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Individual and social determinants of multiple chronic disease behavioural risk factors in Canadian children and adolescents

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Individual and social determinants of multiple chronic disease behavioural risk factors in Canadian children and adolescents

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RÉSUMÉ

Contexte: Les facteurs de risque comportementaux, notamment l'inactivité physique, le comportement sédentaire, le tabagisme, la consommation d'alcool et le surpoids sont les principales causes modifiables de maladies chroniques telles que le cancer, les maladies cardiovasculaires et le diabète. Ces facteurs de risque se manifestent également de façon concomitante chez l'individu et entraînent des risques accrus de morbidité et de mortalité. Bien que les facteurs de risque comportementaux aient été largement étudiés, la distribution, les patrons d'agrégation et les déterminants de multiples facteurs de risque comportementaux sont peu connus, surtout chez les enfants et les adolescents.

Objectifs: Cette thèse vise 1) à décrire la prévalence et les patrons d'agrégation de multiples facteurs de risque comportementaux des maladies chroniques chez les enfants et adolescents canadiens; 2) à explorer les corrélats individuels, sociaux et scolaires de multiples facteurs de risque comportementaux chez les enfants et adolescents canadiens; et 3) à évaluer, selon le modèle conceptuel de l'étude, l'influence longitudinale d'un ensemble de variables distales (c'est-à-dire des variables situées à une distance intermédiaire des comportements à risque) de type individuel (estime de soi, sentiment de réussite), social (relations sociales, comportements des parents/pairs) et scolaire (engagement collectif à la réussite, compréhension des règles), ainsi que de variables ultimes (c'est-à-dire des variables situées à une distance éloignée des comportements à risque) de type individuel (traits de personnalité, caractéristiques démographiques), social (caractéristiques socio-économiques des parents) et scolaire (type d'école, environnement favorable, climat disciplinaire) sur le taux d'occurrence de multiples facteurs de risque comportementaux chez les enfants et adolescents canadiens.

Méthodes: Des données transversales (n = 4724) à partir du cycle 4 (2000-2001) de l'Enquête longitudinale nationale sur les enfants et les jeunes (ELNEJ) ont été utilisées pour décrire la prévalence et les patrons d'agrégation de multiples facteurs de risque comportementaux chez les jeunes canadiens âgés de 10-17 ans. L'agrégation des facteurs de risque a été examinée en utilisant une méthode du ratio de cas observés sur les cas

attendus. La régression logistique ordinale a été utilisée pour explorer les corrélats de multiples facteurs de risque comportementaux dans un échantillon transversal (n = 1747) de jeunes canadiens âgés de 10-15 ans du cycle 4 (2000-2001) de l'ELNEJ. Des données prospectives (n = 1135) à partir des cycle 4 (2000-2001), cycle 5 (2002-2003) et cycle 6 (2004-2005) de l'ELNEJ ont été utilisées pour évaluer l'influence longitudinale des variables distales et ultimes (tel que décrit ci-haut dans les objectifs) sur le taux d'occurrence de multiples facteurs de risque comportementaux chez les jeunes canadiens âgés de 10-15 ans; cette analyse a été effectuée à l'aide des modèles de Poisson longitudinaux.

Résultats: Soixante-cinq pour cent des jeunes canadiens ont rapporté avoir deux ou plus de facteurs de risque comportementaux, comparativement à seulement 10% des jeunes avec aucun facteur de risque. Les facteurs de risque comportementaux se sont agrégés en de multiples combinaisons. Plus précisément, l'occurrence simultanée des cinq facteurs de risque était 120% plus élevée chez les garçons (ratio observé/attendu (O/E) = 2.20, intervalle de confiance (IC) 95%: 1.31-3.09) et 94% plus élevée chez les filles (ratio O/E = 1.94, IC 95%: 1.24-2.64) qu'attendu. L'âge (rapport de cotes (RC) = 1.95, IC 95%: 1.21-3.13), ayant un parent fumeur (RC = 1.49, IC 95%: 1.09-2.03), ayant rapporté que la majorité/tous de ses pairs consommaient du tabac (RC = 7.31, IC 95%: 4.00-13.35) ou buvaient de l'alcool (RC = 3.77, IC 95%: 2.18-6.53), et vivant dans une famille monoparentale (RC = 1.94, IC 95%: 1.31-2.88) ont été positivement associés aux multiples comportements à risque. Les jeunes ayant une forte estime de soi (RC = 0.92, IC 95%: 0.85-0.99) ainsi que les jeunes dont un des parents avait un niveau d'éducation postsecondaire (RC = 0.58, IC 95%: 0.41-0.82) étaient moins susceptibles d'avoir de multiples facteurs de risque comportementaux. Enfin, les variables de type social distal (tabagisme des parents et des pairs, consommation d'alcool par les pairs) (Log du rapport de vraisemblance (LLR) = 187.86, degrés de liberté = 8, $P < 0{,}001$) et individuel distal (estime de soi) (LLR = 76.94, degrés de liberté = 4, $P < 0{,}001$) ont significativement influencé le taux d'occurrence de multiples facteurs de risque comportementaux. Les variables de type individuel ultime (âge, sexe, anxiété) et social ultime (niveau d'éducation du parent, revenu du ménage, structure de la famille) ont eu une influence moins prononcée sur le taux de cooccurrence des facteurs de risque comportementaux chez les jeunes.

Conclusion: Les résultats suggèrent que les interventions de santé publique devraient principalement cibler les déterminants de type individuel distal (tel que l'estime de soi) ainsi que social distal (tels que le tabagisme des parents et des pairs et la consommation d'alcool par les pairs) pour prévenir et/ou réduire l'occurrence de multiples facteurs de risque comportementaux chez les enfants et les adolescents. Cependant, puisque les variables de type distal (telles que les caractéristiques psychosociales des jeunes et comportements des parents/pairs) peuvent être influencées par des variables de type ultime (telles que les caractéristiques démographiques et socioéconomiques), les programmes et politiques de prévention devraient également viser à améliorer les conditions socioéconomiques des jeunes, particulièrement celles des enfants et des adolescents des familles les plus démunies.

Mots-clés: Épidémiologie, maladies chroniques, adolescent, enfant, multiples facteurs de risque, habitudes de vie, déterminants individuels, déterminants sociaux.

ABSTRACT

Background: Behavioural risk factors including physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking, and being overweight are major modifiable causes of chronic diseases such as cancer, cardiovascular diseases and diabetes. These lifestyle risk factors also co-occur in individuals and lead to increased risks of chronic diseases morbidity and mortality. Although single behavioural risk factors have been extensively studied, little is known about the distribution, clustering patterns and potential determinants of multiple behavioural risk factors for chronic diseases, particularly in children and adolescents.

Objectives: This thesis aims 1) to describe the prevalence and clustering patterns of multiple chronic disease behavioural risk factors in Canadian children and adolescents; 2) to explore potential individual, social and school correlates of multiple chronic disease behavioural risk factors in Canadian children and adolescents; and 3) to assess, based on the conceptual framework of this study, the longitudinal influence of selected individual (sense of self, sense of achievement), social (social relations, others' behaviours) and school (collective commitment to success, comprehension of rules) distal variables (variables situated at an intermediate distance from behaviours), as well as selected individual (demographics and personality traits), social (parental socioeconomic characteristics) and school (type of school, supportive environment, disciplinary climate) ultimate variables (variables situated at an utmost distance from behaviours) on the rate of occurrence of multiple chronic disease behavioural risk factors in Canadian children and adolescents.

Methods: Cross-sectional data (n = 4724) from Cycle 4 (2000-2001) of the National Longitudinal Survey of Children and Youth (NLSCY) were used to describe the prevalence and clustering patterns of multiple behavioural risk factors in Canadian youth aged 10-17 years. Clustering was assessed using an observed to expected ratio method. Ordinal logistic regression was used to explore correlates of multiple behavioural risk factors in a cross-sectional sample (n = 1747) of Canadian youth aged 10-15 years from Cycle 4 (2000-2001)

of the NLSCY. Prospective data (n = 1135) from Cycle 4 (2000-2001), Cycle 5 (2002-2003) and Cycle 6 (2004-2005) of the NLSCY were used to assess the longitudinal influence of selected distal and ultimate variables (as described above in the objectives) on the rate of occurrence of multiple behavioural risk factors in Canadian youth aged 10-15 years; this analysis was performed using longitudinal Poisson models.

Results: Sixty-five percent of Canadian youth had two or more behavioural risk factors compared to only 10% with no risk factor. Behavioural risk factors clustered in multiple combinations. Specifically, the simultaneous occurrence of all five risk factors was 120% greater in males (observed/expected (O/E) ratio = 2.20, 95% confidence interval (CI): 1.31-3.09) and 94% greater in females (O/E ratio = 1.94, 95% CI: 1.24-2.64) than expected by chance. Older age (odds ratio (OR) = 1.95, 95% CI: 1.21-3.13), caregiver smoking (OR = 1.49, 95% CI: 1.09-2.03), reporting that most/all of one's peers smoked (OR = 7.31, 95% CI: 4.00-13.35) or drank alcohol (OR = 3.77, 95% CI: 2.18-6.53), and living in a lone-parent family (OR = 1.94, 95% CI: 1.31-2.88) increased the likelihood of having multiple health risk behaviours. Youth with high self-esteem (OR = 0.92, 95% CI: 0.85-0.99) and youth from families with post-secondary education (OR = 0.58, 95% CI: 0.41-0.82) were less likely to have a higher number of behavioural risk factors. Finally, social distal variables (caregiver smoking, peer smoking, peer drinking) (Log-likelihood ratio (LLR) = 187.86, degrees of freedom = 8, $P < 0.001$) and individual distal variables (such as self-esteem) (LLR = 76.94, degrees of freedom = 4, $P < 0.001$) significantly influenced the rate of occurrence of multiple behavioural risk factors. Individual ultimate variables (age, sex, anxiety) and social ultimate variables (parental education, household income, family structure) exerted a less pronounced influence on the rate of co-occurrence of behavioural risk factors among youth.

Conclusion: The results suggest that public health interventions should primarily target the individual distal (such as self-esteem) and social distal variables (such as parental smoking, peer smoking and peer drinking) to reduce or prevent the occurrence of multiple behavioural risk factors among youth. However, since distal variables (such as psychosocial characteristics and others' behaviours) may be influenced by ultimate variables (such as demographic and socioeconomic characteristics), prevention programs

and policies should also aim to improve the socioeconomic conditions of children and adolescents, particularly those of youth from less affluent families.

