seems complete), youth are asked to rate their physical development in a number of domains. Males and females both rate their body hair growth. Males also rate their facial hair development and their voice change, while females rate their breast development and indicate whether or not they had begun to menstruate. Scores on the three domains for each gender are averaged to produce a PDS score, ranging from 1 to 4, with 4 representing completed puberty.

Pubertal timing. Individuals' pubertal timing was classified at age 10 or 11. Using age- and gender-specific scores, a total PDS score more than one standard deviation above the mean indicates *early maturation.* A total PDS score less than one standard deviation below the mean indicates *late maturation.* Other scores indicate *on-time maturation.* For individuals with PDS scores at both ages 10 and 11, pubertal timing was classified at age 10.

Regular smoking and age of initiation. At each survey cycle, individuals are asked about their lifetime and current use of cigarettes. Individuals who report currently smoking every day (6-7 days a week), are said to be *daily smokers.* The youngest age at

interview at which individuals report daily smoking is taken as the age of initiation of daily smoking. Individuals are also asked whether they have ever smoked one or more cigarettes every day for at least seven days in a row. Those who answer affirmatively are said to be *consistent smokers*. Individuals who report ever being consistent smokers are asked at what age they first smoked consistently. Those who report being either daily or consistent smokers were considered to have engaged in *regular smoking*, and the minimum age of initiation of either behaviour was used to indicate age of initiation of regular smoking.

Drunkenness and age of initiation. Drunkenness is assessed in two ways in the NLSCY. In the first method, 12- to 15-year-olds are asked if they have ever been drunk and at what age they were first drunk. In the second method, 10- to 11-year-olds and 16- to 19-year-olds are asked how many times in the past year they got drunk. Individuals' reported age of first drunkenness assessed via the first method were averaged across cycles and rounded up to the nearest full year age. If no reported age of first drunkenness was available through the first method, then the earliest age at which individuals reported past year drunkenness via the second method was used.

Weekly marijuana use and age of initiation. Individuals who report using marijuana at least once a week in the past year are considered to be *weekly marijuana users*. The youngest age at interview at which they report this behaviour is taken as their age of initiation of weekly marijuana use.

Other drug use and age of initiation. The NLSCY asks about use of other substances, including solvents and inhalants, hallucinogens, crack, cocaine, stimulants,

depressants, tranquilizers, or other drugs obtained without a prescription. Individuals who report use of any or multiple of these substances are considered to be *other drug users*. The earliest age at interview at which an individual reports engaging in use of other drugs is coded as the age of initiation of other drug use.

Analytic Approach

For each substance use outcome, survival to initiation was modelled using a refinement of discrete-time survival analysis, as described by Singer and Willett (2003). A complementary log-log link function was used in the models (Graber et al., 1996; Hosmer & Lemeshow, 1999; Singer & Willet, 2003). Discrete-time hazard refers to the probability that an individual *i* will experience an event within the time period *j*, given that they did not experience the event in an earlier time period (Singer & Willet, 2003). Computationally, the value of the discrete-time hazard in time period *j* is equal to the number of events occurring within time period *j* divided by the number of individuals at risk, i.e. the number remaining in the sample who have not experienced the event prior to time period *j*. A completely general hazard model, in which dummy variables are included for each year of age, was compared to linear, quadratic, and cubic hazard functions to determine the shape of the hazard function. Based on changes in log likelihood and the Bayesian Information Criterion (BIC), the general hazard model was deemed optimal for each outcome, and was therefore retained in further analyses. Models were constructed for the whole sample to assess the impact of gender on the hazard of substance use initiation. Models were then run separately by gender for each of the behaviour outcomes.

For each gender-specific model, the indicators for early and late maturation were added to the model (on-time maturers as the reference group). To check for nonproportionality in the effect of pubertal timing, interaction terms between the pubertal timing indicators and the dummy variables for age were added to the model. For each outcome, based on the model with the lowest absolute BIC, the nonproportional model was deemed optimal. In each model, timing by age interaction terms that were similar in magnitude and chronologically concurrent were combined into composite terms. Composite terms were retained only if there was no significant change in log likelihood.

Hazard models were constructed for each substance use behaviour, comparing those with complete PDS information at age 10 or 11 to all individuals providing any substance use information. In no case did the exclusion of those with missing PDS data significantly affect the estimated hazards.

Results

Participants and Pubertal Timing

Of the 9785 with PDS information at ages 10 and 11, approximately half (50.35%) were male, 16.59% were from single parent families, 70.74% had a PMK with at least some post-secondary education, and 70.56% were from families with a household income of $40,000 or more. When categorized by pubertal timing, 59.04% of males and 72.07% of females were classified as maturing on-time (see Table 23). Age- and sex-specific PDS scores for individuals in each pubertal timing category are given in Table 23. In general, early maturers have consistently higher PDS scores than on-time

maturers, who in turn have consistently higher PDS scores than late maturers. The gap narrows at later ages when nearly all respondents have completed their physical maturation. These results indicate that, although our classification of pubertal timing was made at one time point only, the classification describes pubertal differences that persist between groups across time.

Attrition, Censoring and Missing Data Analysis

In this study, individuals are censored for one of two reasons: the study period ends or they are lost to follow-up. Early maturers were significantly more likely to be lost to follow-up than on-time maturers. Loss to follow-up was similar for on-time and late maturers, as well as for males and females. Although more likely to be lost to follow-up, early maturers were similar in age at attrition to on-time maturers. Females were significantly younger at attrition than males (data not shown).

Pubertal Timing and Onset of Substance Use

For each outcome, discrete models that allowed the effects of pubertal timing to vary with age (i.e. nonproportional effects) provided a better fit than proportional hazard models. As shown in Table 24, the differences between pubertal timing groups were not always significant. Only those ages for which timing categories showed significant difference in hazard were retained in the models.

For younger females prior to age 14, in those cases where early maturers differed from on-time maturers (i.e., smoking, ages 8-9; drunkenness, age 11; marijuana use, ages 8-9), they had a significantly increased hazard of initiating in the substance use

behaviours examined. For example, early maturing females had a five times greater hazard of first initiating regular smoking at ages 8 or 9 as compared to on-time females (see Table 24). However, in real terms the probability of initiating regular smoking at these ages is very low for both early and on-time maturing females, i.e. 0.130% and 0.03% at age 8, respectively (Figure 18 top left panel).

After age 14, early maturing females who had not yet engaged in smoking or marijuana use were significantly *less* likely to engage in those behaviours than on-time maturing females. Therefore, it seems that the risk incurred by early maturing females is limited to the period of early adolescence, and does not carry throughout the full period. Late maturation seldom exerts an effect on the hazard of substance use onset for females. This is demonstrated in Figure 18 by the overlapping survival curves for on-time and late maturing females. In the case where late maturation has an effect, i.e. drunkenness, the effect is protective (see Table 24 and Figure 18).

For males, the pattern is less consistent. Early maturing males show an increased hazard of initiating each of the behaviours at various points during early adolescence (i.e., smoking, ages 9-12; drunkenness, ages 10-15; marijuana use, age 13; other drugs, ages 12 & 15). There are also indications that, for those who have not yet initiated the behaviours, early maturers have a lower hazard of initiation in later adolescence (i.e., smoking, drunkenness, marijuana use). However, the age at which this occurs differs by several years, depending on the behaviour in question. For regular smoking, this effect is seen as early as age 13, whereas this does not occur until age 16 in the case of drunkenness, and does not seem to occur at all for the initiation of other drugs.

Late maturing males, in general, have a significantly lower hazard of initiating substance use at any age. As shown clearly in Figure 17, the cumulative probability curve of late maturing males always lies below that of on-time maturers.

Discussion

The results of the present study show that, while pubertal timing has a significant effect on the initiation of substance use behaviours, its effect is not consistent across the period of adolescence, nor is it the same for males and females. Results reported herein do not support the hypothesis that both early and late maturing youth will be more likely to engage in deviant behaviours such as substance use than on-time maturers (i.e. maturational deviance hypothesis). Rather, there is no indication that late maturers, male or female, show greater risk of initiating substance use at any age relative to their peers. In this study, late pubertal timing seems to have a protective effect on the initiation of certain substance using behaviours, particularly among males, or no effect at all, as with females. This may be because they have had peers to model the transition into and through puberty, and thus are better prepared when faced with the challenges themselves (Alsaker, 1996).

While certain results of this study are consistent with the early maturation hypothesis, whereby early maturers are said to be at increased risk relative to either on-time or late-maturing youth, this increase in risk does not hold across the whole period of adolescent development. Early maturation appears to increase the risk of substance use initiation only during early adolescence. At a certain age, which seems to lie between 13

and 15, the risk associated with early puberty either subsides, with early maturers reporting similar behaviours as their on-time peers, or early maturers are less likely to initiate use of certain substance use behaviours. This may be because early maturers were more likely than others to be lost to follow-up. If they had remained in the survey, many may have reported initiating the substance using behaviours during later adolescence. It is possible that these individuals may return in future cycles of the NLSCY, thereby allowing subsequent studies to address this issue. Early maturers who do not succumb to initiation in early adolescence may also differ from other early maturers in important environmental or familial characteristics, such as strong social support or parental attachment, which reduce the risk of initiation.

However, there is another potential explanation linking the protective effect of early maturation with the neurophysiological changes that accompany puberty. Non-human primate models have shown that, during puberty, there are significant changes in the dorsolateral prefrontal cortex (DLPFC), which is implicated in executive control, the process that facilitates the processing of complex information and behaviour (Lewis, Cruz, Eggan, & Erickson, 2004). Gonadal and adrenal steroid hormones, which are released at the onset of puberty, modulate the function of various neural systems (i.e. serotonergic, noradrenergic, and dopaminergic systems) that are involved in the regulation of behavioural affect (Cameron, 2004a; Cameron, 2004b). If the hormonal and DLPFC changes are initiated or completed sooner in early maturers than other youth, it may be that early maturers are the first among their peers to develop the skills necessary to control their behaviour and moderate their risk-taking propensities. Early

maturing youth who experience non-healthy development of the DLPFC may be those who initiate risky behaviours early in adolescence, such as substance use, whereas those early maturers who undergo healthy DLPFC development are better equipped and are able to delay initiation or maintain abstinence from substance use.

The analyses in this study imply a causal direction to the relationship between pubertal timing and substance use initiation. The major theories imply that pubertal status and timing influence the initiation of substance use, and not the reverse. However, there is evidence from animal models that suggests that pre-pubertal use of alcohol may precipitate the onset of puberty (Hernandez-Gonzalez, Rivera Sanchez, Oropeza Blando, Orozco-Suarez, Arteaga Silva, & Guevera, 2004). In human models, there is evidence that prenatal and childhood exposure to tobacco, marijuana or alcohol may precipitate pubertal milestones for both males and females (Fried, James, & Watkinson, 2001; Stice & Martinez, 2005; Windham, Bottomley, Birner, & Fenster, 2004).

Other factors related to pubertal onset and timing, including diet, body mass (Adair & Gordon-Larsen, 2001; Warren & Vu, 2003), and excessive exercise (Warren & Vu, 2003) were not included in this analysis. A further examination of this topic may wish to include such covariates in its analysis. For instance, Tremblay & Frigon (Tremblay & Frigon, 2005) found an interaction between obesity and pubertal timing in their analysis of psychosocial maladjustment among adolescent girls.

The classification of pubertal timing used in this analysis, although consistent with that used in other research (Bratberg et al., 2005; Ge et al., 2001a; Ge, Brody, Conger, Simons, & Murry, 2002; Wiesner & Ittel, 2002; Williams & Dunlop, 1999), may

not fully reflect the relationship between physical maturation and substance use initiation. In the current analysis, pubertal timing was considered time-independent, and classified only once at age 10 or 11. However, physical maturation may accelerate and decelerate over the course of adolescence. Consequently, a child who may be classified as late relative to his peers at one point may be considered to be maturing on-time at another. It would have been possible to include physical maturation as a time-dependent covariate in the models, although the interpretation of such models becomes necessarily more complex. Furthermore, at older ages there is less heterogeneity in pubertal status, rendering classifications such as early and late less meaningful. Nevertheless, the present study demonstrated that the longitudinal changes in youths' pubertal assessment was captured by the time-independent classification of maturation at age 10 or 11. An alternate means of classification is given by Ge et al. (2003), who compared children who maintain a consistent pace of pubertal maturation to those whose rate of maturation increases or decreases over time. Future studies could examine whether the acceleration or deceleration of the pace of pubertal maturation affects the results found in the present analysis.

The information drawn from the NLSCY and used in the present study relies on adolescents' self-reports of pubertal maturation and substance use. Validation studies of the PDS have found that youth's self-reports of physical maturation correlated well with physicians' Tanner stage ratings (Brooks-Gunn, Warren, Rosso, & Gargiulo, 1987). Researchers have also found adolescents' self-reports of substance use to be generally reliable (Smith, McCarthy, & Goldman, 1995). However, there is a possibility that

individuals may be misclassified in regards to pubertal timing or the age at which they initiated a particular behaviour. Nevertheless, given the size of the sample surveyed, and the burden associated with other methods of data collection and verification, reliance on self-reports is the best method available in the current context.

The present study improves significantly upon previous studies examining the association between pubertal timing and substance use initiation by addressing the nonproportionality of the effect of early and late maturation. Our study indicates that, while late maturing youth have similar or lower rates of substance initiation as on-time maturing youth, early maturation increases risk only during the early portion of adolescence. Early-maturing youth who do not initiate substance use prior to age 14 or 15 are significantly less likely to do so than other youth. Further research should focus on this protective effect, both with respect to substance use as well as to other behaviours that may also be affected.

The results of this study indicate that a broad conceptualization of early maturation as a risk factor may be overly simplistic. Instead, a more multifaceted approach is warranted, one that recognizes the risk environments and relationships that early maturing youth face that may increase their likelihood of engaging in detrimental behaviours, as well as the emotional, cognitive and social skills that these youth develop prior to their peers that may improve their long-term well-being. Greater research is needed to understand the interplay between the biological and neurophysiological changes that accompany puberty and how changes in the timing and tempo of pubertal maturation affect the cognitive and social skills of adolescents.

References

Adair, L. S. & Gordon-Larsen, P. (2001). Maturational timing and overweight prevalence in US adolescent girls. *American Journal of Public Health, 91,* 642-644.

Alsaker, F. D. (1996). Annotation: The impact of puberty. *Journal of Child Psychology & Psychiatry, 37,* 249-258.

Andersson, T. & Magnusson, D. (1990). Biological maturation in adolescence and the development of drinking habits and alcohol abuse among young males: A prospective longitudinal study. *Journal of Youth and Adolescence, 19,* 33-41.

Apostol, G. G., Jacobs, D. R., Tsai, A. W., Crow, R. S., Williams, O. D., Townsend, M. C. et al. (2002). Early life factors contribute to the decrease in lung function between ages 18 and 40 - The coronary artery risk development in young adults study. *American Journal of Respiratory and Critical Care Medicine, 166,* 166-172.

Beckdale, M. R., Ghezzo, H., & Ernst, P. (2005). Childhood predictors of smoking in adolescence: A follow-up study of Montreal schoolchildren. *Canadian Medical Association Journal, 173,* 377-379.

Bratberg, G. H., Nilsen, T. I. L., Holmen, T. L., & Vatten, L. J. (2005). Sexual maturation in early adolescence and alcohol drinking and cigarette smoking in late adolescence: A prospective study of 2,129 Norwegian girls and boys. *European Journal of Pediatrics, 164,* 621-625.

Brener, N. D. & Collins, J. L. (1998). Co-occurrence of health-risk behaviors among adolescents in the United States. *Journal of Adolescent Health, 22,* 209-213.

Brooks-Gunn, J., Warren, M. P., Rosso, J., & Gargiulo, J. (1987). Validity of self-report measures of girls' pubertal status. *Child Development, 58,* 829-841.

Cameron, J. L. (2004a). Interrelationships between hormones, behavior, and affect during adolescence: Complex relationships exist between reproductive hormones, stress-related hormones, and the activity of neural systems that regulate behavioral affect. Comments on part III. *Annals of the New York Academy of Sciences, 1021,* 134-142.

Cameron, J. L. (2004b). Interrelationships between hormones, behavior, and affect during adolescence: Understanding hormonal, physical, and brain changes occurring in association with pubertal activation of the reproductive axis. Introduction to part III. *Annals of the New York Academy of Sciences, 1021,* 110-123.

Caspi, A. & Moffitt, T. E. (1991). Individual differences are accentuated during periods of social change: The sample case of girls at puberty. *Journal of Personality & Social Psychology, 61,* 157-168.

Chung, H., Park, Y., & Lanza, S. T. (2005). Latent transition analysis with covariates: Pubertal timing and substance use behaviours in adolescent females. *Statistics in Medicine, 24,* 2895-2910.

Dick, D. M., Rose, R. J., Viken, R. J., & Kaprio, J. (2000). Pubertal timing and substance use: Associations between and within families across late adolescence. *Dev.Psychol., 36,* 180-189.

Ellickson, P. L., Martino, S. C., & Collins, R. L. (2004). Marijuana use from adolescence to young adulthood: Multiple developmental trajectories and their associated outcomes. *Health Psychology, 23,* 299-307.

Fried, P. A., James, D. S., & Watkinson, B. (2001). Growth and pubertal milestones during adolescence in offspring prenatally exposed to cigarettes and marihuana. *Neurotoxicology & Teratology, 23,* 431-436.

Ge, X., Brody, G. H., Conger, R. D., Simons, R. L., & Murry, V. M. (2002). Contextual amplification of pubertal transition effects on deviant peer affiliation and externalizing behavior among African American children. *Developmental Psychology, 38,* 42-54.

Ge, X., Conger, R. D., & Elder, G. H. J. (2001a). Pubertal transition, stressful life events, and the emergence of gender differences in adolescent depressive symptoms. *Developmental Psychology, 37,* 404-417.

Ge, X., Conger, R. D., & Elder, G. H. J. (2001b). The relation between puberty and psychological distress in adolescent boys. *Journal of Research on Adolescence, 11,* 49-70.

Ge, X., Kim, I. J., Brody, G. H., Conger, R. D., Simons, R. L., Gibbons, F. X. et al. (2003). It's about timing and change: Pubertal transition effects on symptoms of major depression among African American youths. *Developmental Psychology, 39,* 430-439.

Graber, J. A., Lewinsohn, P. M., Seeley, J. R., & Brooks-Gunn, J. (1997). Is psychopathology associated with the timing of pubertal development? *Journal of the American Academy of Child & Adolescent Psychiatry, 36,* 1768-1776.

Graber, J. A., Petersen, A. C., & Brooks-Gunn, J. (1996). Pubertal processes: Methods, measures, and models. In J.A.Graber, J. Brooks-Gunn, & A. C. Petersen (Eds.), *Transitions Through Adolescence: Interpersonal Domains and Context* (pp. 23-53). New Jersey: Lawrence Erlbaum Associates.

Graber, J. A., Seeley, J. R., Brooks-Gunn, J., & Lewinsohn, P. M. (2004). Is pubertal timing associated with psychopathology in young adulthood? *Journal of the American Academy of Child & Adolescent Psychiatry, 43,* 718-726.

Harrell, J. S., Bangdiwala, S. I., Deng, S., Webb, J. P., & Bradley, C. (1998). Smoking initiation in youth: The roles of gender, race, socioeconomics, and developmental status. *Journal of Adolescent Health, 23,* 271-279.

Hawkins, J. D., Catalano, R. F., & Miller, J. Y. (1992). Risk and protective factors for alcohol and other drug problems in adolescence and early adulthood: Implications for substance abuse prevention. *Psychological Bulletin, 112,* 64-105.

Hawkins, J. D., Graham, J. W., Maguin, E., Abbott, R., Hill, K. G., & Catalano, R. F. (1997). Exploring the effects of age of alcohol use initiation and psychosocial risk factors on subsequent alcohol misuse. *Journal of Studies in Alcohol, 58,* 280-290.

Hegmann, K. T., Fraser, A. M., Keaney, R. P., Moser, S. E., Nilasena, D. S., Sedlars, M. et al. (1993). The effect of age at smoking initiation on lung-cancer risk. *Epidemiology, 4,* 444-448.

Hernandez-Gonzalez, M., Rivera Sanchez, K. E., Oropeza Blando, M. V., Orozco-Suarez, S., Arteaga Silva, M., & Guevera, M. A. (2004). Effects of alcohol on behavioral and morphologic indices of sexual maturation in male rats. *Alcohol, 33,* 117-126.

Hosmer, D. W. & Lemeshow, S. (1999). *Applied survival analysis: Regression modeling of time to event data.* New York: Wiley.

Hovell, M. F., Hillman, E. R., Blumberg, E., Sipan, C., Atkins, C., Hofstetter, C. R. et al. (1994). A behavioral-ecological model of adolescent sexual development: A template for AIDS-prevention. *Journal of Sex Research, 31,* 267-281.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2006). *Monitoring the Future national survey results on adolescent drug use: Overview of key findings, 2005* (Rep. No. NIH Publication No. 06-5882). Bethesda, MD: National Institute on Drug Abuse.

Kaltiala-Heino, R., Kosunen, E., & Rimpela, M. (2003). Pubertal timing, sexual behaviour and self-reported depression in middle adolescence. *Journal of Adolescence, 26,* 531-545.

Kandel, D., Simchafagan, O., & Davies, M. (1986). Risk-factors for delinquency and illicit drug-use from adolescence to young adulthood. *Journal of Drug Issues, 16,* 67-90.

Langer, L. M. & Tubman, J. G. (1997). Risky sexual behavior among substance-abusing adolescents: Psychosocial and contextual factors. *American Journal of Orthopsychiatry, 67,* 315-322.

Lanza, S. T. & Collins, L. M. (2002). Pubertal timing and the onset of substance use in females during early adolescence. *Prevention Science, 3,* 69-82.

Lewis, D. A., Cruz, D., Eggan, S., & Erickson, S. (2004). Postnatal development of prefrontal inhibitory circuits and the pathophysiology of cognitive dysfunction in schizophrenia. *Annals of the New York Academy of Sciences, 1021,* 64-76.

Marcus, P. M., Newman, B., Millikan, R. C., Moorman, P. G., Baird, D. D., & Qaqish, B. (2000). The associations of adolescent cigarette smoking, alcoholic beverage consumption, environmental tobacco smoke, and ionizing radiation with subsequent breast cancer risk (United States). *Cancer Causes & Control, 11,* 271-278.

Marshall, W. A. & Tanner, J. M. (1969). Variations in the pattern of pubertal changes in girls. *Archives of Disease in Childhood, 44,* 291-303.

Marshall, W. A. & Tanner, J. M. (1970). Variations in the pattern of pubertal changes in boys. *Archives of Disease in Childhood, 45,* 13-23.

Marti-Henneberg, C. & Vizmanos, B. (1997). The duration of puberty in girls is related to the timing of its onset. *Journal of Pediatrics, 131,* 618-621.

Martin, C. A., Kelly, T. H., Rayen, M. K., Brogli, B. R., Brenzel, A., Smith, W. J. et al. (2002). Sensation seeking, puberty, and nicotine, alcohol and marijuana use in adolescence. *Journal of the American Academy of Child & Adolescent Psychiatry, 41,* 1495-1502.

Peskin, H. (1973). Influence of the developmental schedule of puberty on learning and ego functioning. *Journal of Youth and Adolescence, 2,* 273-290.

Petersen, A. C., Crockett, L., Richards, M., & Boxer, A. (1988). A self-report measure of pubertal status: Reliability, validity and initial norms. *Journal of Youth and Adolescence, 17,* 117-133.

Porter, L. & Lindberg, D. (2000). *Reaching out to multiple risk adolescents* The Urban Institute.

Rosen, D. S. & Foster, C. (2001). Delayed puberty. *Pediatrics in Review, 22,* 309-315.

Schubert, C. M., Chumlea, W. C., Kulin, H. E., Lee, P. A., Himes, J. H., & Sun, S. S. (2005). Concordant and discordant secual maturation among U.S. children in relation to body weight and BMI. *Journal of Adolescent Health, 37,* 356-362.

Singer, J. D. & Willet, J. B. (2003). *Applied longitudinal data analysis: Modeling change and event occurrence*. New York, NY: Oxford University Press.

Smith, G. T., McCarthy, D. M., & Goldman, M. S. (1995). Self-reported drinking and alcohol-related problems among early adolescents: Dimensionality and validity over 24 months. *Journal of Studies in Alcohol, 56,* 383-394.

Stattin, H. & Magnusson, D. (1990). *Pubertal maturation in female development.* Hillsdale, NJ.: Erlbaum.

Stice, E. & Martinez, E. E. (2005). Cigarette smoking prospectively predicts retarded physical growth among female adolescents. *Journal of Adolescent Health, 37,* 363-370.

Sun, S. S., Schubert, C. M., Liang, R., Roche, A. F., Kulin, H. E., Lee, P. A. et al. (2005). Is sexual maturity occurring earlier among U.S. children? *Journal of Adolescent Health, 37,* 345-355.

Tremblay, L. & Frigon, J. Y. (2005). The interaction role of obesity and pubertal timing on the psychosocial adjustment of adolescent girls: Longitudinal data. *Int J.Obes.(London), 29,* 1204-1211.

Tschann, J. M., Adler, N. E., Irwin, C. E., Jr., Millstein, S. G., Turner, R. A., & Kegeles, S. M. (1994). Initiation of substance use in early adolescence: The roles of pubertal timing and emotional distress. *Health Psychology, 13,* 326-333.

Warren, M. P. & Vu, C. (2003). Central causes of hypogonadism--functional and organic. *Endocrinology & Metabolism Clinics of North America, 32,* 593-612.

Wiesner, M. & Ittel, A. (2002). Relations of pubertal timing and depressive symptoms to substance use in early adolescence. *Journal of Early Adolescence, 22,* 5-23.

Williams, J. M. & Dunlop, L. C. (1999). Pubertal timing and self-reported delinquency among male adolescents. *Journal of Adolescence, 22,* 157-171.

Windham, G. C., Bottomley, C., Birner, C., & Fenster, L. (2004). Age at menarche in relation to maternal use of tobacco, alcohol, coffee, and tea during pregnancy. *American Journal of Epidemiology, 159,* 862-871.

Windle, M. & Wiesner, M. (2004). Trajectories of marijuana use from adolescence to young adulthood: Predictors and outcomes. *Developmental Psychology, 16,* 1007-1027.

Young, S. E., Corley, R. P., Stallings, M. C., Rhee, S. H., Crowley, T. J., & Hewitt, J. K. (2002). Substance use, abuse and dependence in adolescence: Prevalence, symptom profiles and correlates. *Drug & Alcohol Dependence, 68,* 309-322.

Table 23 Mean (standard deviation) age-specific PDS scores, by gender and maturational timing category

	Early maturers	On-time maturers	Late maturers	ANOVA p-value
Males (n=4927)	n=732	n=2909	n=1286	
Age 10	2.57 (0.29)	1.61 (0.27)	1.01 (0.05)	< .0001
Age 11	2.56 (0.27)	1.67 (0.26)	1.01 (0.11)	< .0001
Age 12	2.38 (0.47)	2.06 (0.56)	1.79 (0.62)	< .0001
Age 13	2.78 (0.49)	2.42 (0.59)	2.11 (0.65)	< .0001
Age 14	2.88 $(0.57)_a$	2.80 $(0.54)_a$	2.61 (0.55)	< .0001
Age 15	3.18 (0.42)	3.00 (0.55)	2.84 (0.59)	< .0001
Age 16	3.21 $(0.51)_a$	3.26 $(0.46)_a$	3.21 $(0.52)_a$	.39
Age 17	3.45 $(0.33)_{ab}$	3.44 $(0.44)_a$	3.33 $(0.49)_b$	.03
Females (n=4858)	n=639	n=3501	n=718	
Age 10	2.57 (0.37)	1.59 (0.24)	1.00 (0.05)	< .0001
Age 11	3.18 (0.32)	1.85 (0.34)	1.07 (0.31)	< .0001
Age 12	3.08 (0.72)	2.64 (0.74)	2.18 (0.69)	< .0001
Age 13	3.52 (0.35)	3.09 (0.63)	2.49 (0.76)	< .0001
Age 14	3.55 $(0.40)_a$	3.49 $(0.45)_a$	3.19 (0.64)	< .0001
Age 15	3.75 (0.27)	3.61 (0.37)	3.48 (0.40)	< .0001
Age 16	3.87 (0.21)	3.77 (0.26)	3.64 (0.42)	< .0001
Age 17	3.90 $(0.17)_a$	3.85 $(0.24)_a$	3.85 $(0.22)_a$	.21

Note. Percentages having the same subscript are not significantly different at $p < .05$.