Keywords: Epidemiology, chronic diseases, adolescent, child, multiple risk factors, health behaviours, individual determinants, social determinants.

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LIST OF ABBREVIATIONS

BMI: body mass index

CCHS: Canadian Community Health Survey

CDC: Centers for Disease Control and Prevention

CI: confidence interval

CVD: cardiovascular disease

GEE: generalized estimating equations

HBSC: Health Behaviour in School-aged Children

IOTF: International Obesity Task Force

LLR: log-likelihood ratio

Kcal: kilocalorie

NHANES: National Health and Nutrition Examination Survey

NHES: National Health Examination Survey

NLSCY: National Longitudinal Survey of Children and Youth

NPHS: National Population Health Survey

O/E: observed/expected

OR: odds ratio

RR: rate ratio

PMK: person most knowledgeable

SAS: Statistical Analysis System

SES: socioeconomic status

SUDAAN: Survey Data Analysis

TTI: Theory of Triadic Influence

TV: television

U.S.: United States

WHO: World Health Organization

DEDICATION

This dissertation is dedicated to the memory of my father whose hard work, compassion, care and many sacrifices in life contributed and motivated me to pursue my academic goals, and strive for excellence.

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INTRODUCTION

CHAPTER 1: INTRODUCTION

Cigarette smoking, physical inactivity, sedentary behaviour, alcohol drinking, and being overweight are among the leading causes of chronic diseases morbidity and mortality worldwide (1-4). At least 80% of new cases of cardiovascular disease (CVD) and type 2 diabetes are related to physical inactivity, cigarette smoking and unhealthy diet (5), while 35% of all cancers are preventable by modifying or avoiding key risk factors such as physical inactivity, tobacco use, poor diet, alcohol use or being overweight or obese (6). In Canada, 17% of all deaths (37 209 deaths) were attributable to tobacco use (7), 6% (4010 deaths) to alcohol use (8), over 9% (4321 deaths) to overweight and obesity (9) and 10% (21 000 deaths) to physical inactivity in 1999-2002 (10). Total direct and indirect health expenditures associated with physical inactivity were estimated to be $5.3 billion in Canada in 2001, while the total cost associated with obesity was $4.3 billion (11). The economic costs of tobacco use were estimated to be $17 billion in Canada in 2002, while alcohol-related health problems accounted for $14.6 billion in total costs (7).

Although chronic diseases predominately occur in adulthood (12), there is convincing evidence that the precursors of these diseases manifest in childhood and adolescence. Autopsy evidence from the Bogalusa Heart study (13) and the Pathobiological Determinants of Atherosclerosis in Youth study (14, 15) has confirmed that atherosclerotic plaques can originate in the first two decades of life (16). Specifically, fatty streaks and atherosclerotic lesions have been found at postmortem examination in the aorta and arteries of young adults who died of violent causes and these were related to antemortem CVD risk factors, such as high body mass index (BMI), cigarette smoking and elevated cholesterol levels measured years earlier when these subjects were children[1] (13-16).

Chronic disease behavioural risk factors are present in children and adolescents[2] and many of these risk factors including obesity (17, 18), physical inactivity (19-23), tobacco smoking (20) and alcohol consumption (24) track from childhood to adulthood. Indeed, longitudinal studies confirm that obesity is often acquired during childhood and

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[1] In this thesis, the term “children” refers to persons aged 0-11 years (25).

[2] In this thesis, the term “adolescents” refers to persons aged 12-17 years (26, 27).

adolescence and that the majority of obese children become obese adults (17, 28). Similarly, children who are physically inactive at a young age remain inactive later in life (19, 20). School children who experiment with cigarette smoking are more likely to be regular smokers during adulthood than those who refuse to experiment with smoking while in school (20). Alcohol consumption among youth[3] in grades 8 or 9 has also been linked to regular alcohol intake in young adulthood (24).

Numerous studies document alarming increases in the prevalence of overweight and obesity (26), sedentary behaviour (29) and alcohol drinking (30) among youth. Despite recent declines in levels of physical inactivity (30) and cigarette smoking (30), over two-thirds of Canadian youth aged 12-19 years are still not active enough (31, 32), and nearly one in three Canadian students in grades 5 to 12 report having ever tried smoking (33). In turn, these behavioural risk factors are associated with important health and social consequences. During childhood and adolescence, physical inactivity is linked to an unfavourable CVD risk profile including obesity (34), insulin resistance (35), elevated triglycerides and low-density lipoprotein (36, 37), and higher blood pressure (36). Sedentary behaviour is also associated with obesity because it involves a decrease in energy expenditure and it is often associated with an increase in energy intake from consumption of high-fat and high-energy containing foods (38, 39). Smoking at a young age is associated with emotional and psychological problems (40), engaging in risky behaviours such as fighting and unprotected sexual activity (41), and a higher risk for lung cancer later in life (41). Youth who drink alcohol are at increased risk of experiencing school and social problems, higher suicide and homicide rates, changes in brain development and even death from alcohol poisoning (42). Lastly, obesity during childhood is associated with an increased risk of dyslipidemia, hyperinsulinemia, hypertension and a number of psychological problems (43-45). If juvenile obesity continues to rise and death rates associated with obesity remain constant in the 21st century, obese youth are likely to live shorter lives than their parents (46). Because of the growing physical and psychological

[3] In this thesis, the terms “youth”, “young persons” and “young people” are used interchangeably and refer to both children and adolescents, as per other studies (47, 48).

consequences associated with cigarette smoking, alcohol drinking, physical inactivity, sedentary behaviour and overweight, these risk factors are identified as top public health priorities in both the United States (U.S.) (1) and Canada (49).

In addition to the burden of disease attributed to presence of single behavioural risk factors in individuals, there is evidence that chronic disease behavioural risk factors cluster in both youth (50, 51) and adults (52-58). The co-occurrence of these risk factors in adulthood predisposes subjects to even greater risks for disease and mortality from cancer, CVD and stroke (59, 60). Previous studies on multiple behavioural risk factors have mainly reported pairwise associations (51, 61-63) and only a few investigated the associations between three or more behavioural risk factors related to chronic diseases such as cancer and CVD; the majority of these studies has been conducted in adults (52, 54-57, 64) and only a limited number has been interested in children and adolescents (50, 65, 66).

Lifestyle risk behaviours are known to be influenced by multiple individual (genetic, demographic, psychological), social (family and peer characteristics) and environmental determinants (school and built environment) (67-77). Single health risk behaviours have been widely studied, but less is known about potential factors influencing the occurrence of multiple health risk behaviours, particularly among youth. The existing evidence is mainly of cross-sectional nature and generally inconsistent (50, 66, 78, 79), thus offering little insight as to which factors influence the rate of occurrence of two or more behavioural risk factors in children and adolescents. In addition, most studies of determinants of multiple behavioural risk factors have been undertaken atheoretically (58, 66, 78), and without considering a theory applicable to multiple behaviours (80). Investigating the prevalence, clustering patterns and potential determinants of multiple chronic disease behavioural risk factors in youth is therefore warranted and of great importance, so that appropriate interventions can be developed to minimize the risk of disease later in life.

There is no published study on the clustering patterns and factors influencing the rate of co-occurrence of chronic disease behavioural risk factors in Canadian youth. Therefore, this thesis aims at i) describing the prevalence and clustering patterns of multiple chronic disease behavioural risk factors (including cigarette smoking, physical inactivity, alcohol

drinking, sedentary behaviour and overweight) in a representative sample of Canadian children and adolescents aged 10-17 years; and ii) identifying potential determinants of multiple chronic disease behavioural risk factors in the same population, using a novel conceptual framework applicable to multiple behaviours.

This dissertation is divided into six chapters. Chapter 1 is a general introduction. Chapter 2 consists of a literature review of single and multiple chronic disease behavioural risk factors including an overview of definitions and measurements used, prevalence and trends as well as determinants of behavioural risk factors. Chapter 3 presents an overview of some of the most influential theoretical models used in the field of health behaviour research, followed by the conceptual framework which guided the research.

Chapter 4 presents the methods used in this research including, a detailed description of the source of data, the study population, data collection procedures, measures and data analysis. Chapter 5 presents the results of this thesis in the form of three manuscripts. The first article describes the prevalence, distribution and clustering patterns of multiple chronic disease behavioural risk factors in Canadian youth aged 10-17 years. The second article explores potential individual, social and school correlates of multiple chronic disease behavioural risk factors in a sample of Canadian youth aged 10-15 years. Lastly, based on the conceptual framework of this research, the third article assesses the longitudinal influence of a set of conceptually-related distal and ultimate variables on the rate of occurrence of multiple chronic disease behavioural risk factors in Canadian children aged 10-11 years at baseline and followed biannually until the age of 14-15 years.

Finally, Chapter 6 presents a general discussion of the results of this thesis by emphasizing its novel aspects and contributions to the literature, its strengths and limitations as well as implications of the findings and directions for future research.

LITERATURE REVIEW

CHAPTER 2: LITERATURE REVIEW

This literature review summarizes the current state of knowledge about the five behavioural risk factors for chronic diseases (i.e., physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking and overweight/obesity) considered in this thesis; it is divided into two main sections: Section 2.1 presents a global overview of single chronic disease behavioural risk factors and their determinants in children and adolescents. Section 2.2 presents a detailed review of the literature of multiple chronic disease behavioural risk factors including the burden of multiple behavioural risk factors, definitions and methodological issues, evidence of clustering as well as the prevalence and determinants of multiple behavioural risk factors among children and adolescents.

2.1 Chronic disease behavioural risk factors

2.1.1 Physical inactivity

2.1.1.1 Definitions

Health Canada defines physical inactivity as "a relative term which refers to lack of exercise, the definition of which varies between researchers" (81). Indeed, several surveys and studies have used different definitions for physical inactivity among youth. The Canada Fitness Survey conducted in 1981 (82), and the Campbell Survey in 1988 (83), defined inactivity as engaging in less than three hours of physical activity per week, for fewer than nine months of the year among subjects 10 years and older. The Physical Activity Monitor, a series of surveys conducted between 1995 to 2000 to monitor trends in physical activity among Canadian youth and adults, defined inactivity as expending less than 3 kilocalories per kilogram of body weight per day (kcal/kg/day), or the equivalent of less than 1 hour of walking per day (84, 85). The Canadian Community Health Survey (CCHS) conducted since 2000 in a representative sample of Canadians aged 12 years and older, has used a threshold of <1.5 kcal/kg/day, or the equivalent of less than 15 minutes of walking per day, for defining physical inactivity (86). Several authors have criticized the current "inactive" threshold used by the CCHS as it is likely below the level associated with substantial health benefits (85). Instead, experts recommend using the threshold of <3 kcal/kg/day to define inactivity which better approximates the minimum amount of activity required to gain health benefits when information on frequency, duration, and intensity is available (85).

2.1.1.2 Measurements

Methods to assess physical activity in youth include direct measurements (observing or recording physical activity behaviour), heart rate monitoring, objective monitoring (accelerometers and step counters), and self-reports (87-89). While use of direct measurements, heart rate monitoring and objective monitoring can provide valid and reliable estimates of activity (87, 90), their use is limited in large prospective epidemiological studies, because they are impractical for measuring physical activity over long periods of time (88) and they underestimate energy expenditure from any activity focused on the upper extremities (91). Due to their ease of administration, low cost and versatility, self-, parent/guardian- or interviewer reports are the most widely used methods for assessing physical activity in epidemiological studies (88). With self-reports, subjects are asked to report participation in physical activity during a given period of time in the recent past. While questionnaires have been validated against direct observation (92) and objective monitoring (93), they are susceptible to recall bias, misinterpretations and subjectivity in response (87).

2.1.1.3 Prevalence and trends

In 1994, The International Consensus Conference on Physical Activity Guidelines for Adolescents recommended that all adolescents be physically active daily (or nearly every day) as part of their lifestyles, and engage in three or more vigorous sessions of activities per week (at last 20 minutes or more at a time or the equivalent of 6 kcal/kg/day) (94). In 2002, Health Canada and the Canadian Society for Exercise Physiology's physical activity guidelines for children (95) and youth (96) recommended 90 minutes or more of daily participation in moderate and vigorous activities. Although data from recent national surveys, including the National Population Health Survey (NPHS) and the CCHS indicate a favourable increasing trend in physical activity among Canadian adolescents (30), many young people do not meet the recommended guidelines (97). According to the CCHS data, 51% of Canadian youth aged 12 to 19 years are not active during their leisure time (using the threshold of <3kcal/kg/day) and up to 78% of Canadian youth do not meet the recommended international guidelines for optimal growth and development (31). Specifically, 55% of females aged 12 to 14 years are inactive compared to 43% of males in the same age group, whereas 63 % of females aged 15 to 19 years are inactive compared to

44% of males in the same age group (31). Recent pedometer data from CAN PLAY, a representative survey of Canadian children and adolescents aged 5-19 years, suggests that nearly 88% of Canadian youth do not meet the current recommended 90 minutes of physical activity per day (equivalent to a daily step count of 16 500) (32).

2.1.1.4 Determinants

Determinants of behavioural risk factors identified in the literature can be grouped into three major categories: individual characteristics (genetic, demographic, psychosocial), social influences (family and peer) and environmental influences (school and built environment).

Individual characteristics

There is some evidence suggesting that being physically active may be related to a genetic predisposition (98). In particular, some authors suggest that certain characteristics or traits such as body mass and body type are genetically determined, which could in part explain the observed differences in levels of physical activity among youth (98, 99). The literature consistently reports sex differences in levels of physical activity. Specifically, females are less active than males, both during childhood (100) and adolescence (101, 102). Females are particularly less likely to participate in unorganized sports than males in or outside of school (103). Both cross-sectional (104, 105) and longitudinal studies (68, 106) report age-related declines in level of physical activity starting in childhood (grades four or five) and through the transition into adolescence. While there seems to be few ethnic differences in levels of physical activity among children (102), non-Hispanic Caucasian adolescents are generally more active than adolescents from other ethnic groups (107). Among the psychosocial determinants, higher self-esteem (i.e., overall estimation of one's own worth as a person) (108) and a more favourable self-image have been associated with regular physical activity among both children (109) and adolescents (110, 111). Higher academic achievement (compared to other schoolmates) has been also correlated with higher physical activity among youth aged 11 to 15 years (69). Lastly, a few studies have reported an association between self-efficacy and levels of physical activity in children (112) and adolescents (113), although a large review concluded that no such association existed (107).

Social influences

Greater parental socioeconomic status (SES) measured by a variety of indicators, including educational attainment (113), occupational category (70) and income (113) has been linked with increasing levels of physical activity among youth. Family structure or single- *versus* two-parent family status is also associated with physical activity. Indeed, youth living with only one parent are generally less active than those living with both parents (102). Stronger parental and peer role-modeling (in terms of their physical activity behaviour) seem to be positively associated with levels of physical activity in children (114) and to a lesser extent in adolescents (107, 115). Research also indicates the presence of a significant association between greater parental support (71, 116) and peer support (108, 117) for physical activity and an active lifestyle among adolescents.

Environmental influences

At school, participation in physical education classes has been found to be positively correlated with levels of physical activity among both children (102) and adolescents (113). Administrative and teacher's support for physical activity, teaching skills of teachers and characteristics of principals can also influence the patterns of physical activity of youth (118, 119). While some authors have found positive associations between physical activity levels of youth and characteristics of the built environment such as proximity to green spaces and parks as well as access to sports facilities and equipment (120, 121), others did not find such associations (122).

2.1.2 Sedentary behaviour

2.1.2.1 Definitions

Sedentary behaviour is not formally defined in the scientific literature. Nevertheless, among researchers, sedentary behaviour is commonly referred to time spent in low energy expenditure pursuits such as screen-based media use (i.e., watching television (TV) or videos, playing video games, using the computer/internet), as well as sleeping, sitting, lying down and reading books (72, 123).

2.1.2.2 Measurements

Assessment of sedentary behaviour relies mainly on parent/child/interviewer reports and direct observation in the form of questions to measure TV/video viewing or video

game/computer use. Time unit referents and periods for recall have varied widely (e.g., minutes, hours, days, 1-day, 3-day, 1-week) (124-127). Some authors have also used aggregate measures of sedentary behaviour (e.g., TV viewing combined with video game playing and computer use) (124). Little however is published in the literature regarding the reliability and validity of sedentary behaviour data (127).

2.1.2.3 Prevalence and trends

In 2001, the American Academy of Pediatrics guidelines set boundaries for total time spent on screen viewing at ≤2 hours per day and ≥4 hours per day for low viewing and high viewing, respectively (128). In a recent review of more than 90 studies, 66% of children and adolescents aged 7 to 18 years were classified as "low users", while 28% were classified as "high users" of TV (124). In the same review, the total screen-based media use was estimated at about 208 minutes per day or 3.47 hours per day, including 134 minutes spent watching TV, 40 minutes playing video games and 34 minutes using computers (124). The most recent Canadian data indicate that 30% of males and 18% of females aged 12 to 17 years spend 30 hours or more per week in sedentary activities, an estimation which is quite alarming (129). Although secular data on sedentary behaviour are limited, the available evidence suggests that total screen-based media use, and TV viewing in particular, have remained stable in the past 50 years among youth aged 11 to 17 years at approximately 35 to 40 hours per week of total media use and 2.5 hours per day of TV viewing (124).

2.1.2.4 Determinants

Individual characteristics

According to a large review by Marshall et al. (2006), males are more likely to engage in sedentary behaviour (in particular TV viewing and playing video games) than females, although there is no sex-related effects for computer use (124). Evidence suggests a curvilinear relationship between TV viewing and age with peak viewing occurring at around 9 to 12 years of age. Screen-based media use decreases during adolescence but those considered "high users" at young ages (7-12 years) are likely to remain "high users" at older ages (13-18 years) (124). A greater proportion of young people from ethnic minorities and African Americans report watching TV than youth from other ethnic

backgrounds (72). Among the psychosocial characteristics, higher depression is correlated with more time spent watching TV and playing video games among males and females aged 11 to 15 years, while a higher perception of academic achievement is correlated with less time using screen-based media (69).

Social influences

Lower parental SES measured by lower parental education (72, 125) and income (125) has been associated with sedentary behaviour among children and adolescents. Young people living in single-parent/guardian families report watching more TV than those living with two parents/guardians (72). Authoritative parenting style (i.e., providing control and support) toward screen-based media use is correlated with less time spent watching TV and playing video games among youth (69). Moreover, more favourable parental viewing habits (i.e., less time spent on viewing) are linked to more favourable viewing habits among children and adolescents (72).

Environmental influences

Increased support for low use of screen-based media at school has been suggested to decrease sedentary behaviour and risk of becoming overweight among youth (130). Also, there is some evidence that a larger proportion of youth watch TV during the weekend than during the week, probably because school is closed during the weekend (72). Children living in unsafe neighbourhoods seem to spend longer hours inside the home and greater time viewing TV than those living in safe neighbourhoods (131). Moreover, a greater proportion of young people living in urban areas tend to watch TV than those living in rural areas (72).

2.1.3 Cigarette smoking

2.1.3.1 Definitions

The term "smoking" refers to active smoking behaviour, defined as "the intentional inhalation of tobacco smoke" (132). Based on responses to questions in surveys about smoking, such as the Youth Smoking Survey in Canada, respondents are classified as *never* smokers (i.e., have never tried a cigarette, not even a few puffs) and *ever* smokers (i.e., have ever tried a cigarette, even a few puffs). Ever smokers include *former* smokers (i.e., have smoked at least 100 cigarettes in their lifetime, but have not smoked at all during the 30 days preceding the survey) and *current* smokers (i.e., have smoked at least 100

cigarettes in their lifetime, and have smoked in the 30 days preceding the survey); the latter include *regular/daily* smokers (i.e., current smokers who have smoked at least one cigarette per day for each of the 30 days preceding the survey) and *occasional/non-daily* smokers (i.e., current smokers who have smoked at least one cigarette during the past 30 days, but have not smoked every day) (133).

2.1.3.2 Measurements

In epidemiological studies, the assessment of cigarette smoking is based on self-reports or parent/guardian/interviewer reports using specific questionnaires developed according to the developmental stage of children and adolescents (89). Because smoking is a behaviour for which there is considerable social stigma, participants may not always respond truthfully to surveys. Indirect information obtained about tobacco use in youth from their parents/guardians may not be very accurate (89). In addition to indicators based on self-reports, there exist several biochemical methods to assess tobacco use; these include measuring nicotine or its metabolite cotinine in a variety of body fluids such as blood, saliva and urine. Carbon monoxide can also be measured in the expired breath (89). While biochemical methods can be used to validate responses obtained from self-reports, they are generally expensive and do not allow measuring the number of cigarettes smoked which is important for prevention/treatment interventions (89).