Table 24 Effect of maturational status in nonproportional discrete survival models of substance use, by gender and behaviour category

	Males				Females			
	Age period	B	HR	95% CI	Age period	B	HR	95% CI
				Regular Smoking				
Early maturation	Ages 9 – 12	0.4921**	1.64	1.22 – 2.19	Ages 8 – 9	1.6170**	5.04	2.29 – 11.08
	Ages 13 – 14	-0.5584*	0.57	0.37 – 0.89	Ages 15 – 18	-1.9523**	0.14	0.05 – 0.43
Late maturation	Ages 12 – 14	-0.9001**	0.41	0.30 – 0.56		ns		
	Ages 16 – 17	-0.9965**	0.37	0.19 – 0.70				
				Drunkenness				
Early maturation	Ages 10 – 12	0.7306**	2.08	1.57 – 2.75	Age 11	0.7700*	2.16	1.08 – 4.30
	Ages 14 – 15	0.3117*	1.37	1.03 – 1.81	Age 14	-0.4202*	0.66	0.45 – 0.96
	Age 16	-0.8281**	0.44	0.26 – 0.72	Age 15	-1.2286**	0.29	0.13 – 0.65
					Age 16-17	-0.3882**	0.68	0.51 – 0.91
Late maturation	Ages 11 – 13	-0.6823**	0.51	0.39 – 0.66	Ages 12 – 14	-0.4815**	0.62	0.49 – 0.79
	Ages 15 – 17	-0.2182**	0.80	0.65 – 0.99	Age 15	-1.5077**	0.22	0.09 – 0.53
				Weekly Marijuana Use				
Early maturation	Age 13	1.0524**	2.86	1.41 – 5.82	Age 13	2.2826**	9.80	3.69 – 26.03
	Ages 18 – 19	-1.9871**	0.14	0.03 – 0.74	Ages 14 – 15	-0.7237*	0.48	0.26 – 0.90
Late maturation	Ages 12 – 17	-0.4091**	0.66	0.51 – 0.86		ns		
	Age 18	0.6606*	1.94	1.15 – 3.26				
				Initiation of Other Drug Use				
Early maturation	Age 12	1.0007**	2.72	1.39 – 5.33		ns		
	Age 15	0.7746**	2.17	1.21 – 3.91				
Late maturation	Ages 11 – 14	-0.8568**	0.42	0.29 – 0.63		ns		

Note. All non-significant effects were removed from the models. In cases where pubertal timing had no effect on hazard of substance use, no coefficients are reported.
HR=hazard ratio; *p< .05; **p< .01; ns=not significant

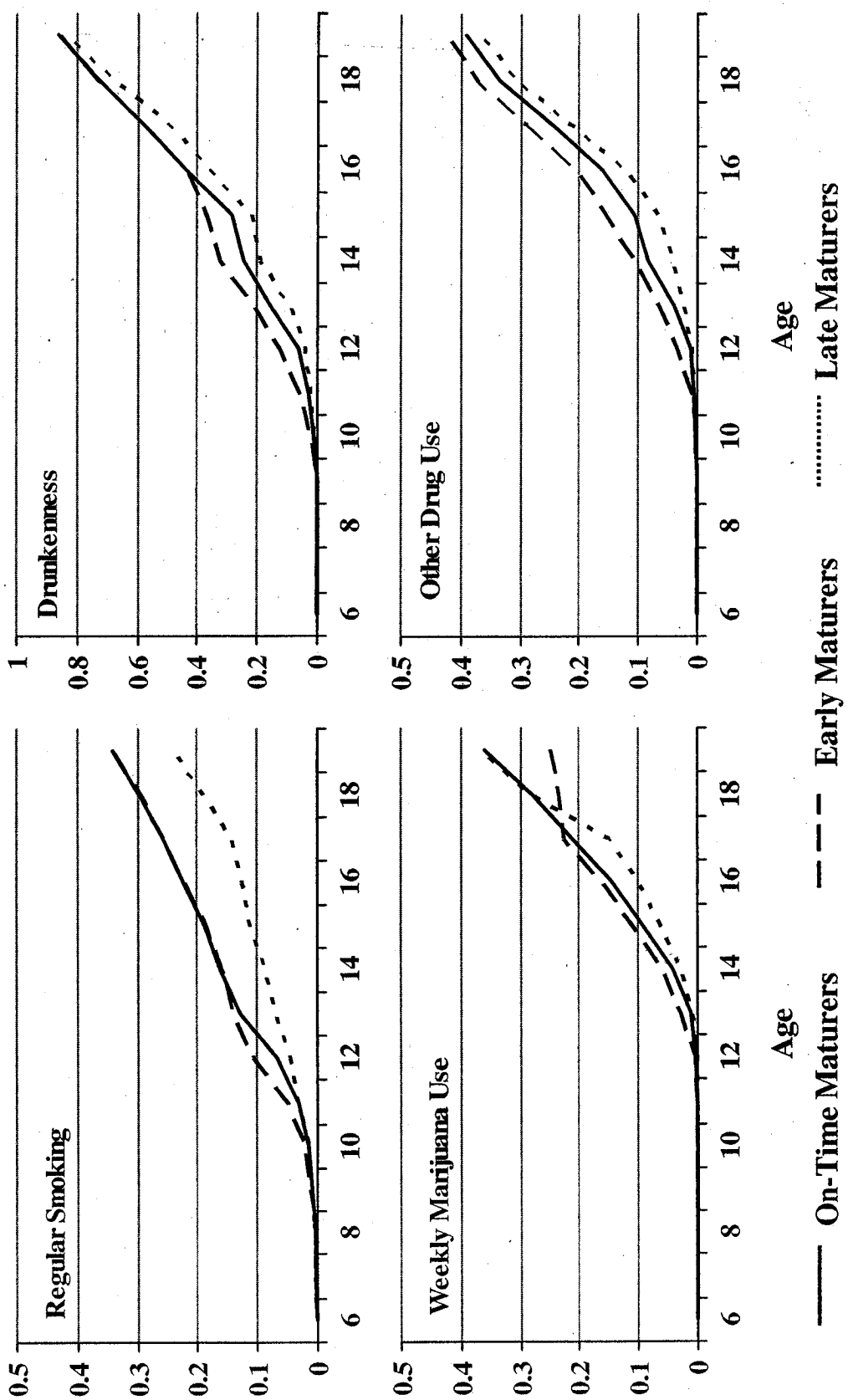

Figure 17 Cumulative probability of initiating regular smoking (top left), drunkenness (top right), weekly marijuana use (bottom left) or other drug use (bottom right) by year of age among males, by pubertal timing group

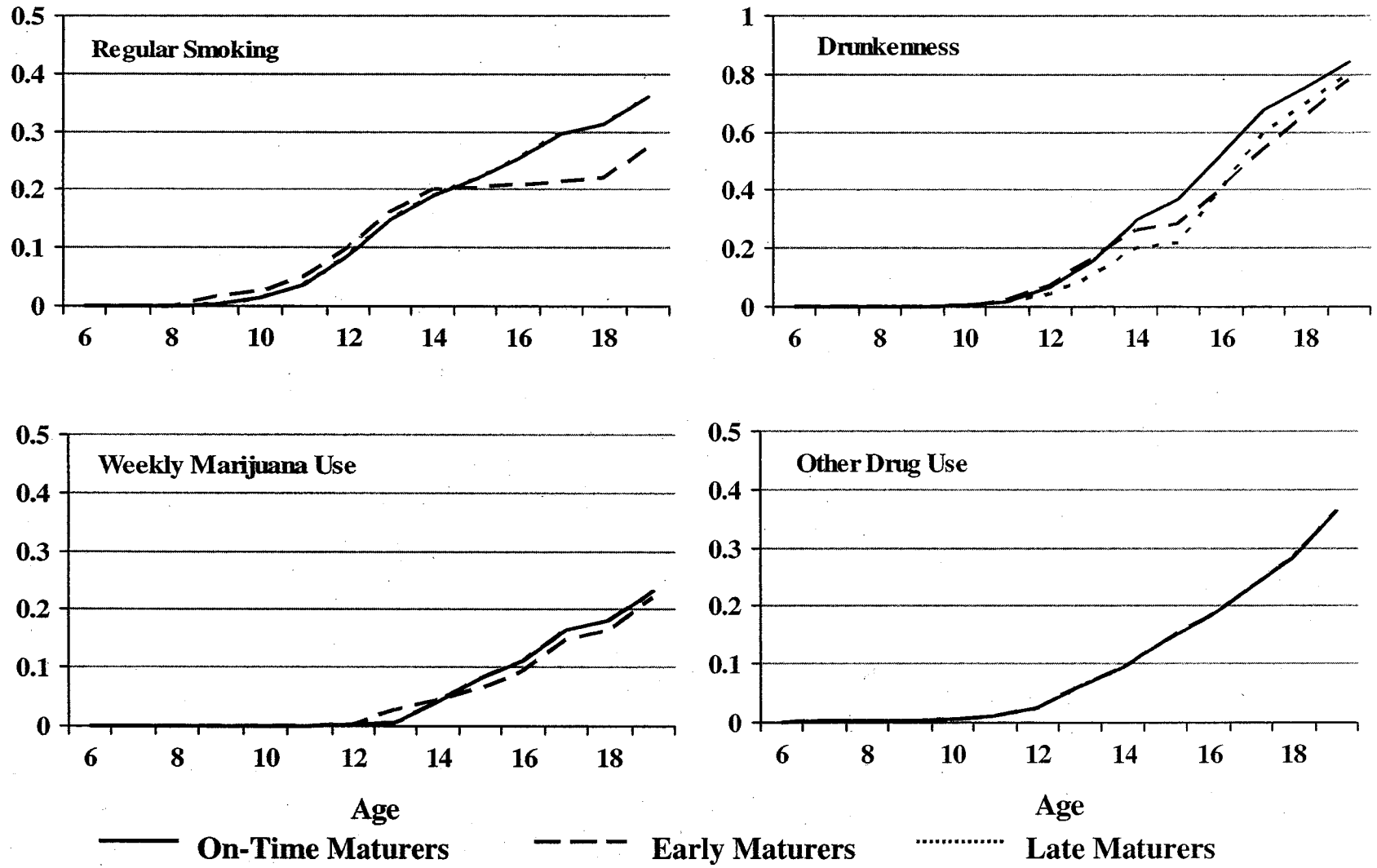

Figure 18 Cumulative probability of initiating regular smoking (top left), drunkenness (top right), weekly marijuana use (bottom left) or other drug use (bottom right) by year of age among females, by pubertal timing group

Concluding Discussion

> *"If the aim [of policy] is to deter [drug use], one needs to know what is to be deterred and within what target group. If the aim is to help people for whom consumption poses a problem, one must have at least an idea of the composition and size of the group in question. And if one is looking for indications that a public policy reduces all use or at-risk use, then knowing the evolution of patterns of use within a population is a requisite".*
>
> *(Senate Special Committee on Illegal Drugs, 2002a)*

The preceding projects provide insight into adolescent substance use rates and patterns, both in Canada and the United States, as well as factors related to use. Project #1 describes the developmental trajectories of smoking and marijuana use among Canadian adolescents. Significant proportions of youth do not initiate smoking (38% of males, 33% of females) or marijuana use (31% of males, 46% of females) before age 19. Among those who do initiate, there are various patterns of continued use, from minimal and infrequent to daily use of substances. Furthermore, project #1 finds that, while males and females may share similar patterns of initiation, the patterns of continued use differ significantly by gender. In addition, members of the various trajectory groups differ significantly in terms of their sociodemographic characteristics.

Project #2 finds that childhood behaviour problems are significantly associated with the initiation of smoking and marijuana use in a sample of U.S. children and youth. Children who exhibited high levels of either externalizing or internalizing behaviour problems were more likely than other children to follow trajectories of early initiation for

both cigarette smoking and marijuana use in adolescence. Conversely, children who exhibited few externalizing or internalizing problems were more likely than other children to abstain from cigarette or marijuana use during adolescence.

Project #3 finds that pubertal timing is significantly associated with the age at which youth initiate problematic use of substances, i.e. daily smoking, drunkenness, weekly use of marijuana and initiation of other substance use. When they differ from youth who mature at a similar pace as their peers (i.e. on-time maturers), late-maturing youth have a lower probability of initiating any of the observed behaviours. This was primarily true for males. Early-maturing youth showed a higher hazard of initiating problematic substance use behaviours in early adolescence, but those who did not initiate prior to age 14 were less likely than on-time maturers to initiate these behaviours thereafter.

The following discussion draws upon the conclusions reached in the preceding projects to address current policy issues. In addition, recommendations are made to improve current surveys that collect substance use data, both in Canada and in the United States. Recommendations are also made for the improvement of substance use surveillance in Canada.

Meeting Policy Goals

Two goals of Canada's Renewed Drug Strategy involve deterring drug use and abuse among youth. In order to meet these goals, it is necessary to identify the national scope of this task. Although Canada does produce substance use data at the provincial

level through various student drug use surveys, these cannot necessarily be pooled to reveal the picture at the national level. While the United States has several large, nationally-representative surveys of substance use among both adults and youth, the NLSCY is the only nationally-representative source of information on the substance use behaviours of youth in Canada.

Based on the results of the preceding studies, the trajectories of initiation among Canadian (project #1) and American (project #2) youth indicate that 60% to 70% of teens will initiate smoking or marijuana use at some point between the ages of 10 and 19. Of particular concern are those trajectories that describe early ages at initiation, i.e. early smokers and early marijuana initiators. Early initiation of substance use has been found to increase the likelihood of developing substance use problems in later life (Hawkins et al., 1992; Hawkins et al., 1997; Kandel et al., 1986). Early initiation has also been linked with increased risk of other health conditions, such as decreased lung function (Apostol et al., 2002), lung cancer (Hegmann et al., 1993), and breast cancer (Marcus et al., 2000). Due to the deleterious consequences associated with early initiation, health and drug use policies may wish to focus particular attention on individuals who follow these trajectories.

However initiation indicates only that a substance was ever consumed: it does not indicate subsequent levels of use. For many adolescents, their lifetime experience of smoking or marijuana use will be limited to one or two occasions when they were compelled by curiosity to try these substances. As shown in project #1, 42% of males and 31% of females who ever tried smoking did not adopt the habit (i.e. ex-smokers) or

only ever smoked once or twice a year. It is important, therefore, to also examine the frequency of use following initiation.

Future Steps

Future steps for projects #1 and #2 may include an examination of the association between substance use initiation trajectories and behaviours or events that occur subsequently in early adulthood. For example, there is a current debate in the literature regarding whether substance experimentation is associated with better or worse psychosocial health than those who abstain from substance use (Ellickson, Martino, & Collins, 2004; Fillmore et al., 1998; Pedersen & Kolstad, 2000; Shedler & Block, 1990) An examination of the previously identified trajectories of initiation with measures of emotional and psychological well-being in early adolescence may aid in clarifying this debate.

A second possibility would be to examine the educational outcomes of adolescents in the early initiating trajectories compared to those of abstainers. The literature suggests that youth who initiate substance use early are more likely than others to engage in other high-risk behaviours, including poor academic achievement and dropping out of school (Ellickson, Tucker, & Klein, 2001; Ellickson, Tucker, & Klein, 2003; Lynskey & Hall, 2000).

A third potential direction for future research would be to conduct a dual trajectory analysis to examine the association between the initiation and frequency of use trajectories. For example, are early initiators more likely than later initiators to engage in

more frequent use of substances? An additional focus would be to examine the overlap between initiation and frequency of use trajectories for different drug types, e.g. smoking and marijuana use.

Typologies of Substance Use

Various researchers and research organizations have developed substance-specific typologies of use in order to categorize and identify individuals who may be at increased risk for health problems, including substance dependence, on the basis of their drug use. For example, Table 25 delineates a four-group typology used by the Observatoire Français des Drogues et des Toxicomanies (French Observatory of Drugs and Drug Addiction) to describe different types of substance users. This typology is based on the number of episodes of use within a given time period.

Table 25 Typologies of substance use developed by the Observatoire Français des Drogues et des Toxicomanies

Type of Consumption	Substance	Frequency of Use
Experimenter	Alcohol	At least once in lifetime
	Tobacco	At least once in lifetime
	Cannabis	At least once in lifetime
	Other illicit drugs	At least once in lifetime
Occasional users	Alcohol	At least once in the past year
	Tobacco	Admit to being active smokers
	Cannabis	At least once in the past year
	Other illicit drugs	At least once in the past year
Repeated users	Alcohol	At least 3 times/week or 10 times/month
	Tobacco	At least 1 cigarette in the past 30 days
	Cannabis	At least 10 times/year
	Other illicit drugs	At least 10 times/year
Daily users	Alcohol	At least 1 glass/day in the last 12 months
	Tobacco	At least 1 cigarette/day currently
	Cannabis	At least 30 times during the last 30 days
	Other illicit drugs	At least 30 times during the last 30 days

Source: (Observatoire Français des Drogues et des Toxicomanies, 2006)

The Canadian Senate Special Committee on Illegal Drug Use has also proposed a cannabis-specific typology of use (Table 26). This typology is more complex than that in Table 25 as it includes a measure of quantity consumed and the social context (environment) within which a substance is consumed. This last inclusion is important given that much substance use begins and is maintained within a social context, particularly for youth. However, use that continues outside of the peer structure and that is undertaken by the individual alone is often used as a marker of dependence.