2.1.3.3 Prevalence and trends

Regular measurements of the prevalence and secular trends of tobacco use in Canadian youth is obtained by the Canadian Tobacco Use Monitoring Survey, for youth aged 15 to 24 years, and the Youth Smoking Survey, for children and adolescents in grades 5 to 12. The prevalence of cigarette smoking among Canadians aged 15 to 19 years increased from 24% in 1994 to a peak of 29% in 1996 but has been edging down since then (134). In 2009, 14% of adolescents aged 15 to 19 years were current smokers, 8% smoked daily and 5% smoked occasionally. Daily smokers consumed on average 10.9 cigarettes per day, with females smoking fewer cigarettes than males (10.0 *versus* 11.6, respectively) (135). Based on the most recent data from the 2006-2007 Youth Smoking Survey, the prevalence of ever smokers in grades 5 to 9 was nearly 19%, while the prevalence of ever smokers in grades 10 to 12 was 48% (33).

2.1.3.4 Determinants

Individual characteristics

Evidence from twin and adoption studies indicates that genetic factors play a role in the aetiology of cigarette smoking (136). However, the findings are not consistent between adults and adolescents. For example, in adults, having a defective CYP2A6 gene has been linked to lower risk of becoming nicotine dependent (137) while in adolescents, it is suggested that having the same defective gene increases risk of becoming nicotine dependent (138). The association between sex and cigarette smoking is also inconsistent in the literature. While the Canadian Tobacco Use Monitoring Survey indicates higher prevalence of smoking among young males compared to females (16% *versus* 12%, respectively) (135), other reports have found similar rates of smoking among males and females (33, 139). Cigarette smoking increases with age especially during adolescence (140). The transition period from elementary school to high school seems to be a critical time at which teenagers initiate smoking (140). Youth who are from a Caucasian background are more likely to smoke cigarettes than those from other ethnic groups (141). Lower self-esteem (142), lower self-image (140), greater depression (74, 143), rebelliousness (142) and worse academic achievement (140, 142) are also associated with greater cigarette smoking among youth.

Social influences

Low SES defined by low parental education and income is associated with greater smoking in young people (141). Youth are more likely to initiate smoking if their fathers have less than a high school diploma compared to youth whose fathers have higher education (140). While living with a single parent increases the risk of smoking in children and adolescents (140), living with two parents decreases the odds of smoking among youth (142, 144). Parental smoking behaviour is also positively associated with smoking status in adolescents (145), especially among young females (146). In contrast, parental support for non-smoking such as having strict rules at home and discussing the health risks of smoking are linked with less smoking among youth (147). Similarly, better parent-child relationships (148) and connectedness (76) have been associated with lower smoking rates among adolescents. Having friends who smoke is however a strong predictor of smoking behaviour among teenagers (149).

Environmental influences

School type seems to be correlated with smoking among youth. In particular, youth attending public nonreligious schools are more likely to smoke than youth attending private or public religious schools (150, 151). Some authors suggest that religious schools exert spiritual control over students by reminding them that they should not harm their bodies, as per their religious principles (150). Lack of health policies and rules (73, 75), high teacher workload (73) and weak collective sense of belonging to school among students (i.e., school connectedness) (152) have been also correlated with increased cigarette smoking in children and adolescents. Some studies also suggest that youth living in deprived neighbourhoods are more likely to smoke cigarettes than those living in more affluent neighbourhoods (153, 154).

2.1.4 Alcohol drinking

2.1.4.1 Definitions

A standard drink is defined as 13.6 grams of alcohol. This is equivalent to 5 ounces of wine, 12 ounces of beer or 1.5 ounces of spirit. The Canadian Centre for Addiction and Mental Health has set guidelines for alcohol drinking in adults (155). However, there are no standard Canadian guidelines for youth, nor a consensus regarding classification of youth alcohol drinking. Nevertheless, based on responses to questions in certain provincial surveys about alcohol consumption in youth, adolescents are often classified as *never* drinkers (i.e., never drank alcohol), *ever* drinkers (i.e., ever having had at least one standard drink), *experimental* drinkers (i.e., only tried consuming alcohol once in the past year), *occasional* drinkers (i.e., consumed more than one standard drink but only once every month or less in the past year), *regular* drinkers (i.e., drank at least once every week in the past year) and *daily* drinkers (i.e., drank every day in the past year) (156). Some authors also use the terms monthly or weekly "binge", "heavy" or "excessive" alcohol drinking which are generally defined as consuming five or more standard alcoholic drinks on a single occasion for males and four or more standard alcoholic drinks on a single occasion for females in the past month or week, respectively (157, 158).

2.1.4.2 Measurements

In epidemiological studies, alcohol consumption in youth is assessed through self- or parent/guardian reports. Typically, survey questions measure the frequency and/or dose of alcohol use in a given period of time. However, similar to cigarette smoking, self-reported alcohol consumption is subject to social desirability bias (89). Biological markers are rarely used in epidemiological studies to assess alcohol consumption in youth (89).

2.1.4.3 Prevalence and trends

According to the Health Behaviour in School-aged Children (HBSC) study, an international survey administered every four years to a representative sample of youth in grades 6, 8 and 10 in 34 participating countries, the prevalence of regular alcohol drinking among Canadian 6th graders decreased from 5% in 1994 to 2% in 1998, but increased to 6% in 2002. Similar patterns of regular alcohol drinking were reported among 8th graders (10%, 8%, 14%) and 10th graders (22%, 20%, 29%) in 1994, 1998 and 2002, respectively (159). The 2006-2007 Canadian data on alcohol consumption indicates that 59% of students in grades 7 to 9 reported ever consuming alcohol while 83% of students in grades 10 to 12 were ever drinkers (33). It is estimated that by late adolescence, nearly 90% of Canadian youth (2.7 million people) have consumed alcohol (158).

2.1.4.4 Determinants

Individual characteristics

Genetics seems to play a significant role in adolescent alcohol drinking although its influence seems to be weaker than that of social factors (i.e., family and peer influence) (160). Specifically, children of alcoholics are significantly more likely than children of nonalcoholics to initiate drinking during adolescence (161) and to develop alcoholism (162). While there seems to be no sex differences for ever drinking (33), males are more likely to be regular and binge drinkers than females (62, 73, 163). Sex differences in regular and heavy alcohol consumption may be because females tend to have more self-control over their drinking behaviour than males (164), while males tend to be more open and enthusiastic toward drinking than females (165). Being older or in a higher grade is positively associated with ever, regular and binge drinking among adolescents (73, 166, 167). In addition to age and sex, ethnicity is related to alcohol drinking among youth.

Caucasians aged 15 to 19 years are more likely to be regular drinkers than non-Caucasian youth in the same age group (145). Certain psychosocial characteristics such as low self-esteem, low academic achievement and depression are also associated with alcohol consumption among children and adolescents (167, 168).

Social influences

Family and peer characteristics influence drinking patterns in youth. Among family-related characteristics, greater parental SES (169), caregiver drinking behaviour (168), lack of parental support and monitoring (170), and poor parent-child relationships (76) are positively associated with adolescents' initiation and continued drinking. Peer drinking and peer acceptance of drinking are also associated with adolescent drinking (171). According to one study, youth who report that all or most of their friends drink alcohol are up to 11 times more likely to engage in binge drinking than those with fewer friends who use alcohol on a regular basis (172).

Environmental influences

Adolescents attending religious schools seem to have lower drinking rates than youth attending nonreligious schools (158). It is believed that religious institutions promote healthy behaviour through communication and supervision of clear rules and expectations (173). The presence of clearly formulated and communicated rules at school is also correlated with lower drinking consumption among youth (73). In turn, feeling unsafe at school (174)**,** low school connectedness and poor collective commitment to academic endeavours at school (175) increase the likelihood of excessive drinking among high school students. Some evidence also suggests that living in a more socioeconomically advantaged community increases the likelihood of alcohol drinking among adolescents (176). In contrast, youth residing in urban and high population density areas report lower drinking rates than those living in rural and low population density areas (152).

2.1.5 Overweight and obesity (High BMI)

2.1.5.1 Definitions

Overweight and obesity are defined as "abnormal or excessive fat accumulation that may impair health" (177). BMI calculated as weight (kg)/height (m^2) is recognized as a simple and valid measure of adiposity (fat) in youth (178, 179). There are currently three BMI-for-age based references to define overweight and obesity in children and adolescents (179).

First, following recommendations by the U.S. Expert Committee on Childhood Obesity in 1998 (180), the revised 2000 U.S. Centers for Disease Control and Prevention (CDC) growth charts define at-risk of overweight in children and adolescents as a BMI between the 85th and 94th age- and sex-specific percentile from the National Health Examination Surveys (NHES) II and III, and the National Health and Nutrition Examination Surveys (NHANES) I and II, and overweight as a BMI ≥95th age- and sex-specific percentile from the same surveys (181). Some clinicians use U.S. CDC growth charts to classify children and adolescents as overweight (≥85th to ≤94th percentile) and obese (≥95th percentile) (179).

Alternatively, the International Obesity Task Force (IOTF) proposed an international reference, age- and sex-specific BMI cutoffs for children and adolescent in the year 2000 (178). Since BMI level-associated health risks among youth are unclear, the IOTF recommended extrapolating the well-established adult BMI cutoffs of 25 and 30 kg/m^2 backward to specify sex- and age-specific cutoffs for children and adolescents aged 2 to 18 years. Specifically, data from six large, nationally representative surveys from Brazil, Great Britain, Hong Kong, the Netherlands, Singapore and the U.S. were used to construct BMI centile curves that pass through the adult BMI cutoffs at age 18 years. Level 1 cutoffs correspond to a BMI of 25 kg/m^2 at age 18 years (reflecting overweight), and level 2 cutoffs correspond to a BMI of 30 kg/m^2 at age 18 years (reflecting obesity). Overweight is therefore defined as a BMI ≥ level 1 and < level 2 cutoffs, and obesity is defined as BMI ≥ level 2 cutoffs (178).

More recently, in 2006, the World Health Organization (WHO) released new growth standards for children aged 0 to 5 years in an attempt to describe how children *should grow* under desirable conditions rather than how children *do grow* based on some reference populations (182). The WHO growth standards were based on a cohort of children (from the U.S., Brazil, Ghana, India, Norway and Oman) who were deliberately exposed to conditions that allowed for optimal growth, including breastfeeding, appropriate diet, non-smoking mother, and access to basic immunization and health care. As such, the WHO growth curves represent a desired growth "standard", whereas the CDC and the IOTF approaches describe how children grow based on nationally representative samples of children (182). In 2007, the WHO produced a series of growth references for children and

adolescents aged 5 to 19 years using data from NHES II, NHES III and NHANES I to ensure a smooth transition from the WHO growth standards for 0 to 5 year-olds. The development of growth standards for children aged 5 years and older was not feasible because it would not be possible to control the dynamics of their environment. Based on the WHO growth references, children whose BMI is more than two standard deviations above the mean (approximately the 97th percentile) are considered obese, and those whose BMI is between one and two standard deviations above the mean (approximately the 84th percentile) are considered overweight (183).