Table 26 Typology of cannabis use proposed by the Senate Special Committee on Illegal Drugs

Type of Consumption	Environment	Quantity	Frequency	Period of Use and Intensity
Experimental / Occasional	Curiosity	Variable	A few times over a lifetime	None
Regular	Recreational, social; Mainly in evening; Mainly in a group	A few joints; Less than one gram per month	A few times per month	Spread over several years but rarely intensive
At-risk	Recreational and occupational (to got to school, to go to work, for sport, etc.); Alone, in the morning; Under 16 years of age	Between 0.1 and 1 gram per day	A few times per week, evenings, especially weekends	Spread over several years with high intensity periods
Excessive	Occupational and personal problems; No self-regulation of use	Over one gram per day	More than once per day	Spread over several years with several months at a time of high intensity of use

(Senate Special Committee on Illegal Drugs, 2002b)

Projects #1 and #2 utilize a multiple-trajectory methodology to describe patterns of substance use initiation and their on-going use. Assigning a name to these trajectories yields what may be considered a typology of use. However these trajectories differ in important ways from the typologies in Table 25 and Table 26. Firstly, whereas as typologies to describe different levels and type of use are based on criteria that are determined a priori, group-based developmental trajectories take the observed patterns of outcomes and sub-divided these into groups that share similar patterns. As such, for developmental trajectories the data determines the groupings. Secondly, typologies of substance use are generally only valid cross-sectionally because their "boundaries are fluid and users switch from one type of use to another fairly easily" (Senate, p.117). However, trajectories are useful longitudinally as they show whether, when and at what rate individuals shift between typologies of use. In this way, they are a useful tool for distinguishing between individuals who are likely to progress to risky or excessive levels of use and those who engage in occasional, infrequent use of substances. Furthermore, the developmental trajectories described in projects #1 and #2 are useful in identifying those ages within adolescence when youth are most likely to experiment with substance use, and when shifts in levels of use are most likely to occur. Such information is of use to educators and public health officials who are interested in targeting intervention and education programs to those who are most in need of the attention.

Typologies and trajectories can also be complementary. For example, using the typology of cannabis use described in Table 26, we can examine the frequency of marijuana use trajectories in project #1 and determine the ages at which various trajectory

group members are likely to engage in behaviours that match the criteria for regular, at-risk or excessive use.

Who Is At Risk?

The three thesis projects also examine different characteristics that may increase the risk of individuals engaging in levels of substance use that are deemed to be problematic. For example, in project #1 the early increasing user marijuana trajectory was only found among males. Both males and females were characterized by trajectories of increasingly frequent use of marijuana (i.e. increaser trajectories), although males were more likely to follow this trajectory than females (48% versus 21%, respectively).

Results of project #2 indicate that children who exhibit problem behaviours are more likely to initiate substance use earlier than children who exhibit few or no problems. Results of project #3 indicate that early-maturing youth engage in problematic behaviours earlier than on-time or late-maturing youth. However, at later ages, early-maturing youth are no longer at increased risk of engaging in problematic use.

Due to the paucity of national-level substance use data in Canada, specifically among youth, the projects described herein represent a unique look at these behaviours. The NLSCY is a rich source of information on the development of health and behaviour among Canadian children and youth. As the NLSCY continues to add cycles of data, the information inherent in the data becomes richer. Although there were presently not sufficient time points to undertake the examination of childhood behaviour problems and

adolescent substance use, by cycle 7 of the NLSCY (to be collected in 2006-2007) it will be possible to attempt to replicate the results garnered by project #2.

Limitations

The data and methods used in each of the preceding studies were selected on the basis that they were the means by which to best examine the proposed questions. Nevertheless, any method makes assumptions of the data and has inherent limitations that may affect results. Limitations of each study are described in their respective manuscripts. However, overarching limitations are discussed below. These relate to potential limitations of the group-based developmental trajectory method, as well as limitations of the survey data utilized.

Statistically Significant Versus (Clinically) Important Differences

Statistical significance is an indicator of how certain one can be that an effect is not due to chance. It says nothing, however, concerning the magnitude of the effect or difference. Unfortunately, few cut-points analogous to $p<0.05$ have been developed to distinguish 'big' differences from those that are less big. One attempt at quantifying the magnitude of an effect involves the standardized increment, called *effect size* by Cohen (1988), which is defined by

$$\text{standardized increment} = \frac{|\text{mean in group A - mean in group B}|}{\text{average standard deviation}}$$

$$\text{average standard deviation} = \sqrt{\frac{(n_A - 1)s_A^2 + (n_B - 1)s_B^2}{n_A + n_B - 2}}$$

where n_A and n_B are the sample sizes of groups A and B, and s_A^2 and s_B^2 are the variances in groups A and B. The calculation of a standardized increment is also possible for binomial measures, i.e. proportions, and is given by

$$\text{standardized increment (SI)} = \frac{|p_A - p_B|}{\sqrt{PQ}}$$

$$P = \frac{(n_A p_A + n_B p_B)}{n_A + n_B}, Q = 1 - P$$

Cohen defines the strength of effect size in the following manner: 0.2 is small, 0.5 is medium, and 0.8 is large (Feinstein, 1999).

The three thesis studies presented herein are based on surveys that have relatively large samples. This has both advantages and disadvantages. An advantage is that even groups (trajectories) that are proportionately small, e.g. 6% of the sample, contain enough individuals to draw meaningful conclusions. The disadvantage is that of 'statistical dissidence' (Feinstein, 1999) whereby the large sample renders trivial differences statistically significant.

Effect size was not discussed in the preceding thesis projects. One reason for this is that even Cohen's effect size cut-points are simply a matter of convention and may not be any more meaningful than a p-value of 0.05 (Norman, Sloan, & Wyrwich, 2003). Furthermore, the meaning of a particular magnitude of change is driven by the outcome

under investigation. For example, does a 5% increase in the proportion of youth who initiate cigarette smoking mean the same thing from a health or policy perspective as a 5% increase in the proportion of youth initiating crack-cocaine use? Given the potentially greater harm that may arise from the latter behaviour, this result may be more alarming than the former, even though they are measured in the same manner.

Potential Limitations of Group-Based Developmental Trajectories

Nagin's group-based developmental trajectory is a relatively new descriptive and analytic technique that is becoming increasingly popular with researchers. Because it is a new technique, critiques of the methodology are only beginning to emerge. Some researchers have raised concerns over the use of developmental trajectories to describe the patterns of behaviour using longitudinal data, including important commentaries by Raudenbush (2005) and Eggleston, Sampson and Laub (2004; Sampson, Laub, & Eggleston, 2004). Issues addressed by these authors are the sensitivity of developmental trajectory methods to sample size, length of follow-up, and the validity of groups.

There are indications that the number of trajectory groups identified by the group-based procedure may vary with sample size, with larger sample yielding a greater number of groups (Sampson et al., 2004). However, the number of groups seems to plateau for sample sizes of 200 and greater (d'Unger, Land, McCall, & Nagin, 1998; Sampson et al., 2004). Given that the samples in the two studies using this procedure were well above this threshold, often in the thousands, the number of groups ought to be relatively stable for the time period examined.

The length of follow-up may also affect the number and shape of trajectories. In general, the longer the period of follow-up, the greater the number of trajectory groups that may be identified. The shape and age at peak behaviour may also shift (Eggleston, Laub, & Sampson, 2004). This is particularly true if behaviour is ongoing: the longer the period of observation, the greater the likelihood of recording change in behaviour. However, this becomes a problem only if the trajectories are used to extrapolate outside of the time period examined (Nagin, 2004; Nagin & Tremblay, 2005a; Nagin & Tremblay, 2005b). This is a danger of using trajectories to project behaviour into the future. In actuality, trajectories only model the patterns of behaviour that have been observed, i.e. the behaviour that has transpired prior to and including the present. This limitation applies equally to other analytic techniques using longitudinal data, not just group-based trajectory modeling. Hierarchical linear models and growth curves will equally fall prey to the temptation to extrapolate outside of the observed period, and may equally alter in their appearance if individuals are followed for a longer period of time.

Limitations of the Data: Recommendations for Future Content

Each of the preceding studies conducted a secondary analysis of previously collected data. Given that the research questions posed by this thesis were not the primary objectives of either survey, it is not unexpected that the data were limited in certain ways to answer the study questions. Nevertheless, it may be helpful for future waves of the NLSCY and the NLSY79-C, as well as for the planning of other surveys to

be conducted in the future, to examine aspects that were missing in the data and to recommend ways to improve future data collection.

Most surveys that examine substance use include questions regarding the use of cigarettes; however few include questions regarding the use of tobacco products other than cigarettes, such as smokeless tobacco, cigars or cigarillos. Surveys that have asked youth to report their use of such substances have found that adolescents use non-cigarette tobacco products at non-negligible rates. For example, the Youth Risk Behaviour Survey (YRBS) found that 8.0% of students had used smokeless tobacco (e.g. chewing tobacco, snuff, or dip) and 14.0% had smoked cigars or cigarillos in the 30 days prior to the survey (Centers for Disease Control and Prevention, 2006). Student drug use surveys in the Atlantic Canadian provinces also include questions regarding the use of tobacco products other than cigarettes and have found that between 13% and 15.5% of Atlantic students had smoked cigars or pipes in the year prior to survey, and between 2% and 4.8% had chewed tobacco (Liu, Jones, Grobe, Balram, & Poulin, 2002; Poulin, 2002; Poulin, Martin, & Murray, 2005; Van Til & Poulin, 2002). Although use of tobacco products other than cigarettes is primarily a male-specific behaviour (Centers for Disease Control and Prevention, 2006; Johnston, O'Malley, Bachman, & Schulenberg, 2006; Liu et al., 2002; Poulin, 2002; Poulin et al., 2005; Van Til & Poulin, 2002), and that few users of such products don't also use cigarettes (5.4% of students reported using non-cigarette tobacco products but not cigarettes in the 2005 YRBS), the omission of this substance category may underestimate the frequency of youth's smoking behaviour.

Recommendation #1: Include questions related to the use of tobacco products other than cigarettes, such as chewing tobacco, cigars or cigarillos, in surveys of substance use.

Many surveys of substance use ask respondents about their lifetime and current use of a small number of drugs, and finish by asking the respondent if they have ever used any other drugs. This is useful from a practical standpoint to limit survey length and the resultant respondent burn-out. However, though the nature and meaning of this catch-all "other drug" category may often be of interest to researchers or policy makers, the specific drugs contained in that group cannot be identified or distinguished from one another. The reported use of other drugs is often not as high as the use of tobacco, alcohol or marijuana, but this should not be interpreted as an indication that their use is not a reason for concern. These other drugs are often illicit, e.g. cocaine or heroin, and their use may indicate a problem of dependence. Furthermore, collecting data regarding low-prevalence substances provides a baseline measure and a means of determining whether use of particular substances is becoming more common, and whether new drugs that weren't previously on the radar are becoming more popular. For example, several newspaper and news wire stories report the increasing prevalence of the prescription medication OxyContin® as a street drug in the United States (Carpenter, 2006; Doup, 2006; McKenna, 2006). In the 2005 Monitoring the Future survey, the annual prevalence of OxyContin use among 12th graders was 5.5%, an increase of 40% over 2002. As the authors of the survey point out, "considering the addictive potential of this drug, this rate seems quite high for [youth] to have attained" (Johnston et al., 2006). In Canada, OxyContin is the number one street drug in Cape Breton (Moulton, 2003). Provincial

health premiers, stakeholders and leaders in the Atlantic provinces were so concerned about the escalation in the number of deaths due to Oxycontin overdose in their provinces that they asked Health Canada to investigate the issue (Office of Controlled Substances, 2005; OxyContin Task Force, 2004). The Ontario Student Drug Use Survey first asked students about use of OxyContin in 2005: 1.0% of students reported using OxyContin in the past year, which represents approximately 10,200 students in Ontario (Adlaf & Paglia-Boak, 2005; Adlaf, Paglia-Boak, & Brands, 2006).

Recommendation #2: Include a greater number of drug-specific questions to address the prevalence of use of particular substances, even if use is not thought to be high.

Recommendation #3: Include a checklist of other drugs so that respondents may indicate which substances they have used. Such information may be informative for future versions of the survey.

Recommendation #4: Include a text-field where respondents can write (or type) the names of other drugs that they have used. This would serve both to increase awareness of other drugs that are used in the population, as well as to verify responses in other categories.

Although substance use initiation and frequency of use were considered in the preceding studies, the quantity used per occasion was not examined, e.g. the number of cigarettes smoked daily, the number of drinks consumed per occasion, the number of marijuana joints smoked per occasion or daily, etc. For example, among daily smokers there will be variation in the number of times a day that an individual smokes. Also, for use of alcohol it may be important to distinguish light-infrequent drinkers from heavy-infrequent drinkers. Such information would also allow for an examination of binge drinking, often defined as five or more drinks on a given occasion.

The NLSCY only collects quantity information for cigarettes, e.g. "on the days that you smoke, about how many cigarettes do you usually smoke?", but not for other substances. The NLSY79-C collects quantity information for cigarettes and alcohol only, e.g. "on the days that you smoked in the last 30 days, how many cigarettes per day did you smoke?", "on the days that you drank alcoholic beverages (including beer, wine, and liquor) in the last 30 days, how many drinks per day did you usually have?". Additionally, the NLSY79-C self-administered questionnaire for youth aged 15 and up includes questions that assess problem-drinking and marijuana dependence.

> *Recommendation #5: Include questions that assess the average amount of each substance that is used daily or on each occasion of use. Assess use using a metric of time that is appropriate for the substance under investigation.*

The results of the three projects described herein also indicate that substance use is a behaviour that not only evolves during adolescence, but also evolves as the individual enters young adulthood. The non-smoker and marijuana non-user trajectories described in project #1 are prime examples. The slight increase in the probability of initiation at ages 18 and 19 indicates that members of these trajectories may go on to initiate these behaviours in early adulthood. However, one cannot extrapolate trajectories outside of the time frame for which behaviours are observed. Therefore, longitudinal studies such as the NLSCY and the NLSY79-C need to follow these youth into adulthood to examine whether behaviours are maintained, whether they desist or whether they escalate. The NLSY79-C currently includes respondents who are in their 20s, and has interviewed them regarding their post-secondary education and work experience, as well as their

marriages and any children they may have. There is currently no indicated age at which NLSY79-C respondents will no longer be followed. The initial plan for the NLSCY was to follow children up to age 25; the maximum age of respondents currently in the NLSCY was 19 years as of 2002/03. It will remain to be seen how many more cycles of the NLSCY are undertaken, and how many young adults contribute information to the survey.

> *Recommendation #6: Follow youth, not only through adolescence, but also into adulthood. This allows for an examination of the long-term patterns of substance use and the changes that occur over time in these behaviours.*

Youth who are only familiar with the street names of substances and not more technical descriptors may not report their use of a particular substance. For example, adolescents are more likely to know the terms "crystal meth" or "crank" than they are to be familiar with the term "methamphetamine", even though they refer to the same substance. Alternately, youth may report the use of a particular substance category without fully understanding the meaning. For example, Johnson and O'Malley (1997) found that recanting of substance use was more common for tranquilizers and barbiturates than for marijuana or cocaine, and that the definitions of the former substances were likely less clear to respondents than the latter.