Research comparing the U.S. CDC growth charts and the IOTF cutoffs has shown similar prevalence estimates for the combined overweight/obesity category among children and adolescents aged 6-17 years (184). However, prevalence estimates for overweight/obesity based on the WHO growth references were found to be higher than estimates obtained from the U.S. CDC growth charts or the IOTF cutoffs (184). While the CDC growth charts and the IOTF cutoffs have been widely used in the literature, the clinical utility of the WHO growth references remains to be determined (179, 184).

2.1.5.2 Measurements

In epidemiological studies of youth, BMI is assessed either by objective measurements of height and weight according to standardized protocols or through self- (for adolescents) and parent/guardian reports (for children). While self-reported height and weight are highly correlated with objective measures, females tend to underestimate their weight and males tend to overestimate their height (185). Other simple and quick methods such as skinfold thickness measurements (triceps and subscapular) and waist circumference measurements have been also used to assess the size of regional and central adiposity in youth, respectively. However, the precision and accuracy of skinfold thickness and waist circumference measurements have been shown to be poor (186).

2.1.5.3 Prevalence and trends

According to data based on measured height and weight from the 1981 Canada Fitness Survey and the 2007-2009 Canada Measures Health Survey, the proportion of young males aged 15 to 19 years classified as overweight or obese has more than doubled, rising from

14% in 1981 to 31% in 2009. Among females aged 15 to 19 years, the proportion classified as overweight or obese increased from 14% in 1981 to 25% in 2009 (187). In the past 25 years, similar rates of increase in the prevalence of overweight and obesity among children and adolescents have been reported in other developed countries, including the U.S, the United Kingdom and Australia (188). Recent results from the 2007-2009 Canada Measures Health Survey, and using the IOTF cutoffs, indicate that the prevalence of overweight was 17% and 18% among 12-17 year-old males and females, respectively, and that the prevalence of obesity was 12% and 8%, respectively (189).

2.1.5.4 Determinants

Individual characteristics

The underlying mechanism of obesity is an imbalance between the amount of energy intake and energy expenditure. Over-consumption of energy-dense, nutrient-poor food and beverages (190, 191) and low levels of physical activity and high sedentary behaviour (34, 192, 193) have been associated with greater rates of overweight and obesity in children and adolescents. Data from large surveys in Canada and the U.S. indicate similar rates of overweight and obesity among young males and females (26, 189, 194). Results from the 2007-2008 U.S. NHANES indicate age-related increases in the prevalence of overweight and obesity between the ages of 2-5 years (21% overweight and 10% obese) to 6-11 years (36% overweight and 20% obese). However, no age-related increase in the prevalence of overweight or obesity was found among youth between the ages of 6-11 years to 12-17 years (194). Recent Canadian data also indicate no age-related differences in the percentage of overweight or obese children aged 6-11 (17% overweight and 7% obese) and youth aged 12-17 years (17% overweight and 10% obese) (189). Ethnicity is related to BMI among youth. Specifically, Black and Hispanic children aged 6 to 11 years and Hispanic adolescents aged 12 to 17 years are more likely to be overweight compared to Caucasian children and adolescents (26, 195). A few studies have reported inverse associations between self-esteem and weight status (196, 197), while other studies did not find any significant association between self-esteem and overweight or obesity among children and adolescents (198, 199). In contrast, lower academic achievement has been consistently correlated with overweight and obesity among youth (200-202). Several studies conducted in twins, nuclear families and extended pedigrees also suggest a genetic predisposition to

weight gain (203-205). For example, data from the British 1958 birth cohort showed that obese children of obese parents are more likely to be obese in adulthood, especially when both of their parents are obese (203). Another study demonstrated high correlations between adoptees' BMI and the BMI of their biological parents compared to the BMI of their adoptive parents (204).

Social Influences

Certain family characteristics including lower family SES (192, 206, 207), living in a single-parent family (208) and parental unhealthy characteristics or behaviours such as obesity (192, 209, 210) and smoking (77) have been associated with overweight and obesity among children and adolescents. Better parent-child relationships, stronger cohesion and less conflict between the parents and the child have been also correlated with lower weight among youth (211-213). A recent study also reported strong correlations between youth BMI in grades 7 to 12 and their peers' BMI (214).

Environmental influences

At school, the presence of nutritional programs (215) and policies (216), as well as physical education classes has been correlated with lower rates of overweight and obesity among youth (217). Youth attending public schools are also more likely to be overweight than youth attending private schools (218). According to a recent systematic review, the empirical evidence for the associations between the built and biophysical environmental variables and youth obesity is weak (219). Only a few variables including access to physical activity facilities and availability of bicycle and walking trails (220), living in rural areas (210) and deprived neighbourhoods (221) have been correlated with high BMI among children and adolescents. However, there is more evidence concerning a link between neighbourhood deprivation and CVD risk factors among adults. For example, a few studies conducted in the U.S. (222) and in Europe (223) have reported that adults living in high deprived neighbourhoods are between 30% to 40% more likely to be obese, physically inactive and cigarette smokers than adults living in low deprived neighbourhoods (224). Thus, children of adults living in poor neighbourhoods may be at greater risk of being exposed to and/or developing health risk behaviours than children of adults living in affluent neighbourhoods.

2.2 Multiple chronic disease behavioural risk factors

Much of previous research has focused on single chronic disease behavioural risk factors and their potential determinants. There is however increasing evidence, mainly from the adult literature, that chronic disease behavioural risk factors do not occur in isolation and that they may share common sets of determinants (52, 54, 56, 58, 64). While studies on multiple chronic disease behavioural risk factors among youth are now emerging (65, 66, 79), the field of multiple-behaviour research remains young and its boundaries are still being defined (80). Research among youth has primarily comprised of studies on the occurrence of multiple biological risk factors such as insulin resistance, glucose intolerance, dyslipidemia and hypertension (225-229). Many studies among youth have also focused on the occurrence of multiple risky or problem behaviours such as delinquency, non-use of seatbelts, drinking and driving, unsafe sexual behaviour, substance abuse, aggression and violence (230-237). Few studies among youth have investigated the occurrence of multiple behavioural risk factors likely to influence chronic diseases such as CVD, cancer, type 2 diabetes or other diseases related to lifestyle in adulthood (50, 66, 238).

It is important to study multiple behavioural risk factors for chronic diseases among youth for several reasons. First, describing the prevalence and distribution of multiple chronic disease behavioural risk factors may inform health promotion planning efforts across multiple settings such as public health agencies and primary care units (239, 240). Second, multiple chronic disease behavioural risk factors tend to have synergistic effects on health outcomes such that combinations of behavioural risk factors may be more detrimental to health than the sum of their individual independent effects (240, 241). As such, an increased understanding of clustering patterns of chronic disease behavioural risk factors in childhood and adolescence may support efforts to reduce incidence of chronic diseases and improve overall health later in life. Lastly, identifying characteristics possibly associated with multiple chronic disease behavioural risk factors among youth can help health professionals design more effective and setting-specific intervention strategies (242).

2.2.1 Burden of multiple chronic disease behavioural risk factors

The co-existence of behavioural risk factors among both youth and adults increases the risks of chronic diseases morbidity and mortality. For example, in a large prospective study conducted among 31 700 American adults, Meng et al. (1999) found that subjects with five behavioural risk factors including, alcohol drinking, cigarette smoking, overweight, high fat and low fruits and vegetables intake had significantly higher risks for cancer incidence (Relative risk = 1.61, 95% confidence interval (CI): 1.26-2.06 for men; Relative risk = 1.48, 95% CI: 1.12-1.96 for women), cancer mortality (Relative risk = 1.97, 95% CI: 1.32-2.94 for men; Relative risk = 2.84, 95% CI: 1.72-4.73 for women) and coronary heart disease mortality (Relative risk = 1.96, 95% CI: 1.31-2.95 for men; Relative risk = 2.04, 95% CI: 1.17-3.59 for women) than those with zero or one risk factor, after controlling for age, education and ethnicity (60). Using data on antemortem CVD risk factors including high BMI and cigarette smoking, Berenson et al. (1998) showed that the severity of coronary and aortic atherosclerosis was related to the number of CVD risk factors in children and young American adults aged 2 to 39 years who had died from various causes (243). In particular, subjects with zero, one, two and three or four risk factors had, respectively, 19.1%, 30.3%, 37.9% and 35% of the intimal surface of their aorta covered with fatty streaks (*P* for trend = 0.01). In the coronary arteries, 1.3%, 2.5%, 7.9%, and 11.0%, respectively, of the intimal surface was covered with fatty streaks (*P* for trend = 0.01), and 0.6%, 0.7%, 2.4%, and 7.2%, respectively, was covered with collagenous fibrous plaques (*P* for trend = 0.003) (243).

Furthermore, the occurrence of two or more behavioural risk factors reduces life expectancy considerably (244). In a recent large prospective study, Khaw KT et al. (2008) quantified the combined effect of four health behaviours (including, non-smoking, physical activity, moderate alcohol intake and fruits and vegetables intake) on mortality in 20 244 British adults aged 45 to 79 years. The authors used a score index where each behaviour received a score of 1, for a total score ranging from 0 to 4. After an average 11 years follow-up, the age-, sex-, body mass-, and social class-adjusted relative risk for all-cause mortality for subjects with three, two, one, and zero compared to four health behaviours were respectively, 1.39 (95% CI: 1.21-1.60), 1.95 (95% CI: 1.70-2.25), 2.52 (95% CI: 2.13-3.00), and 4.04 (95% CI: 2.95-5.54) (*P* for trend < 0.001). In addition, the adjusted

cumulative survival was shown to be 75% for those with zero health behaviours and 95% for those with four health behaviours, respectively. This was found to be equivalent to approximately a 14-year shorter life expectancy for subjects with zero compared to four health behaviours (244).