> *Recommendation #7: Use common and slang terms for substances in addition to or in lieu of more technical terms in order to improve youth's comprehension of the questions and encourage more accurate reporting.*

A further limitation of many surveys of youth substance use is that teens may not regard certain products as drugs, and therefore do not report their use, even if they ought

to. For example, "dusting" is the practice of inhaling aerosolized computer keyboard cleaners that contain compressed gas. Many teens do not consider this practice to be substance use, even if probed regarding the use of inhalants, because they believe that they are simply inhaling oxygen. However, the high from the gas paralyzes the user for several minutes and gives a feeling of euphoria. This practice was dramatized in the openings scene of the movie "Thirteen".

Recommendation #8: Include a question that seeks to elicit information about any other behaviour the youth undertakes in order to experience a euphoria or high. E.g. 'Is there anything else you do or substance that you use to get stoned or high?'

Limitations: Recommendations for the Surveillance of Drug Use in Canada

As indicated in the introduction, there is a paucity of information in Canada regarding the drug use of Canadians. Previous efforts to derive national-level prevalence estimates have occurred sporadically. The most recent survey, the Canadian Addiction Survey (CAS), is promising, but must be repeated if its true value is to be realized. However, the CAS is not designed to include adolescents under the age of 15. Given data available from provincial-level student drug use surveys, we know that there are non-negligible proportions of youth who initiate and maintain use of substances before they reach age 15. Therefore, the CAS misses the opportunity to monitor use of these young and vulnerable citizens.

Recommendation #9: Ensure on-going funding and support for the Canadian Addiction Survey, which may serve to provide national-level data on the substance use of youth and adults in Canada.

Because health issues in Canada are ultimately the responsibility of provincial governments, it is sensible to have drug use surveillance data at the provincial level. Currently seven provinces undertake student drug use surveys. It would be beneficial if all provinces and territories collected data on the drug using experiences of students. Furthermore, to increase comparability between student surveys, it would be useful for the content to be similar across provincial student drug use surveys. Students in the Atlantic provinces currently complete the same survey, rendering the collected data easily comparable.

> *Recommendation #10: Implement student drug use surveys in those provinces and territories where such surveys are lacking. Where possible, include comparable content in all surveys.*

Longitudinal data offers significant insight into the developmental course of behaviours. Although the NLSCY is not intended as an in-depth survey of adolescent drug use, it offers the best (and only) source of longitudinal information that covers the issue of adolescent substance use in Canada. There are currently processes that are evaluating the value of continued collection of longitudinal information by Statistics Canada: this includes the NLSCY. It is important to note that, should the NLSCY be discontinued, not only would we lose the only national-level data of substance use among youth, but we would also lose the only survey that evaluates the health and well-being of children in Canada.

> *Recommendation #11: Maintain funding and content support for the National Longitudinal Survey of Children and Youth in Canada.*

Summary of Recommendations

1. Include questions related to the use of tobacco products other than cigarettes, such as chewing tobacco, cigars or cigarillos, in surveys of substance use.
2. Include a greater number of drug-specific questions to address the prevalence of use of particular substances, even if use is not thought to be high.
3. Include a checklist of other drugs so that respondents may indicate which substances they have used. Such information may be informative for future versions of the survey.
4. Include a text-field where respondents can write (or type) the names of other drugs that they have used. This would serve both to increase awareness of other drugs that are used in the population, as well as to verify responses in other categories.
5. Include questions that assess the average amount of each substance that is used daily or on each occasion of use. Assess use using a metric of time that is appropriate for the substance under investigation.
6. Follow youth, not only through adolescence, but also into adulthood. This allows for an examination of the long-term patterns of substance use and the changes that occur over time in these behaviours.

7. Use common and slang terms for substances in addition to or in lieu of more technical terms in order to improve youth's comprehension of the questions and encourage more accurate reporting.
8. Include a question that seeks to elicit information about any other behaviour the youth undertakes in order to experience a euphoria or high. E.g. 'Is there anything else you do or substance that you use to get stoned or high?'
9. Ensure on-going funding and support for the Canadian Addiction Survey, which may serve to provide national-level data on the substance use of youth and adults in Canada.
10. Implement student drug use surveys in those provinces and territories where such surveys are lacking. Where possible, include comparable content in all surveys.
11. Maintain funding and content support for the National Longitudinal Survey of Children and Youth in Canada.

References

Adlaf, E. M. & Paglia-Boak, A. (2005). *Drug use among Ontario students 1977-2005: Detailed OSDUS findings.* Toronto, ON: Centre for Addiction and Mental Health.

Adlaf, E. M., Paglia-Boak, A., & Brands, B. (2006). Use of OxyContin by adolescent students. *Canadian Medical Association Journal, 174,* 1303.

Apostol, G. G., Jacobs, D. R., Tsai, A. W., Crow, R. S., Williams, O. D., Townsend, M. C. et al. (2002). Early life factors contribute to the decrease in lung function between ages 18 and 40: The coronary artery risk development in young adults study. *American Journal of Respiratory and Critical Care Medicine, 166,* 166-172.

Carpenter, N. (2006, July 14). Powerful problem: Illegal use of OxyContin is making its mark in eastern Idaho. *Idaho Falls Post Register.*

Centers for Disease Control and Prevention (2006). Youth Risk Behavior Surveillance — United States, 2005. *Morbidity and Mortality Weekly Report, 55,* 1-108.

Cohen, J. (1988). *Statistical Power Analysis for the Behavioral Sciences.* (2nd edition ed.) Hillsdale,NJ: L. Erlbaum Associates.

d'Unger, A. V., Land, K. C., McCall, P. L., & Nagin, D. S. (1998). How many latent classes of delinquent/criminal careers? Results from mixed Poisson regression analyses. *American Journal of Sociology, 103,* 1593-1630.

Doup, L. (2006, April 24). Teens swapping legal drugs at 'pharming' parties. *South Florida Sun-Sentinel.*

Eggleston, E. P., Laub, J. H., & Sampson, R. J. (2004). Methodological sensitivities to latent class-analysis of long-term criminal trajectories. *Journal of Quantitative Criminology, 20,* 1-26.

Ellickson, P. L., Martino, S. C., & Collins, R. L. (2004). Marijuana use from adolescence to young adulthood: Multiple developmental trajectories and their associated outcomes. *Health Psychology, 23,* 299-307.

Ellickson, P. L., Tucker, J. S., & Klein, D. J. (2001). High-risk behaviors associated with early smoking: Results from a 5-year follow-up. *Journal of Adolescent Health, 28,* 465-473.

Ellickson, P. L., Tucker, J. S., & Klein, D. J. (2003). Ten-year prospective study of public health problems associated with early drinking. *Pediatrics, 111,* 949-955.

Feinstein, A. R. (1999). Indexes of contrast and quantitative significance for comparisons of two groups. *Statistics in Medicine, 18,* 2557-2581.

Fillmore, K. M., Golding, J. M., Graves, K. L., Kniep, S., Leino, E. V., Romelsjo, A. et al. (1998). Alcohol consumption and mortality. I. Characteristics of drinking groups. *Addiction, 93,* 183-203.

Hawkins, J. D., Catalano, R. F., & Miller, J. Y. (1992). Risk and protective factors for alcohol and other drug problems in adolescence and early adulthood: Implications for substance abuse prevention. *Psychol.Bull., 112,* 64-105.

Hawkins, J. D., Graham, J. W., Maguin, E., Abbott, R., Hill, K. G., & Catalano, R. F. (1997). Exploring the effects of age of alcohol use initiation and psychosocial risk factors on subsequent alcohol misuse. *J.Stud.Alcohol, 58,* 280-290.

Hegmann, K. T., Fraser, A. M., Keaney, R. P., Moser, S. E., Nilasena, D. S., Sedlars, M. et al. (1993). The effect of age at smoking initiation on lung-cancer risk. *Epidemiology, 4,* 444-448.

Johnson, L. D. & O'Malley, P. M. (1997). The recanting of earlier reported drug use by young adults. The validity of self-reported drug use: Improving the accuracy of survey estimates. *NIDA Research Monograph, 167,* 59-80.

Johnston, L. D., O'Malley, P. M., Bachman, J. G., & Schulenberg, J. E. (2006). *Monitoring the Future: National survey results on drug use -- Overview of key findings, 2005.* Bethesda, MD: National Institute on Drug Abuse.

Kandel, D., Simchafagan, O., & Davies, M. (1986). Risk-factors for delinquency and illicit drug-use from adolescence to young adulthood. *Journal of Drug Issues, 16,* 67-90.

Liu, J., Jones, B., Grobe, C., Balram, C., & Poulin, C. (2002). *New Brunswick Student Drug Use Survey 2002: Highlights Report.*

Lynskey, M. & Hall, W. (2000). The effects of adolescent cannabis use on educational attainment: A review. *Addiction, 95,* 1621-1630.

Marcus, P. M., Newman, B., Millikan, R. C., Moorman, P. G., Baird, D. D., & Qaqish, B. (2000). The associations of adolescent cigarette smoking, alcoholic beverage consumption, environmental tobacco smoke, and ionizing radiation with subsequent breast cancer risk (United States). *Cancer Causes & Control, 11,* 271-278.

McKenna, P. (2006, July 14). OxyContin panel seeks tougher tracking. *The Boston Globe.*

Moulton, D. (2003). "Hillbilly heroin" arrives in Cape Breton. *Canadian Medical Association Journal, 168,* 1172.

Nagin, D. S. (2004). Response to "Methological sensitivities to latent class analysis of long-term criminal trajectories. *Journal of Quantitative Criminology, 20,* 27-35.

Nagin, D. S. & Tremblay, R. E. (2005a). Developmental trajectory groups: Fact of a useful statistical fiction? *Criminology, 43,* 873-904.

Nagin, D. S. & Tremblay, R. E. (2005b). What has been learned from group-based trajectory modeling? Examples from physical aggression and other problem behaviors. *Annals of the American Academy of Political and Social Science, 602,* 82-117.

Norman, G. R., Sloan, J. A., & Wyrwich, K. W. (2003). Interpretation of changes in health-related quality of life: The remarkable universality of half a standard deviation. *Medical Care, 41,* 582-592.

Observatoire Français des Drogues et des Toxicomanies (2006). *Drugs and Dependence: Indicators and Trends in 2002.* Paris: Observatoire Français des Drogues et des Toxicomanies.

Office of Controlled Substances, H. C. (2005). *Report on the Review of Sales Transactions for Oxycodone-based Products in Atlantic Canada (Retail Pharmacies Only)* Ottawa, ON: Health Canada.

OxyContin Task Force (2004). *OxyContin Task Force Final Report.*

Pedersen, W. & Kolstad, A. (2000). Adolescent alcohol abstainers: Traditional patterns in new groups. *Acta Sociologica, 43,* 219-233.

Poulin, C. (2002). *Nova Scotia Student Drug Use 2002: Technical Report.* Dalhousie University.

Poulin, C., Martin, D. S., & Murray, M. (2005). *Newfoundland and Labrador Student Drug Use 2003: Summary Report.* St. John: Dalhousie University.

Raudenbush, S. W. (2005). How do we study "what happens next"? *Annals of the American Academy of Political and Social Science, 602,* 131-144.

Sampson, R. J., Laub, J. H., & Eggleston, E. P. (2004). On the robustness and validity of groups. *Journal of Quantitative Criminology, 20,* 37-42.

Senate Special Committee on Illegal Drugs (2002a). *Cannabis: Our position for a Canadian public policy: Report of the Senate Special Committee on Illegal Drugs, Vol. I, Parts I and II.* Ottawa: Senate of Canada.

Senate Special Committee on Illegal Drugs (2002b). *Cannabis: Our position for a Canadian public policy: Report of the Senate Special Committee on Illegal Drugs, Vol. III, Part IV and Conclusions.* Ottawa: Senate of Canada.

Shedler, J. & Block, J. (1990). Adolescent drug use and pscyhological health: A longitudinal inquiry. *American Psychologist, 45,* 612-630.

Van Til, L. & Poulin, C. (2002). *2002 PEI Student Drug Survey: Highlights Report.* Charlottetown: Department of Health and Social Services.

Appendix A: Recoding of Substance Use Questions in the National Longitudinal Survey of Children and Youth (NLSCY)

Table 27 Recoding of frequency of smoking questions from the NLSCY

Year (variable)	Frequency of smoking	Old Code	New Code
1994	I do not smoke, or only tried once or twice	1	0
(AG1CQ02)	Every day	2	4
If you do smoke, how often do you smoke cigarettes?	At least once or twice a week but not every day	3	3
	At least once or twice a month but not every week	4	2
	A few times a year	5	1
	Once or twice a year	6	1
1996	I only tried once or twice	1	0
(BDRCbQ02)	Every day	2	4
If you do smoke, how often do you smoke cigarettes?	About once or twice a week	3	3
	About once or twice a month	4	2
	A few times a year	5	1
	I do not smoke now	6	0
1998	I do not still smoke		0
(CDRCcQ2A)	A few times a year	1	1
Do you still smoke cigarettes?	About once or twice a month	2	2
(CDRCcQ02)	About once or twice a week	3	3
How often do you smoke cigarettes?	About 3 to 5 times a week	4	3
	Every day	5	4
2000	I have never smoked	1	.
(DDRCdQ01)	I have only had a few puffs	2	0
Which of the following best describes your experience with smoking cigarettes?	I do not smoke anymore	3	0
	A few times a year	4	1
	About once or twice a month	5	2
	About 1-2 days a week	6	3
	About 3-5 days a week	7	3
	About 6-7 days a week	8	4
2002	I have never smoked	1	.
(EDRCdQ01)	I have only had a few puffs	2	0
Which of the following best describes your experience with smoking cigarettes?	I do not smoke anymore	3	0
	A few times a year	4	1
	About once or twice a month	5	2
	About 1-2 days a week	6	3
	About 3-5 days a week	7	3
	About 6-7 days a week	8	4

Note. The new codes for frequency of smoking refer to the following: 0=I do not smoke, or only tried once or twice, 1=I smoke a few times a year, 2=I smoke at least once or twice a month but not every week, 3=I smoke at least once or twice a week but not every day, 4=I smoke every day