2.2.2 Definitions and methodological issues

The term "co-occurrence" of behavioural risk factors refers to the simultaneous presence of two or more behavioural risk factors (i.e., multiple behavioural risk factors) in individuals (228, 245). The most widely used method to assess the co-occurrence of behavioural risk factors is by means of a multiple risk factor index (or score) approach (30, 52, 54, 56, 65, 66, 78, 228, 238, 246). In this method, each behavioural risk factor is first dichotomized at the recommended criterion based on what is generally accepted in the literature. Each subject is then assigned a score of 1 if they have the risk factor and a score of 0 if they don't have the risk factor. Individual risk factor scores are then summed to yield a multiple risk factor index ranging from 0 (indicating 0 risk factors) to *X* (*X* number of risk factors) for each subject (55, 56). Some authors have questioned the use of such indices where risk factors are attributed equal weights (247, 248). In contrast, other experts have shown that equally weighted risk factor indices result in the identification of very similar at risk population sub-groups than those identified with unequally weighted risk factor indices (249, 250). In addition, multiple risk factor indices have been successfully used to explain the combined impact of unhealthy behaviours on risks of morbidity and mortality in different populations and age groups (59, 243, 244, 251).

The co-occurrence or combination of a greater than expected number of risk factors or behaviours among individuals is commonly referred to as "clustering" (228, 245). Different methods have been used in the literature to describe clustering of risk factors and characterize patterns of behaviours. Logistic regression (51, 61, 252, 253) and discriminant analysis (254) have been applied to study associations between behaviours treated as categorical variables. In discriminant analysis, the goal is to determine which variables discriminate between two or more naturally occurring groups (255). Specifically, discriminant analysis has been used to investigate the associations between a selected risk behaviour (e.g., smoking) and a risk factor index comprised of two or more behavioural

risk factors (e.g., poor diet and physical inactivity) (254). Logistic regression has been used to study the associations between pairs of behavioural risk factors, by choosing one of the behavioural risk factors as the outcome and the other behavioural risk factor as the independent variable (51, 61). Both logistic regression and discriminant analysis take one of the behavioural risk factors as a starting point in the analysis and examine the association between that specific risk factor and other risk factors (255, 256). Therefore, a major limitation of logistic regression and discriminant analysis in describing clustering patterns of behavioural risk factors is that they require to arbitrarily pre-defining the order of importance of the risk factors under study. This may overemphasize the contribution of the selected primary behavioural risk factor.

Cluster analysis and factor analysis which do not require selecting a behavioural risk factor as a starting point in the analysis have been also used to describe clustering patterns of behavioural risk factors (257, 258). In cluster analysis, individuals are segregated into groups on the basis of similarities in their patterns of behaviours (259). Factor analysis involves reducing a number of observed variables, in this case behavioural risk factors, to relatively smaller number of components or groups of risk factors (260, 261). Despite their application in describing clustering patterns of behaviours, cluster analysis and factor analysis are purely exploratory analytical techniques such that their findings often require further investigation and validity confirmation (262). In turn, different clustering methods can and do generate different solutions or clusters of risk behaviours using the same dataset (259). Lastly, both cluster analysis and factor analysis are particularly suitable for studies involving a large number of items derived from questionnaires, attitudinal scales or developmental tests (259, 261).

One of the most cited and frequently used methods in epidemiological studies to investigate clustering patterns of behavioural risk factors is the measurement of the occurrence of each of possible behavioural risk factor combination (i.e., the observed proportion of the co-occurrence of risk factors) and comparison to its expected occurrence assuming mutual independence of risk factors (228, 245). The expected proportions are calculated by multiplying the individual probabilities of each risk factor based on their occurrence in the study population. The ratio of the observed over expected (O/E) proportions describes both

the direction and the intensity of the association between behavioural risk factors. Values above 1 indicate a positive association and those below 1 an inverse association between the studied risk factors. The greater the deviation of the ratio from 1 the more strongly the behavioural risk factors are associated. Similar to cluster analysis and factor analysis, the O/E ratio is a completely impartial method such that selection of a particular behavioural risk factor as a starting point of the analysis is not required (56, 57, 263). Moreover, 95% CIs can be calculated for the O/E ratios using the bootstrap technique which requires no distributional assumptions about the statistic (264).

2.2.3 Prevalence of multiple chronic disease behavioural risk factors

Only a few studies have estimated the observed prevalence of the *co-occurrence* of behavioural risk factors for chronic diseases among children and adolescents (Table I, *p.27*). In the U.S., Pronk et al. (2004) documented the prevalence of multiple healthy lifestyle factors among a random sample of 616 American adolescents (13-17 years), 585 adults (18-64 years) and 685 seniors (≥65 years) who were members of a Midwestern health plan (78). The authors reported that only 31% of adolescents met the recommended guidelines for four healthy lifestyle factors including physical activity, non-smoking, high diet quality and healthy weight. This finding implies that more than two-thirds of adolescents aged 13 to17 years had at least one or more behavioural risk factors (78). However, results of this study were only applicable to the youth population of the upper Midwestern U.S. In another study conducted among 878 American youth, aged 11 to 15 years and recruited through primary care clinics in San Diego, the authors found that 89% of females and 79% of males had two or more behavioural risk factors including physical inactivity, sedentary behaviour, high fat intake and low fruits/vegetables consumption (66). The most prevalent three-risk factor combination was formed by physical inactivity, high fat intake and low consumption of fruits/vegetables; the proportion of males in this combination was 14% and the corresponding figure for females was 25%. The most prevalent combination of two risk factors consisted of high fat intake and low consumption of fruits/vegetables; the corresponding percentages for males and females for this two-way combination were 25% and 12%, respectively (66). Similar to the study of Pronk et al. (2004), this study focused only on one geographical location and thus its findings were not

Table I. Studies reporting the prevalence of multiple chronic disease behavioural risk factors in children and adolescents

Author (year)	Design	Sample (age/grade)	Behavioural risk factors (definition)	Method for assessing the co-occurrence of risk factors	Prevalence (%)	Limitations
Pronk NP et al. (2004)[a]	Cross-sectional	Random sample of 616 American adolescents (13-17 years), 585 adults (18-64 years) and 685 seniors (≥65 years) from upper Midwest	Non-smoking (never or former smoker) High diet quality (scored ≥11 on RFS)[b] Normal BMI (2000 CDC cutoffs) Physical activity (≥30 minutes of moderate activity for 5 days/week or ≥20 minutes of vigorous activity for 3 days/weak)	Multiple lifestyle index	0 healthy lifestyles: 1 1 healthy lifestyle: 7 2 healthy lifestyles: 22 3 healthy lifestyles: 39 4 healthy lifestyles: 31	-Non-representative sample -Lack of sex- and age-specific prevalence
O'Loughlin J et al. (2004)	Cross-sectional	Independent samples of 4659 Canadian children in grades 4-6 from Montreal	Ever smoking even a few puffs Physical inactivity (≤6 activities/week) Frequently consuming high-fat/junk food Obesity (based on IOTF cutoffs) Playing video games every day Watching ≥6 TV programs/day	Multiple risk factor index	0 risk factors: 32 1 risk factor: 36 2 risk factors: 21 3 risk factors: 8 4 -7 risk factors: 3	-Non-representative sample -Lack of sex- and age-specific prevalence
Klein-Geltink J et al. (2006)	Cross-sectional	Representative sample of 125 574 Canadians (≥12 years)	Smoking (current smoker) Physical inactivity (<1.5 kcal/kg/day) High BMI (based on IOTF cutoffs) High alcohol intake (>14 drinks/week for males and >9 drinks/week for females)	Multiple risk factor index	0 risk factors: 47 1 risk factor: 39 2 risk factors: 12 3 or 4 risk factors: 2	-Lack of age-specific prevalence among youth

Table I. Studies reporting the prevalence of multiple chronic disease behavioural risk factors in children and adolescents (continued)

Author (year)	Design	Sample (age/grade)	Behavioural risk factors (definition)	Method for assessing the co-occurrence of risk factors	Prevalence (%)	Limitations
Sanchez A et al. (2007)	Cross-sectional	Sample of 878 American adolescents (11-15 years) recruited through their primary care providers from San Diego	Physical inactivity (<60 minutes/day) Sedentary behaviour (watch TV >2h /day) High fat intake (fat percentage >30%) Low fruits/vegetables (<5 servings/day)	Multiple risk factor index	0 risk factors: 2 1 risk factor: 14 2 risk factors: 36 3 risk factors: 36 4 risk factors: 12	-Non-representative sample -Lack of age-specific prevalence
Driskell MM et al. (2008)	Cross-sectional	Random sample of 4091 American youth in grades 4 to 12 recruited in 44 schools in 22 states	Low fruits/vegetables (<5 servings/day) Sedentary behaviour (watch TV >2h /day) Physical inactivity (<60 minutes/day for at least 5 days of the week)	Multiple risk factor index	0 risk factors: 7 1 risk factor: 27 2 risk factors: 41 3 risk factors: 25	-Non-representative sample -Lack of sex-specific prevalence
Plotnikoff RC et al. (2009)	Cross-sectional	Random sample of 4932 Canadian youth in grades 7-10 from Alberta	Physical inactivity (scored <3 on PAQ-C)[c] High fat intake (fat percentage >35%) Poor diet (consumed <2 food groups/day) High BMI (based on IOTF cutoffs) Smoked during the last 30 days	Multiple risk factor index	0 risk factors: 15 1 risk factor: 37 2 risk factors: 32 3 risk factors: 13 4 or 5 risk factors: 3	-Non-representative sample

[a] This study assessed the occurrence of multiple healthy lifestyle factors.
[b] Recommended Food Score (RFS): a diet quality scale with a maximum range of 23.
[c] Physical Activity Questionnaire for Older Children (PAQ-C): assessed physical activity in the previous 7-day period and comprised a maximum score range of 5.

representative of the American youth population (66). Driskell et al. (2008) also estimated the prevalence of multiple unhealthy behaviours among a sample of 4091 American children and adolescents in grades 4 to 12 recruited in 44 schools throughout 22 U.S. states. According to their findings, 66% of youth reported having at least two behavioural risk factors including physical inactivity, frequent TV viewing and low consumption of fruits/vegetables. Only 7% of the participants reported having none of the three risk factors (65). While results of this study were applicable to the youth population of the 22 selected U.S. states, they were not representative of the remaining 28 U.S. states. In addition, the authors did not present the sex-specific proportions of multiple behavioural risk factors in this study (65).

In Canada, a cross-sectional study conducted among 4659 school children in grades 4 to 6 from disadvantaged, multiethnic neighbourhoods in Montreal reported that 32% of youth had at least two behavioural risk factors, 8% had three risk factors and 3% had four or more risk factors including ever smoking, physical inactivity, frequent TV and video playing, frequent consumption of high-fat and junk foods and obesity (265). While results of this study are important, external generalizability is limited due to the uniqueness of its sample. Using data from the CCHS Cycle 1.1 (2000), Klein-Geltink et al. (2006) estimated the prevalence of multiple exposures to current smoking, high alcohol intake, physical inactivity and high BMI in a representative sample of Canadians aged 12 years and over (246). According to this report, 49% of Canadian males aged 12-19 years had zero risk factors, 38% had one risk factor, 11% had two risk factors and 2% had three or four risk factors in the year 2000; the corresponding figures for Canadian females aged 12-19 years were 45%, 40%, 13% and 2%, respectively. Among the risk factor combinations, the observed prevalence of the co-occurrence of physical inactivity and high BMI was the highest for both males and females (5% for both sexes). Although this study used a large representative sample, the authors did not estimate the age-specific prevalence of multiple behavioural risk factors among youth. Moreover, this study did not describe the *clustering* patterns of multiple behavioural risk factors among children and adolescents. Lastly, in a recent cross-sectional study by Plotnikoff et al. (2009), nearly 43% of males and 53% of females in grades 7 to 10 in Alberta reported having two or more behavioural risk factors including physical inactivity, high fat intake, poor diet, smoking and high BMI. External

validity of this study is however limited to the youth population in grades 7 to 10 from Alberta (238).

In summary, the studies reviewed in this section indicate that a high percentage of youth engage in multiple unhealthy behaviours. However, these studies included different behavioural risk factors, used various definitions and cutoffs and focused on diverse populations. Therefore, comparison of results between these studies is difficult. Also, only one study reported the age- and sex-specific prevalence of multiple behavioural risk factors among children and adolescents in a non-nationally representative sample of youth living in Alberta (238). One study reported only the age-specific prevalence of multiple risk factors (65), two studies estimated only the sex-specific percentage of multiple risk factors (66, 246) and two studies did not report either the sex- or the age-specific proportions of multiple risk behaviours among youth (78, 265). Moreover, none of the studies reviewed in this section described the distribution of multiple behavioural risk factors by other characteristics of youth such as their SES.

2.2.4 Evidence of clustering of chronic disease behavioural risk factors

Most of the evidence regarding clustering of behavioural risk factors originates from studies investigating pairwise associations of risk factors in adults and adolescents. Among adults, both cross-sectional and longitudinal studies have found consistent positive associations between smoking and alcohol drinking (61, 266-268), smoking and physical inactivity (61, 254, 266, 269) and smoking and poor diet (61, 266). Similar positive associations have been found between physical inactivity and overweight (270, 271) and physical inactivity and poor eating habits (269, 272). The association between alcohol drinking and physical inactivity is less clear. While some authors have reported that subjects with higher alcohol consumption are more active (273), others have found an inverted J-shaped association where the likelihood of being active seems to increase with light and moderate drinking and then decreases with heavier alcohol consumption (274). Among youth, pairwise associations between smoking and alcohol drinking are also well documented (275-277). Cigarette smoking has been also positively associated with physical inactivity (51, 238) and overweight/obesity (276) among high school students. In turn, physical inactivity has been found to be associated with high BMI (238), inappropriate

dietary habits (51, 65, 238) and sedentary behaviour such as watching TV or videos for more than 2 hours per day (65, 253). Finally, overweight has been shown to be correlated with alcohol drinking (278) and TV viewing (34, 192, 193) among youth.

Several studies using diverse types of methods have explored associations between three or more behavioural risk factors, but almost exclusively in the adult population (Table II, *p.32*). Two cross-sectional studies from the U.S. employed cluster analysis (257) and discriminant analysis (254) to describe patterns of unhealthy behaviours among adults. In a study conducted in a nationally representative sample of 5484 American adults aged 21 years and older, Patterson et al. (1994) reported clustering of cigarette smoking, heavy alcohol drinking, physical inactivity and adverse dietary choices (257). In particular, seven different patterns emerged with the most prevalent cluster (25%) consisting of subjects who were very inactive, had poor diet quality, smoked every day and drank moderately (257).

Similarly, in a study by Emmons et al. (1994) conducted among 1559 American manufacturing workers (mean age: 40 years) who participated in a self-help intervention for physical activity at 11 worksites in Rohde Island, smokers were significantly more likely to engage in poor dietary habits and low levels of physical activity ($P < 0.001$) than non-smokers (254). Although the authors of this study concluded that smokers should be a particular target for health promotion interventions aimed at several risk behaviours, the findings of this report could only be applied to adults working in manufacturing sites.

Using the O/E ratio method, five studies conducted in Europe reported higher than expected ratios of clustering of three or four behavioural risk factors including cigarette smoking, alcohol drinking, poor diet and physical inactivity among adults. First, in a cross-sectional study by Raitakari et al. (1995) conducted in a representative sample of 484 Finish adults aged 18-24 years, the proportion of subjects with three or four risk factors was 1.5 times higher than expected by chance on the basis of individual frequencies. This indicates a 50% increase in subjects with three or four risk factors over that which would be expected if the risk factors were independent (58). Among the pairwise clusters, smoking and frequent inebriation showed the strongest association with an O/E ratio of 1.60. A limitation of this study was its relatively small sample size which may have reduced the precision of the O/E

Table II. Studies investigating clustering of chronic disease behavioural risk factors among youth and adults

Author (year)	Design	Sample (age)	Behavioural risk factors (definition)	Method for assessing clustering	Clustering results	Limitations
Patterson RE et al. (1994)	Cross-sectional	Representative sample of 5484 American adults (≥21 years)	Smoking (continuous variable - number of cigarettes smoked/day) Alcohol intake (continuous variable - number of drinks/week) Physical inactivity (continuous variable based on Act Index)[a] Diet quality (continuous variable based on DQI)[b]	Cluster analysis	7 clusters emerged with the most prevalent cluster being: Very inactive (Act Index=4.5) Poor diet (DQI=10.3) 1 cigarette/day 4 drinks/week	-Absence of sex-specific clustering patterns -No info. on the intensity and direction of clustering
Emmons KM et al. (1994)	Cross-sectional	Sample of 1559 American adult workers (means age: 40 years) from 11 Rhode Island manufacturing sites	Current smoking High fat intake (fat percentage >32%) Physical inactivity (<20 minutes of activities/day for at least 3 days of the week)	Discriminant analysis	Smoking was associated with lower physical activity and higher fat intake (P<0.001)	-Non-representative sample
Raitakari OT et al. (1995)	Cross-sectional	Representative sample of 484 Finish adults (18-24 years)	Smoking daily Poor diet (upper tertile of a high risk diet score) Physical inactivity (≤1/month of intense activity with a lot of sweating) Frequent inebriation (>10 times feeling drunk in lifetime)	O/E ratio	Clustering of 3 or 4 risk factors: O/E ratio=1.50 Clustering of smoking and frequent inebriation: O/E ratio=1.60	-Small sample size -Lack of confidence intervals for the O/E ratios

Table II. Studies investigating clustering of chronic disease behavioural risk factors among youth and adults (continued)

Author (year)	Design	Sample (age)	Behavioural risk factors (definition)	Method for assessing clustering	Clustering results	Limitations
Laaksonen M et al. (2001)	Cross-sectional	Representative sample of 22 745 Finish adults (20-64 years)	Smoking (daily or occasionally) Physical inactivity (<1/week of leisure time activity for at least 30 minutes) Alcohol use (>8 units/week for men and >5 units/week for women) Poor diet (2 or 3 unhealthy food choices including veggies intake <3 times/week)	O/E ratio	Clustering of all 4 risk factors: Men: O/E ratio=2.70 Women: O/E ratio=3.20 Clustering of smoking, alcohol use and inactivity: Men: O/E ratio=1.50 Women: O/E ratio=2.10	-Results not applicable to youth populations
Schuit AJ et al. (2002)	Cross-sectional	Representative sample of 16 789 Dutch adults (20-59 years)	Smoking (≥1 cigarette per month) Excessive alcohol intake (>2 glasses/day for women and >3 glasses/day for men) Physical inactivity (<30 minutes of moderate to vigorous activity/day) Poor diet (<350 grams of vegetables and fruits/day)	O/E ratio	Clustering of all 4 risk factors: Men: O/E ratio=1.60 Women: O/E ratio=1.70 Clustering of smoking, excess alcohol intake and poor diet: Men: O/E ratio=1.40 Women: O/E ratio=1.50	-Lack of confidence intervals for the O/E ratios
Galan I et al. (2005)	Cross-sectional	Random sample of 16 043 Spanish adults living in Madrid (18-64 years)	Current smoking High alcohol intake (>8 units for men; >6 units for women in the past 30 days) Physical inactivity (<3 times/week of moderate activity for 30 min. each time) Poor diet (<2 servings of fruit, juice or vegetables in the last 24 hours)	O/E ratio	Clustering of all 4 risk factors: Men: O/E ratio=2.15 Women: O/E ratio=2.96 Clustering of smoking, high alcohol intake and poor diet: Men: O/E ratio=1.97 Women: O/E ratio=2.66	-Non-representative sample

Table II. Studies investigating clustering of chronic disease behavioural risk factors among youth and adults (continued)

Author (year)	Design	Sample (age)	Behavioural risk factors (definition)	Method for assessing clustering	Clustering results	Limitations
Poortinga W (2007)	Cross-sectional	Representative sample of 11 492 English subjects (16-64 years)	Current smoking Heavy drinking (≥8 units for men; ≥6 units for women on at least 1 day/week) Low fruits/vegetables (<5 portions/day) Physical inactivity (<5 times/week of moderate activity for 30 min. each time)	O/E ratio	Clustering of all 4 risk factors: Men: O/E ratio=1.32 Women: O/E ratio=1.99 Clustering of smoking, heavy drinking and low fruit/veggie: Males: O/E ratio=1.78 Females: O/E ratio=2.35	-Lack of confidence intervals for the O/E ratios
Chou KL (2008)	Cross-sectional	Representative sample of 4812 Chinese older adults living in Hong Kong (≥60 years)	Current smoking Heavy drinking (drinking ≥4 days/week) Physical inactivity (<3 times/week of moderate activity for 30 min. each time) Low fruits/vegetables (<7 servings/week)	O/E ratio	Clustering of all 4 risk factors: Men: O/E ratio=3.59 Clustering of inactivity and lack of fruits/vegetables: Men: O/E ratio=1.03 Women: O/E ratio=1.22	-Lack of confidence intervals for the O/E ratios
Tobias M et al. (2007)	Cross-sectional	Representative sample 10 241 New-Zealanders (≥15 years)	Smoking (≥1 cigarettes/day) Unhealthy drinking (AUDIT score ≥8)[c] Physical inactivity (<150 minutes/week of moderate activity) Low fruits/vegetables intake (<5 servings/day)	O/E ratio	Clustering of all 4 risk factors: Males: O/E ratio=2.28 Females: O/E ratio=4.48 Clustering of smoking, unhealthy drinking and low fruits/vegetables intake: Males: O/E ratio=1.81 Females: O/E ratio=3.24	-Focused on a general population -Did not include children and younger adolescents