Table 28 Recoding of frequency of alcohol use questions from the NLSCY

Year (variable)	Frequency of alcohol use	Old Code	New Code
1994 (AG1CQ08) If you drink anything alcoholic such as wine, liquor or beer, how often do you do so?	I do not drink alcohol, or only tried once or twice	1	0
	Every day	2	4
	At least once or twice a week but not every day	3	3
	At least once or twice a month but not every week	4	2
	A few times a year	5	1
	Once or twice a year	6	1
1996 (BDRCbQ08) If you drink anything alcoholic, how often do you do so?	I only tried once or twice	1	4
	Every day	2	4
	About once or twice a week	3	3
	About once or twice a month	4	2
	A few times a year	5	1
	I do not drink alcohol now	6	0
1998 (CDRCcQ8A) Do you still drink alcohol? **(CDRCcQ08)** If you drink alcohol, how often do you do so?	I no longer drink alcohol		0
	A few times a year	1	1
	About once or twice a month	2	2
	About once or twice a week	3	3
	About 3 to 5 times a week	4	3
	Every day	5	4
2000 (DDRCdQ6A) Which of the following best describes your experience with drinking alcohol?	I have never had a drink of alcohol	1	.
	I have only had a few sips	2	.
	I only tried once or twice (at least 1 drink)	3	0
	I do not drink alcohol anymore	4	0
	A few times a year	5	1
	About once or twice a month	6	2
	About 1-2 days a week	7	3
	About 3-5 days a week	8	3
	About 6-7 days a week	9	4
2002 (EDRCdQ6A)[a] Which of the following best describes your experience with drinking alcohol?	I have never had a drink of alcohol	1	.
	I have only had a few sips	2	.
	I only tried once or twice (at least 1 drink)	3	0
	I do not drink alcohol anymore	4	0
	A few times a year	5	1
	About once or twice a month	6	2
	About 1-2 days a week	7	3
	About 3-5 days a week	8	3
	About 6-7 days a week	9	4

Note. The new codes for frequency of alcohol use refer to the following: 0=I do not drink anymore, or only tried once or twice, 1=I drink a few times a year, 2=I drink at least once or twice a month but not every week, 3=I drink at least once or twice a week but not every day, 4=I drink every day

[a] Question EDRCdQ6A asked only of those ages 12 to 19

Table 29 Recoding of frequency of marijuana use questions from the NLSCY

Year (variable)	Frequency of marijuana use	Old Code	New Code
1996 (BDRCb11A) How often do you use marijuana or hash?	I only tried once or twice	1	0
	Every day	2	4
	About once or twice a week	3	3
	About once or twice a month	4	2
	A few times a year	5	1
1998 **(CDRCc11A)** **(CDRCcQ17)** In the last 12 months, how often did you do marijuana and cannabis product (also known as joint, pot, grass or hash)?	I have not done it in the last 12 months or I have never done it	1	0
	I only tried it once or twice	2	0
	A few times a year	3	1
	About once or twice a month	4	2
	About once or twice a week	5	3
	About 3 to 5 times a week	6	3
	Every day	7	4
2000 **(DDRCdQ15)**[a] Which of the following best describes your experience with using marijuana and cannabis products (also known as a joint, pot, grass or hash) during the past 12 months?	I have never done it	1	.
	I have done it, but not in the past 12 months	2	0
	A few times	3	1
	About once or twice a month	4	2
	About 1-2 days a week	5	3
	About 3-5 days a week	6	3
	About 6-7 days a week	7	4
2002 **(EDRCdQ15)**[b] Which of the following best describes your experience with using marijuana and cannabis products (also known as a joint, pot, grass or hash) during the past 12 months?	I have never done it	1	.
	I have done it, but not in the past 12 months	2	0
	A few times	3	1
	About once or twice a month	4	2
	About 1-2 days a week	5	3
	About 3-5 days a week	6	3
	About 6-7 days a week	7	4

Note. Frequency of use questions asked only of those aged 12+ in 2000 and 2002. The new codes for frequency of marijuana use refer to the following: 0=I have note used marijuana in the past year, or only tried once or twice, 1=I use marijuana a few times a year, 2=I use marijuana at least once or twice a month but not every week, 3=I use marijuana at least once or twice a week but not every day, 4=I use marijuana every day

[a] Question DDRCdQ15 asked only of 12-17 year-olds

[b] Question EDRCdQ15 asked only of 12-19 year-olds

Table 30 Recoding of frequency of other drug use questions from the NLSCY

Year	Variable & Substance	Frequency of use	Old Code	New Code
1996	**BDRCb11B:** Glue or solvents?*	I only tried once or twice	1	0
	BDRCb11D: Hallucinogens (LSD/acid)?†	Every day	2	4
	BDRCb11E: Crack/cocaine?†	About once or twice a week	3	3
	BDRCb11C: Other drugs?*	About once or twice a month	4	2
	BDRCb11F: Other drugs?†	A few times a year	5	1
1998	**CDRCc11B:** Glue or solvents?†	Not done it in last 12 months or I have never done it	1	0
	CDRCc18B: Glue or solvents?‡			
	CDRCc18A : Hallucinogens?‡	I only tried it once or twice	2	0
	CDRCc18C: Drugs without a prescription? ‡	A few times a year	3	1
		About once or twice/ month	4	2
	CDRCc11C: Other drugs?†	About once or twice/week	5	3
	CDRCc18D: Other drugs? ‡	About 3 to 5 times a week	6	3
		Every day	7	4
2000	**DDRCc18A:** Hallucinogens?	I have never done it	1	
	DDRCd18B: Glue or solvents?	I have not done it in the past 12 months	2	
	DDRCd18C: Drugs without a prescription?	1-2 times	3	
	DDRCc18D: Other drugs?	3-5 times	4	
		6-9 times	5	
		10 or more times	6	
2002	**EDRCc18A:** Hallucinogens?	I have never done it	1	
	EDRCd18B: Glue or solvents?	I have not done it in the past 12 months	2	
	EDRCd18C: Drugs without a prescription?	1-2 times	3	
	EDRCc18D: Other drugs?	3-5 times	4	
		6-9 times	5	
		10 or more times	6	

Note. When coding 'other drug use', the category of drugs that is reportedly used most frequently is used as the primary measure.

* Asked only of those ages 10-11
† Asked only of those ages 12-13
‡ Asked only of those ages 14-15

Appendix B: Recoding of Substance Use Questions in the National Longitudinal Survey of Youth 1979 – Children and Young Adults Data (NLSY79-C)

Table 31 Recoding of frequency of smoking questions from the NLSY79-C

Year	Child or Youth	Recentness		Past month frequency		New code
1994	Child (C1369300, C1369400)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-12 months ago	3	→→→→→→→→→→→→		1
		More than 1 year ago	4	→→→→→→→→→→→→		0
		Never	5	→→→→→→→→→→→→		.
	Youth (Y0364500, Y0364600)	Less than one month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Did not smoke past month	6	.
		1-12 months ago	2	→→→→→→→→→→→→		1
		More than 1 year, less than 4	3	→→→→→→→→→→→→		0
		4 or more yrs	4	→→→→→→→→→→→→		0
1996	Child (C1591700, C1591800)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.
	Youth (Y0658500, Y0658600)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.

Year	Child or Youth	Recentness		Past month frequency		New code
1996 cont'd	Youth (Y0658500, Y0658600)	1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.
1998	Child (C1932400, C1932500)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
	Youth (Y08954400, Y08954500)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.
2000	Child (C2471600, C2471700)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	0	→→→→→→→→→→→→		.

Year	Child or Youth	Recentness		Past month frequency		New code
2000 cont'd	Youth (Y1168300, Y1168400)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.
2002	Child (C2769400, C2769500)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
	Youth (Y1407400, Y1407500)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.

Note. The new codes for frequency of smoking refer to the following: 0=I have not smoked in the last year, 1=I smoke a few times a year, 2=I smoke at least once or twice a month but not every week, 3=I smoke at least once or twice a week but not every day (1-4 days per week), 4=I smoke every day (5-7 days per week).

Table 32 Recoding of frequency of alcohol use questions from the NLSY79-C, Children (ages 10 through 14)

Year	Child Variables	Recentness		Past month frequency		New code
1994	C1369800	Past month	1	Less than once a week	1	2
	C1369900			1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-12 months ago	3	→→→→→→→→→→→→		1
		More than 1 year ago	4	→→→→→→→→→→→→		0
		Never	5	→→→→→→→→→→→→		.
1996	C1592200	Past month	1	Less than once a week	1	2
	C1592300			1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.
1998	C1932900	Past month	1	Less than once a week	1	2
	C1933000			1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.
2000	C2472100	Past month	1	Less than once a week	1	2
	C2472200			1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.

Year	Child Variables	Recentness		Past month frequency		New code
2000 cont'd	C2472100 C2472200 cont'd	1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	0	→→→→→→→→→→→→		.
2002	C2770100 C2770200	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0

Note. The new codes for frequency of drinking refer to the following: 0=I have not had a drink in the last year, 1=I drink a few times a year, 2=I drink at least once or twice a month but not every week, 3=I drink at least once or twice a week but not every day (1-6 days per week), 4=I drink every day (7 days per week).

Table 33 Recoding of frequency of alcohol use questions from the NLSY79-C, Youth (ages 15 and up)

Year	Youth Variables	Recentness		Average Drinking in Past Year		New code
1994	Y0359000 Y0359600	Past month	1	Did not drink alcohol in the past 12 months	1	0
				1-2 days in the past 12 months	2	1
				3-5 days in the past 12 months	3	1
		1-6 months ago	2	Every other month or so (6-11 days a year)	4	1
				1-2 times a month (12-24 days a year)	5	2
				Several times a month (25-51 days a year)	6	2
		6-12 months ago	3	1 or 2 days a week	7	3
				3 to 6 days a week	8	3
				Daily	9	4
		1 to 3 years ago	4	→→→→→→→→→→→→→→→→→→→		0
		3 or more yrs	5	→→→→→→→→→→→→→→→→→→→		0
1996	Y0653100 Y0653700	Past month	1	Did not drink alcohol in the past 12 months	1	0
				1-2 days in the past 12 months	2	1
				3-5 days in the past 12 months	3	1
		1-6 months ago	2	Every other month or so (6-11 days a year)	4	1
				1-2 times a month (12-24 days a year)	5	2
				Several times a month (25-51 days a year)	6	2
		6-12 months ago	3	1 or 2 days a week	7	3
				3 to 6 days a week	8	3
				Daily	9	4
		1 to 3 years ago	4	→→→→→→→→→→→→→→→→→→→		0
		3 or more yrs	5	→→→→→→→→→→→→→→→→→→→		0

Year	Youth Variables	Recentness		Average Drinking in Past Year		New code
1998	Y0949200 Y0949800	Past month	1	Did not drink alcohol in the past 12 months	1	0
				1-2 days in the past 12 months	2	1
				3-5 days in the past 12 months	3	1
		1-6 months ago	2	Every other month or so (6-11 days a year)	4	1
				1-2 times a month (12-24 days a year)	5	2
				Several times a month (25-51 days a year)	6	2
		6-12 months ago	3	1 or 2 days a week	7	3
				3 to 6 days a week	8	3
				Daily	9	4
		1 to 3 years ago	4	→→→→→→→→→→→→→→→→→		0
		3 or more yrs	5	→→→→→→→→→→→→→→→→→		0
2000	Y1165500			Did not drink alcohol in the past 12 months	1	0
				1-2 days in the past 12 mo.	2	1
				3-5 days in the past 12 mo.	3	1
				Every other month or so (6-11 days a year)	4	1
				1-2 times a month (12-24 days a year)	5	2
				Several times a month (25-51 days a year)	6	2
				1 or 2 days a week	7	3
				3 to 6 days a week	8	3
				Daily	9	4
2002	Y1404600			Did not drink alcohol in the past 12 months	1	0
				1-2 days in the past 12 mo.	2	1
				3-5 days in the past 12 mo.	3	1
				Every other month or so (6-11 days a year)	4	1
				1-2 times a month (12-24 days a year)	5	2
				Several times a month (25-51 days a year)	6	2
				1 or 2 days a week	7	3
				3 to 6 days a week	8	3
				Daily	9	4

Note. The new codes for frequency of drinking are the same as those given in Table 32

Table 34 Recoding of frequency of marijuana use questions from the NLSY79-C

Year	Child or Youth	Recentness		Past month frequency		New code
1994	Child (C1370300, C1370400)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-12 months ago	3	→→→→→→→→→→→→		1
		More than 1 year ago	4	→→→→→→→→→→→→		0
		Never	5	→→→→→→→→→→→→		.
	Youth (Y0365000, Y0365100)	Less than one month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Did not smoke past month	6	.
		1-12 months ago	2	→→→→→→→→→→→→		1
		More than 1 year, less than 4	3	→→→→→→→→→→→→		0
		4 or more yrs	4	→→→→→→→→→→→→		0
1996	Child (C1592700, C1592800)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.
	Youth (Y0659000, Y0659100)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.

Year	Child or Youth	Recentness		Past month frequency		New code
1996 cont'd	Youth (Y0659000, Y0659100)	1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.
1998	Child (C1933500, C1933600)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
	Youth (Y0955000, Y0955100)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.
2000	Child (C2472700, C2472800)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	0	→→→→→→→→→→→→		.

Year	Child or Youth	Recentness		Past month frequency		New code
2000 cont'd	Youth (Y1168800, Y1170700)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.
2002	Child (C2770700, C2770800)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
	Youth (Y1408000, Y1409900)	Past month	1	Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.
		1-3 months ago	2	→→→→→→→→→→→→		1
		4-6 months ago	3	→→→→→→→→→→→→		1
		6-12 months ago	4	→→→→→→→→→→→→		1
		1-3 years ago	5	→→→→→→→→→→→→		0
		3 or more yrs ago	6	→→→→→→→→→→→→		0
		Never	7	→→→→→→→→→→→→		.

Note. The new codes for frequency of marijuana use refer to the following: 0=I have not used marijuana in the last year, 1=I use marijuana a few times a year, 2=I use marijuana at least once or twice a month but not every week, 3=I use marijuana at least once or twice a week but not every day (1-4 days per week), 4=I use marijuana every day (5-7 days per week).

Table 35 Recoding of frequency of other drug use questions from the NLSY79-C

Year	Child or Youth	Drug type	Recentness		Past month frequency		New code
1994	Child	Inhalants: C1370700, C1370800 Other drugs: C1371100, C1371200	Past month	1	Less than once a week	1	2
					1 or 2 days per week	2	3
					3 or 4 days per week	3	3
					5 or 6 days per week	4	4
					Every day	5	4
					Never in last 30 days	0	.
			1-3 months ago	2	→→→→→→→→→→→→		1
			4-12 months ago	3	→→→→→→→→→→→→		1
			More than 1 year ago	4	→→→→→→→→→→→→		0
			Never	5	→→→→→→→→→→→→		.
	Youth	Inhalants: Y0365400, Y0365500 Cocaine, not crack: Y0365800, Y0365900 Crack cocaine: Y0366200, Y0366300 Other drugs: Y0366600, Y0366700	Less than one month	1	Less than once a week	1	2
					1 or 2 days per week	2	3
					3 or 4 days per week	3	3
					5 or 6 days per week	4	4
					Every day	5	4
					Did not smoke past month	6	.
			1-12 months ago	2	→→→→→→→→→→→→		1
			More than 1 year, less than 4	3	→→→→→→→→→→→→		0
			4 or more yrs	4	→→→→→→→→→→→→		0
1996	Child	Inhalants: C1593100, C1593200 Other Drugs: C1593500, C1593600	Past month	1	Less than once a week	1	2
					1 or 2 days per week	2	3
					3 or 4 days per week	3	3
					5 or 6 days per week	4	4
					Every day	5	4
					Never in last 30 days	0	.

Year	Child or Youth	Drug type	Recentness		Past month frequency		New code
1996 cont'd	Child cont'd	Inhalants: C1593100, C1593200	1-3 months ago	2	→→→→→→→→→→→→		1
			4-6 months ago	3	→→→→→→→→→→→→		1
			6-12 months ago	4	→→→→→→→→→→→→		1
		Other Drugs: C1593500, C1593600	1-3 years ago	5	→→→→→→→→→→→→		0
			3 or more yrs ago	6	→→→→→→→→→→→→		0
			Never	7	→→→→→→→→→→→→		.
	Youth	Inhalants: Y0659400, Y0659500	Past month	1	Less than once a week	1	2
					1 or 2 days per week	2	3
					3 or 4 days per week	3	3
		Cocaine, not crack: Y0659800, Y0659900			5 or 6 days per week	4	4
					Every day	5	4
					Never in last 30 days	0	.
		Crack cocaine: Y0660200, Y0660300	1-3 months ago	2	→→→→→→→→→→→→		1
			4-6 months ago	3	→→→→→→→→→→→→		1
			6-12 months ago	4	→→→→→→→→→→→→		1
		Other drugs: Y0660600, Y0660700	1-3 years ago	5	→→→→→→→→→→→→		0
			3 or more yrs ago	6	→→→→→→→→→→→→		0
			Never	7	→→→→→→→→→→→→		.
1998	Child	Inhalants: C1934000, C1934100	Past month	1	Less than once a week	1	2
					1 or 2 days per week	2	3
					3 or 4 days per week	3	3
		Hallucinogens: C1934500, C1934600			5 or 6 days per week	4	4
					Every day	5	4
					Never in last 30 days	0	.
		Cocaine: C1935000, C1935100	1-3 months ago	2	→→→→→→→→→→→→		1
			4-6 months ago	3	→→→→→→→→→→→→		1
			6-12 months ago	4	→→→→→→→→→→→→		1
		Uppers/downers: C1935500, C1935600	1-3 years ago	5	→→→→→→→→→→→→		0
			3 or more yrs ago	6	→→→→→→→→→→→→		0

Year	Child or Youth	Drug type	Recentness		Past month frequency		New code
1998 cont'd	Youth	Inhalants: Y0955500, Y0955600	Past month	1	Less than once a week	1	2
					1 or 2 days per week	2	3
					3 or 4 days per week	3	3
		Cocaine, not crack: Y0956000, Y0956100			5 or 6 days per week	4	4
					Every day	5	4
					Never in last 30 days	0	.
		Crack cocaine: Y0956500, Y0956600	1-3 months ago	2	→→→→→→→→→→→→		1
			4-6 months ago	3	→→→→→→→→→→→→		1
		Hallucinogens: Y0957000, Y0957100	6-12 months ago	4	→→→→→→→→→→→→		1
			1-3 years ago	5	→→→→→→→→→→→→		0
		Sedatives/downers: Y0957500, Y0957600	3 or more yrs ago	6	→→→→→→→→→→→→		0
			Never	7	→→→→→→→→→→→→		.
2000	Child	Inhalants: C2473200, C2473300	Past month	1	Less than once a week	1	2
					1 or 2 days per week	2	3
					3 or 4 days per week	3	3
		Hallucinogens: C2473700, C2473800			5 or 6 days per week	4	4
					Every day	5	4
					Never in last 30 days	0	.
		Cocaine: C2474200, C2474300	1-3 months ago	2	→→→→→→→→→→→→		1
			4-6 months ago	3	→→→→→→→→→→→→		1
			6-12 months ago	4	→→→→→→→→→→→→		1
		Uppers/downers: C2474700, C2474800	1-3 years ago	5	→→→→→→→→→→→→		0
			3 or more yrs ago	6	→→→→→→→→→→→→		0
			Never	0	→→→→→→→→→→→→		.

Year	Child or Youth	Drug type	Recentness		Past month frequency		New code
2000 cont'd	Youth	Amphetamines/uppers: Y1171000 Inhalants: Y1171600 Cocaine, not crack: Y1171900 Crack cocaine: Y1172200 Hallucinogens: Y1172500 Sedatives/downers: Y1172800 Other drugs: Y1173000			Less than once a week 1 or 2 days per week 3 or 4 days per week 5 or 6 days per week Every day Never in last 30 days	1 2 3 4 5 0	2 3 3 4 4 .
2002	Child	Inhalants: C2771100, C2771200 Hallucinogens: C2771500, C2771600 Cocaine: C2771900, C2772000 Uppers/downers: C2772300, C2772400	Past month 1-3 months ago 4-6 months ago 6-12 months ago 1-3 years ago 3 or more yrs ago	1 2 3 4 5 6	Less than once a week 1 or 2 days per week 3 or 4 days per week 5 or 6 days per week Every day Never in last 30 days →→→→→→→→→→→→ →→→→→→→→→→→→ →→→→→→→→→→→→ →→→→→→→→→→→→ →→→→→→→→→→→→	1 2 3 4 5 0	2 3 3 4 4 . 1 1 1 0 0

Year	Child or Youth	Drug type	Recentness	Past month frequency		New code
2002 cont'd	Youth	Amphetamines/uppers: Y14102.00 Inhalants: Y14108.00 Cocaine, not crack: Y14111.00 Crack cocaine: Y14114.00 Hallucinogens: Y14117.00 Sedatives/downers: Y14120.00 Other drugs: Y14122.00		Less than once a week	1	2
				1 or 2 days per week	2	3
				3 or 4 days per week	3	3
				5 or 6 days per week	4	4
				Every day	5	4
				Never in last 30 days	0	.

Note. The new codes for frequency of other drug use refer to the following: 0=I have not used other drugs in the last year, 1=I use other drugs a few times a year, 2=I use other drugs at least once or twice a month but not every week, 3=I use other drugs at least once or twice a week but not every day (1-4 days per week), 4=I use other drugs every day (5-7 days per week).

Footnotes

[1] Previous studies (e.g., Vallerand, Guay, & Blanchard, 2000) have shown that self-determined global motivation is positively related to self-determined contextual motivation toward sport.

References

Deci, E. L., & Ryan, R. M. (1985). *Intrinsic motivation and self-determination in human behavior.* New York: Plenum.

Deci, E. L., & Ryan, R. M. (Eds.), (2002). *Handbook of self-determination research.* Rochester, NY: University of Rochester Press.

Duda, J. L. (1992). Motivation in the sport setting: A goal perspective approach. In G. C. Roberts (Ed.), *Motivation in sport and exercise (pp. 57-91).* Champaign, IL: Human Kinetics.

Duda, J. L. (2001). Achievement goal research in sport: Pushing the boundaries and clarifying some misunderstandings. In G. C. Roberts (Ed.), *Motivation in sport and exercise* (pp. 129-182). Champaign, IL: Human Kinetics.

Duda. J. L., & Whitehead, J. (1998). Measurement of goal perspectives in the physical domain. In J. L. Duda (Ed.), *Advances in sport and exercise measurement* (pp. 20-47). Morgantown, WV: Fitness Information Technology.

Nicholls, J. G. (1984). Conceptions of ability and achievement motivation. In R. Ames, & C. Ames (Eds.), *Research on motivation in education: Student motivation, Vol. 1,* New York: Academic Press.

Scanlan, T. K., Carpenter, P. J., Schmidt, G. W., Simons, J. P., & Keeler, B. (1993). An introduction to the sport commitment model. *Journal of Sport and Exercise Psychology, 15,* 1-15.

Scanlan, T. K., Russell, D. G., Beals, K. P., & Scanlan, L. A. (2003). Project on elite athlete commitment (PEAK): II. A direct test and expansion of the sport commitment model with elite amateur sportsmen. *Journal of Sport and Exercise Psychology, 25,* 377-401.

Vallerand, R. J., & Fortier, M. S. (1998). Measures of intrinsic motivation and extrinsic motivation in sport and physical activity. In J. L. Duda (Ed.), *Advancements in sport and exercise psychology measurement* (pp. 81-104). Morgantown, West Virginia: Fitness Information Technology.

Vallerand, R. J., Guay, F., & Blanchard, C. (2000). Les méthodes de mesure verbales enpsychologie. Dans R.J. Vallerand & U. Hess (Éds.), *Méthodes de recherche en psychologie.* Boucherville, QC : Gaëtan Morin.

APPENDIX A – MEASURES AND GENERAL INFORMATION FORMS

Appendix A.1 – Consent Form

Dear Athlete,
The purpose of the present research is to examine the motivational orientation of Masters athletes. This questionnaire may take approximately 40 minutes to complete. Your participation in this study is entirely voluntary. If at any time you no longer wish to continue as a participant, you may withdraw freely without penalty of any kind. In accordance with research ethics procedures at McMaster University (ref. #: 2005-065), all the information that you provide us will remain confidential. If at any time during your completion of the questionnaire you have questions or would like more information, please do not hesitate to contact us at:

Nikola Medic	OR	Dr. Janet Starkes	OR	Bradley Young
Graduate Student		Chair		Graduate Student
Department of Kinesiology		Department of Kinesiology		Department of Kinesiology
McMaster University		McMaster University		McMaster University
Tel: (905) 525-9140 ext. 24625		Tel: (905) 525-9140 ext. 24625		Tel: (905) 525-9140 ext. 24625
E-mail: medicn@mcmaster.ca		E-mail: starkes@mcmaster.ca		E-Mail: youngb2@mcmaster.ca

Once the study is completed we would be glad to provide you with information on the final results. If you would like a copy of the results please provide us a mailing address and we will forward the information to you.

Mailing Address: _____
_____
_____
_____

Appendix A.2 – Descriptive Information (Masters athletes)

1. Name: _____, Gender: _____, Age: _____, Date: _____

2. Telephone Number: _____

3. E-mail Address: _____

We request your telephone number and email address in case we need to clarify any information on the questionnaire. Otherwise you will not be contacted.

4. What sport(s) do you presently participate in? _____

5. How old were you when you first started training for the sport you presently participate in? _____

6. How old were you when you first began to compete and train seriously for your sport on a full-time or year-round basis? _____

7. How much time do you spend presently training and competing for your sport?

   ____ hours/week, ___days/week; ___weeks/year.

8. How many weeks per year do you typically take off? _____

9. How many years have you competed as a Master Athlete? _____

10. How many Master competitions have you attended in the past year? _____

11. Did you ever keep a personal training log/journal? Yes or No

12. What was the highest level of competition that you competed at?

    International National Provincial Club Other_____ (please circle one)

13. What is the highest level of competition that you presently compete at?

    International National Provincial Club Other_____ (please circle one)

14. What age were you when you reached your peak performance? _____
    a) Please provide objective evidence (i.e., fastest time): _____

Appendix A.3 – Open-ended Questions on Motivation for Sport

1. Describe how you initially got involved in your sport?

2. What motivates you the most to continue to train and compete?

3. Can you describe whether or how your motives to train have changed in any way over your competitive career? When do you think this change occurred?

a) During your athletic career, did you ever train for any other sport? Yes or No
If YES, please specify which one(s) and at what age?

b) What motivated you to change to a different sport?

4. Identify the possible reasons/conditions under which you would stop training for your current sport?

5. Can you describe a time(s) when you had a lapse in motivation to train?

a) Can you describe some of the motivational strategies that you have used to motivate yourself to train and compete in the **past**?

b) Comment on whether you continue to use these motivational strategies. If not, please describe new motivational strategies that you **presently** find most successful?

6. When do you think that you performed your best in your sport career? Why do you consider this your best performance?

7. Think back over your career in sport. Can you identify and describe a goal that has always remained unaccomplished?

a) How does this unaccomplished goal influence your present reasons and motives for doing your sport?

Appendix A.4 – Sport Motivation Scale (modified for use with Masters athletes)

Using the scale below, please indicate to what extent you personally agree with each one of the **reasons for which you are presently continuing to train and compete in your main sport**.

1	2	3	4	5	6	7
Do not agree at all			Moderately agree			Completely agree

1. For the pleasure I feel in living exciting experiences.	1 2 3 4 5 6 7
2. For the pleasure it gives me to know more about my sport that I compete in.	1 2 3 4 5 6 7
3. I used to have good reasons for doing sports, but now I am asking myself if I should continue doing it.	1 2 3 4 5 6 7
4. For the pleasure of discovering new training techniques.	1 2 3 4 5 6 7
5. I don't know anymore; I have the impression that I am incapable of succeeding in this sport.	1 2 3 4 5 6 7
6. Because my sport allows me to be well regarded by people I know.	1 2 3 4 5 6 7
7. Because, in my opinion, it is one of the best ways to meet people.	1 2 3 4 5 6 7
8. Because I feel a lot of personal satisfaction while mastering certain difficult training techniques.	1 2 3 4 5 6 7
9. Because it is absolutely necessary to do sports if one wants to be in shape.	1 2 3 4 5 6 7
10. For the prestige of being a Master athlete.	1 2 3 4 5 6 7
11. Because it is one of the best ways I have chosen to develop other aspects of myself.	1 2 3 4 5 6 7
12. For the pleasure I feel while improving some of my weak points.	1 2 3 4 5 6 7
13. For the excitement I feel when I am really involved in the activity.	1 2 3 4 5 6 7
14. Because I must do my sport to feel good about myself.	1 2 3 4 5 6 7
15. For the satisfaction I experience while I am perfecting my abilities.	1 2 3 4 5 6 7

16. Because people around me think it is important to be in shape.	1 2 3 4 5 6 7
17. Because it's an extension of me.	1 2 3 4 5 6 7
18. Because it is a good way to learn lots of things which could be useful to me in other areas of my life.	1 2 3 4 5 6 7
19. For the intense emotions that I feel while I am doing a sport that I like.	1 2 3 4 5 6 7
20. It is not clear to me anymore; I don't really think my place is in sport.	1 2 3 4 5 6 7
21. For the pleasure that I feel while executing certain difficult movements.	1 2 3 4 5 6 7
22. Because participation in my sport is an integral part of my life.	1 2 3 4 5 6 7
23. Because I would feel bad if I was not taking time to do it.	1 2 3 4 5 6 7
24. To show others how good I am at my sport.	1 2 3 4 5 6 7
25. For the pleasure that I feel while learning training techniques that I have never tried before.	1 2 3 4 5 6 7
26. Because it is one of the best ways to maintain good relationships with my friends.	1 2 3 4 5 6 7
27. Because through my sport, I feel that I can now take responsibilities for changes in my life.	1 2 3 4 5 6 7
28. Because I like the feeling of being totally immersed in the activity.	1 2 3 4 5 6 7
29. Because I must do my sport regularly.	1 2 3 4 5 6 7
30. For the pleasure of discovering new performance strategies.	1 2 3 4 5 6 7
31. I often ask myself; I can't seem to achieve the goals that I set for myself.	1 2 3 4 5 6 7
32. Because participation in my sport is consistent with my deepest principles.	1 2 3 4 5 6 7

Appendix A.5 – Task and Ego Orientation in Sport Questionnaire

Using the scale below, please indicate how much do you personally agree with each statement by circling the appropriate response.

1	2	3	4	5
Strongly Disagree	Somewhat Disagree	No Opinion	Somewhat Agree	Strongly Agree

When do you feel most successful in sport? In other words, when do you feel a sport activity has gone really good for you?

I feel most successful in my sport WHEN…

1. I'm the only one who can do the play or skill	1 2 3 4 5
2. I learn a new skill and it makes me want to practice more	1 2 3 4 5
3. I can do better than my friends	1 2 3 4 5
4. The others can't do as well as me	1 2 3 4 5
5. I learn something that is fun to do	1 2 3 4 5
6. Others "mess up" and I don't	1 2 3 4 5
7. I learn a new skill by trying hard	1 2 3 4 5
8. I work really hard	1 2 3 4 5
9. I perform or score the best time/distance/points, etc.	1 2 3 4 5
10. Something I learn makes me want to go practice more	1 2 3 4 5
11. I'm the best	1 2 3 4 5
12. A skill I learn really feels right	1 2 3 4 5
13. I do my very best	1 2 3 4 5

Appendix A.6 – Exercise Commitment Scale (modified for use in sport)

Using the scale below, please indicate to what extent each of the items best describes how you feel about **your main sport.**

1	2	3	4	5	6	7
Do not agree at all			Moderately agree			Completely agree

1. Participation in my sport gives me the opportunity to relieve any stress I am feeling.	1 2 3 4 5 6 7
2. I feel it is necessary for me to continue participating in my sport.	1 2 3 4 5 6 7
3. Compared to participating in my sport, there are other things I could do which would be more fun.	1 2 3 4 5 6 7
4. I have invested a lot of time into my sport.	1 2 3 4 5 6 7
5. People important to me think it is okay to participate in my sport.	1 2 3 4 5 6 7
6. Participation in my sport gives me the opportunity to improve my physical skills.	1 2 3 4 5 6 7
7. I am dedicated to keep participating in my sport.	1 2 3 4 5 6 7
8. I find participating in my sport to be very rewarding.	1 2 3 4 5 6 7
9. I feel pressure from other people to continue participating in my sport.	1 2 3 4 5 6 7
10. I would like to do something else instead of participating in my sport.	1 2 3 4 5 6 7
11. People important to me support my participation in my sport.	1 2 3 4 5 6 7
12. Participation in my sport gives me the opportunity to be with my friends.	1 2 3 4 5 6 7
13. I want to keep participating in my sport.	1 2 3 4 5 6 7
14. I would be happier doing something else instead of participating in my sport.	1 2 3 4 5 6 7
15. I am willing to do almost anything to continue participating in my sport.	1 2 3 4 5 6 7

16. Participation in my sport gives me the opportunity to do something exciting.	1 2 3 4 5 6 7
17. I have invested a lot of effort into my sport.	1 2 3 4 5 6 7
18. Participation in my sport gives me the opportunity to improve my health and fitness.	1 2 3 4 5 6 7
19. I am determined to keep participating in my sport.	1 2 3 4 5 6 7
20. I feel participation in my sport is a duty.	1 2 3 4 5 6 7
21. I have invested a lot of my own money into my sport.	1 2 3 4 5 6 7
22. It would be hard for me to quit participating in my sport.	1 2 3 4 5 6 7
23. Compared to participating in my sport, there are other things I could do which would be more enjoyable.	1 2 3 4 5 6 7
24. People important to me encourage me to participate in my sport.	1 2 3 4 5 6 7
25. People will be disappointed with me if I quit participating in my sport.	1 2 3 4 5 6 7
26. All things considered, participating in my sport is very satisfying.	1 2 3 4 5 6 7
27. I am committed to keep participating in my sport.	1 2 3 4 5 6 7
28. People will think I am a quitter if I stop participating in my sport.	1 2 3 4 5 6 7
29. I feel obligated to continue participating in my sport.	1 2 3 4 5 6 7
30. I have invested a lot of energy into my sport.	1 2 3 4 5 6 7
31. I have to keep participating in my sport to please others.	1 2 3 4 5 6 7
32. Participation in my sport gives me the opportunity to have a good time.	1 2 3 4 5 6 7
33. Compared to participating in my sport, there are other things I could do which would be more worthwhile.	1 2 3 4 5 6 7
34. Because I participate in my sport, I feel satisfied.	1 2 3 4 5 6 7

Appendix A.7 – Descriptive Information (Young Athletes)

1. Name: _____, Gender: _____, Age: _____, Date: _____

2. Telephone Number: _____

3. E-mail Address: _____

We request your telephone number and email address in case we need to clarify any information on the questionnaire. Otherwise you will not be contacted.

4. What sport(s) do you presently participate in? _____

5. How old were you when you first started training for the sport you presently participate in? _____

6. How old were you when you first began to compete and train seriously for your sport on a full-time or year-round basis? _____

7. How much time do you spend presently training and competing for your sport?

   ____ hours/week, ___days/week; ___weeks/year.

8. How many weeks per year do you typically take off? _____

9. How many years have you competed as a competitive athlete? _____

10. How many competitions have you attended in the past year? _____

11. Did you ever keep a personal training log/journal? Yes or No

12. What is the highest level of competition that you presently compete at?

    International National Provincial Club Other_____ (please circle one)

Appendix A.8 – Sport Motivation Scale

Using the scale below, please indicate to what extent you personally agree with each one of the **reasons for which you are presently continuing to train and compete in your main sport**.

1	2	3	4	5	6	7
Do not agree at all			Moderately agree			Completely agree

1. For the pleasure I feel in living exciting experiences.	1 2 3 4 5 6 7
2. For the pleasure it gives me to know more about my sport that I compete in.	1 2 3 4 5 6 7
3. I used to have good reasons for doing sports, but now I am asking myself if I should continue doing it.	1 2 3 4 5 6 7
4. For the pleasure of discovering new training techniques.	1 2 3 4 5 6 7
5. I don't know anymore; I have the impression that I am incapable of succeeding in this sport.	1 2 3 4 5 6 7
6. Because my sport allows me to be well regarded by people I know.	1 2 3 4 5 6 7
7. Because, in my opinion, it is one of the best ways to meet people.	1 2 3 4 5 6 7
8. Because I feel a lot of personal satisfaction while mastering certain difficult training technique.	1 2 3 4 5 6 7
9. Because it is absolutely necessary to do sports if one wants to be in shape.	1 2 3 4 5 6 7
10. For the prestige of being an athlete.	1 2 3 4 5 6 7
11. Because it is one of the best ways I have chosen to develop other aspects of myself.	1 2 3 4 5 6 7
12. For the pleasure I feel while improving some of my weak points.	1 2 3 4 5 6 7
13. For the excitement I feel when I am really involved in the activity.	1 2 3 4 5 6 7
14. Because I must do my sport to feel good about myself.	1 2 3 4 5 6 7

15. For the satisfaction I experience while I am perfecting my abilities.	1 2 3 4 5 6 7
16. Because people around me think it is important to be in shape.	1 2 3 4 5 6 7
17. Because it's an extension of me.	1 2 3 4 5 6 7
18. Because it is a good way to learn lots of things which could be useful to me in other areas of my life.	1 2 3 4 5 6 7
19. For the intense emotions that I feel while I am doing a sport that I like.	1 2 3 4 5 6 7
20. It is not clear to me anymore; I don't really think my place is in sport.	1 2 3 4 5 6 7
21. For the pleasure that I feel while executing certain difficult movements.	1 2 3 4 5 6 7
22. Because participation in my sport is an integral part of my life.	1 2 3 4 5 6 7
23. Because I would feel bad if I was not taking time to do it.	1 2 3 4 5 6 7
24. To show others how good I am at my sport.	1 2 3 4 5 6 7
25. For the pleasure that I feel while learning training techniques that I have never tried before.	1 2 3 4 5 6 7
26. Because it is one of the best ways to maintain good relationships with my friends.	1 2 3 4 5 6 7
27. Because through my sport, I feel that I can now take responsibilities for changes in my life.	1 2 3 4 5 6 7
28. Because I like the feeling of being totally immersed in the activity.	1 2 3 4 5 6 7
29. Because I must do my sport regularly.	1 2 3 4 5 6 7
30. For the pleasure of discovering new performance strategies.	1 2 3 4 5 6 7
31. I often ask myself; I can't seem to achieve the goals that I set for myself.	1 2 3 4 5 6 7
32. Because participation in my sport is consistent with my deepest principles.	1 2 3 4 5 6 7

Appendix A.9 – General Information Letter to the Organizing Committee

Dear _____,

My name is Nikola Medic. I am currently pursuing a Doctorate degree in the Faculty of Social Sciences (Sport Psychology) at McMaster University, Hamilton, Ontario. My research study involves surveying Masters athletes from Canada and United States in order to gain better understanding of their motives for sport participation. The main purpose of my study is to learn what the main motives for sport participation in Masters sports are and how different motivational profiles are related to sport performance. This research has been approved by the McMaster University Research Ethics Board (File # 2005 065) and will be titled "Multifaceted Analyses of Masters Athletes' Motives for Sport Participation".

I am interested in surveying the Masters athletes registered for the _____ event that you are organizing. Your cooperation and athlete's involvement are essential part of this study and would be greatly appreciated. Your involvement would include spending about five minutes on allowing me to explain the purpose and the procedures of the study. A member of the organizing committee such as registration officer would be responsible for distributing the questionnaires to all athletes as part of the registration packet to each Masters athlete upon confirmation of their registration for the event. Athlete's involvement would include spending approximately thirty to forty minutes to complete an Informed Consent Form and a Survey (i.e., athletes would complete the questions during the time period that is most convenient for them, and thus would not be required, but may if they choose, to complete the surveys during the event). Upon completion, athletes will be instructed to place the survey in a postage-paid envelope addressed to the researcher, and leave it at a local postal outlet. A copy of the Survey is attached for your examination.

Please be advised that your participation in this study is voluntary and that you have the right to withdraw your permission to distribute the packages to the athletes without any consequence at any time and for any reason without penalty.

I will be contacting you via e-mail/telephone in order to discuss the possibility of your assistance in conducting this research study. Thank you for your time and consideration.

If you have any questions or concerns about your participation in the study you may contact Research Ethics Officer at McMaster University at extension 23142 (email: mwilson@mcmaster.ca) or my faculty supervisor Dr. Janet Starkes at (

Sincerely,

_____ Date: _____

Nikola Medic
PhD. Candidate
McMaster University

Appendix A.10 – Participation Agreement Letter from the Organizer

The following is a letter of consent which when signed by myself (Please Print First Name, Last Name) will authorize Nikola Medic to proceed with the collection of data for the study "Multifaceted Analyses of Masters Athletes' Motives for Sport Participation".

By signing below, I am certifying that Nikola Medic has provided me with a description of the research project and I have allowed him to supply me with the copies of Informed Consent Forms and Surveys to be handed out to each one of the Masters athletes registered for the (Specific Meet).

Signature of Organizer: _____ Date: _____

Signature of Researcher: _____ Date: _____

Appendix A.11 – General Information Letter to the Participant

Dear Participant,

My name is Nikola Medic. I am currently pursuing a Doctorate degree in the Faculty of Social Sciences (Sport Psychology) at McMaster University, Hamilton, Ontario. My research study involves surveying Masters athletes from Canada and United States in order to gain better understanding of what motives them to participate in their sport through the lifetime. The main purpose of my research is to learn what the main motives for sport participation in Masters sports are and how different motivational profiles are related to sport performance. The questions included in the survey ask you to reflect on your reasons for continuing to participated in sport, how those motives may be different from when you were younger, motivational strategies that you use to help yourself train on daily or weekly basis, unaccomplished goals that you may have and how they influence your present motives for sport, performance accomplishments, how you feel when they train and complete, and your feelings about success in sport.

Your cooperation and involvement are essential part of this study and would greatly be appreciated. Please remember that your participation in this study is voluntary.

Within this package you will find the following forms: General Information Letter to the Participant (the one you are currently reading), two (2) Informed Consent Forms, Summary of Results Form, and a Survey. As part of this study you are being asked to fully read this General Information Letter to the Participant and the Informed Consent Form, both of which you are to keep for your records for future reference or in the case that you may have any questions about the study. Also, you are being asked to read and sign another (same) copy of the Informed Consent Form, complete the Survey questions, as well as if you are interested in receiving the major results of this investigation please complete the Summary of Results Form. This should all take approximately thirty to forty minutes of your time. Upon completion of the Survey, you are to place the signed Informed Consent Form, the completed Survey questionnaire, and the completed Summary of Results Form in the envelope provided and seal it. Since the envelope that is provided already has the postage that has been paid for and is addressed to the researcher, you may choose to place it in any postal outlet in your area.

If you have any questions or concerns you may contact myself at the below address or my faculty supervisor Dr. Janet Starkes at (or at

At this time I would like to thank you for your time and consideration.

Sincerely,

_____

Nikola Medic
PhD. Candidate
McMaster University

Appendix A.12 – Summary of the Results Form

OPTIONAL:

If you wish to receive a summary of the results from this study, please complete this form by providing either your mailing address or your email address. Upon completion of this form, please place it along with the completed Informed Consent Form and the Survey in the postage paid envelope addressed to the researcher. A summary of major results will then be sent to you once all the data has been analyzed. This form will be stored in a locked office and later destroyed once the summary report has been sent to you.

Name: _____

_____

Mailing Address: Street, P. O. Box, Rural Route #, Apt. #, etc.

_____

City Province/State Postal Code/Zip Code

OR

If you wish, you may provide us with your e-mail address and the results will be sent to you via this method.

E-mail: _____

Appendix A.13 – Feedback Letter to Participants

Dear Research Participant,

I Nikola Medic along with my supervisor Dr. Janet Starkes from McMaster University, Hamilton, Ontario, would like to thank you for completing the survey with your patience and honesty. We wish to inform you that the data you have provided us with has been treated with strict confidentiality. This data has been carefully analysed and interpreted for the purpose of exploring the major motives for participation in Masters sport.

The following is an executive summary of the major findings:

∀
∀
∀

I sincerely hope that you found this research study useful and I would like to thank you for taking the time to participate. If you have any questions and/or comments please direct them to myself at medicn@mcmaster.ca or to my supervisor Dr. Janet Starkes at starkes@mcmaster.ca.

Sincerely,

_____

Nikola Medic

Appendix A.14 – Most Recent Certification of Ethics Clearance Form

McMaster University Research Ethics Board (MREB)
c/o Office of Research Services, MREB Secretariat, GH 306K, x 23142, e-mail: ethicsoffice@mcmaster.ca
CERTIFICATE OF ETHICS CLEARANCE TO INVOLVE HUMAN PARTICIPANTS IN RESEARCH

APPLICATION STATUS: NEW: ☒ RENEWAL ☐ ADDENDUM ☐ REB# **2005 065**

TITLE OF RESEARCH PROJECT: **Multifaceted Analyses of Masters Athletes' Motives for Sport Participation**

	NAME	DEPT./ADDRESS	# EXT	E - MAIL
Faculty Investigator(s)/Supervisor(s)	J. Starkes	Kinesiology	23578	starkes
Student Investigator(s)	N. Medic	Kinesiology	24625	medicn

The application in support of the above research project has been reviewed by the MREB to ensure compliance with the Tri-Council Policy Statement and the McMaster University Policies and Guidelines for Research Involving Human Participants. The following ethics certification is provided by the MREB:

☐ The application protocol is approved as presented without questions or requests for modification.
☑ The application protocol is approved as revised without questions or requests for modification.
☐ The application protocol is approved subject to clarification and/or modifications as appended or identified below.

COMMENTS & CONDITIONS:

Reporting Frequency:	Annual Date:
DATE: May 24, 2005	Dr. D. Maurer, Chair, REB: ACTING CHAIR

P:\ethics\reviewer\forms\certificate.frm

Note. The above ethics approval covers the data collected for Manuscript 4 and 5. The data collected for Manuscript 1, 2, and 3 were covered under the SSHRC ethics approval granted to Dr. Janet L. Starkes at McMaster University in May 2003.