Table II. Studies investigating clustering of chronic disease behavioural risk factors among youth and adults (continued)

Author (year)	Design	Sample (age)	Behavioural risk factors (definition)	Method for assessing clustering	Clustering results	Limitations
Terre L et al. (1990)	Cross-sectional	Random sample of 1092 low SES rural American school children (11-18 years)	Physical inactivity (assessed using 7 items on sports/activities participation) Unhealthy eating (assessed using 7 items on eating habits) Alcohol use (assessed using 7 items on drinking habits including ever drinking) Smoking (assessed using 7 items on tobacco use including ever smoking)	Factor analysis	Different patterns were found including: a "Multiple substance use cluster" for youth in grade 6 and a "Junk food cluster" for youth in grades 11-12	-Non-representative sample -Absence of sex-specific patterns of clustering
Lawlor DA et al. (2005)	Cross-sectional	Sample of 3613 Australian youth of a birth cohort examined at age 14 years	Ever smoking Sedentary behaviour (watching ≥5 hours of TV/day Monday to Friday) Overweight (based on IOTF cutoffs) High blood pressure (sex-specific 75th percentile of mean arterial pressure)	O/E ratio	Clustering of 3/4 risk factors: O/E ratio=2.70 (youth from low-income families) O/E ratio=1.70 (youth from affluent families)	-Non-representative sample -Absence of clustering patterns
Mistry R et al. (2009)	Cross-sectional	Random sample of 4010 American youth from California (mean age: 14 years)	Smoking (≥1 days in the last month) Alcohol use (≥1 drinks in the last month) Physical inactivity (equivalent of <60 minutes of activity most days/week) Low fruits/vegetables (<5 servings/day)	Cluster analysis	4 clusters emerged including: Salutary adherents Active snackers Sedentary snackers Risk takers	- Non-representative -Lack of info. on intensity of clustering

[a] Activity Index (Act Index): a measure of self-reported activity from 0 (high) to 5 (low).
[b] Diet Quality Index (DQI): a measure of overall diet quality from 0 (excellent) to 16 (poor).
[c] Alcohol Use Disorders Identification Test (AUDIT): a widely used scale for identifying hazardous drinking with a score of 8 or more indicative of harmful drinking.

ratio estimates which were also reported without any CIs (58). In another cross-sectional study conducted among a representative sample of 22 745 Finish adults aged 20-64 years, the O/E ratios for men and women with four behavioural risk factors were, respectively, 2.70 (95% CI: 2.33-2.97) and 3.20 (95% CI: 2.56-3.77) (64). Among the three-way combinations, smoking, alcohol consumption and physical inactivity showed the strongest clustering with O/E ratios of 1.50 (95% CI: 1.37-1.61) in men and 2.10 (95% CI: 1.82-2.27) in women. As for the pairwise associations, smoking clustered with alcohol consumption and physical inactivity clustered with unhealthy diet among both men and women (64).

In a cross-sectional study by Schuit et al. (2002), conducted among a representative sample of 16 789 Dutch adults aged 20-59 years, the proportion of men and women with four risk factors was higher than expected (O/E ratio = 1.60 for men, 1.70 for women) (55). In addition, smoking, excessive alcohol intake and poor diet showed the strongest three-way clustering with O/E ratios of 1.40 in men and 1.50 in women. Similar to the study by Raitakari et al. (1995) (58), this study did not report any CIs for the estimated ratios (55). However, given its large sample size, one would expect the width of the CIs to be quite narrow. Results of a cross-sectional study using a sample of 16 043 Spanish adults aged 18-64 years, living in Madrid, also showed significant clustering of four behavioural risk factors (O/E ratio (95% CI): 2.15 (1.93-2.38) for men, 2.96 (2.46-3.46) for women). Among the three-way combinations, smoking, high alcohol intake and poor diet was more prevalent than expected by chance (O/E ratio (95% CI): 1.97 (1.57-2.36) for men, 2.66 (1.57-3.74) for women) (56). Lastly, using representative data from the Health Survey for England (n = 11 492), Poortinga (2007) reported clustering of smoking, heavy alcohol drinking, lack of fruits/vegetables and inactivity (O/E ratio = 1.32 for men, 1.99 for women) among subjects aged 16 to 64 years (57). Similar to the findings of Schuit et al.'s (2002) and Galan et al.'s (2005) studies, the combination of smoking, heavy drinking and lack of fruits/vegetables intake showed the strongest three-way clustering in this British population (57). A limitation of this study was the absence of any CIs for the estimated O/E ratios.

Clustering of behavioural risk factors has been also reported in older adults. A study conducted among a representative sample of 4812 Chinese older adults aged 60 years and

above found significant clustering of smoking, heavy drinking, lack of fruits/vegetables intake and physical inactivity among men (O/E ratio = 3.59) (263). However, the four risk factors did not cluster among women probably because the observed prevalence of smoking, heavy drinking and having three risk factors was less than 1% in older women. Nevertheless, the pairwise combination of physical inactivity and lack of fruits/vegetables intake showed clustering among both older men (O/E ratio = 1.03) and older women (O/E ratio = 1.22) (263). The precision of the estimated O/E ratios in this study could not be however assessed due to the absence of 95% CIs.

A study from the New Zealand investigated the clustering of smoking, unhealthy drinking, physical inactivity and low fruits/vegetables intake in a representative sample of 10 241 participants aged 15 years and above (245). In this study, all four behavioural risk factors showed significant clustering in both males (O/E ratio = 2.28) and females (O/E ratio = 4.48). In addition, similar to three other studies conducted among adults (55-57), smoking, unhealthy drinking and low fruits/vegetables intake showed the strongest association among the three-way combinations (O/E ratio = 1.81 for males, 3.24 for females). Other three-behaviour combinations showed moderate clustering including the association of smoking with unhealthy drinking and physical inactivity (O/E ratio = 1.69 for males, 2.44 for females) (245). Similar to several other studies reported herein, no CIs accompanied the sex-specific O/E ratios in this study.

Only a few cross-sectional studies have investigated clustering of three or more behavioural risk factors exclusively in the paediatric and adolescent populations. An American study investigated the relationship between physical inactivity, unhealthy diet, alcohol use and smoking in a random sample of 1092 predominately low SES rural school children (aged 10-18 years) enrolled in grades 6-12 (258). Using factor analysis, the authors identified a multiple substance use pattern among youth in grade 6, which included heightened rates of smoking, chewing tobacco and consumption of multiple drinks per occasion. A junk food cluster was also found among youth in grades 11-12, which comprised of consumption of soda, pop tarts, donuts and pancakes/waffles (258). Despite its use of a detailed multiple-item self-administered questionnaire to collect data on various aspects of health behaviours

including their frequency, quantity and diverse types, results of this study could not be generalized to the American youth population given the uniqueness of its sample.

Using the O/E ratio method, Lawlor et al. (2005) investigated the extent of clustering of smoking, high TV viewing, overweight and high blood pressure (used as a proxy for dietary and physical activity behaviours) by annual family income (<$25 999 *versus* ≥$25 999) in a sample of 3613 adolescents of an Australian birth cohort, examined at age 14 years, in South Brisbane (50). The authors found significant clustering of three or four risk factors among youth from low-income families (O/E ratio = 2.70, 95% CI: 1.80-4.06) as well as among youth from more affluent families (O/E ratio = 1.70, 95% CI: 1.34-2.16). However, the extent of the clustering was greater among adolescents from lower-income families (50). Although clustering of behavioural risk factors was examined in this study, the authors did not present the specific patterns of health risk behaviours. Lastly, using cluster analysis, Mistry et al. (2009) reported clustering of physical inactivity, smoking, alcohol use and low fruits/vegetables consumption in a sample of 4010 American adolescents (mean age: 14 years) who participated in a random-digit-dial California Health Interview Survey (79). Four clustering patterns were found as follows: salutary adherents (no reported health risk behaviours), active snackers (physically active, low fruits/vegetables consumers), sedentary snackers (physically inactive, low fruits/vegetables consumers) and risk takers (smokers, alcohol users, physically inactive and low fruits/vegetables consumers) (79). Despite its relatively large sample size, the generalizability of this study was however limited to the youth population of the state of California.

In summary, the bulk of evidence regarding clustering of behavioural risk factors stems from studies conducted among different adult populations. Concordant with studies describing the prevalence of multiple chronic disease behavioural risk factors, the studies assessing clustering of health risk behaviours included different lifestyle risk factors and used a variety of definitions and methodological approaches. Despite these differences, findings of these studies suggest that behavioural risk factors including cigarette smoking, alcohol drinking, physical inactivity, poor diet, and overweight/obesity cluster (i.e., co-occur more often than expected by chance) in multiple combinations among individuals. However, the evidence of clustering of behavioural risk factors among children and

adolescents is limited. The few studies that investigated clustering of behavioural risk factors among youth did not use nationally representative samples, nor did they thoroughly present all possible combinations and patterns of chronic disease behavioural risk factors, as it has been done in adults. Moreover, there is no known study on *clustering* of behavioural risk factors for chronic diseases among a nationally representative sample of Canadian children and adolescents.

2.2.5 Determinants

There is limited information in the literature regarding potential determinants of multiple chronic disease behavioural risk factors among youth. Empirical evidence from studies conducted among adults is more readily available. Therefore, this section integrates information on variables possibly associated with multiple behavioural risk factors from studies conducted in both youth and adults. A summary of these studies is presented in Table III (*p.40*) and their findings are reviewed in this section. Consistent with determinants of single behavioural risk factors, determinants of multiple behavioural risk factors can be grouped into three main categories including individual characteristics, social influences and environmental influences.

2.2.5.1 Individual characteristics

Sociodemographic factors

Sex: The association between sex and multiple chronic disease behavioural risk factors is inconsistent in the literature. While several studies among adults indicate that men are more likely to have two or more behavioural risk factors (including physical inactivity, cigarette smoking, high alcohol intake, overweight or unhealthy diet) compared to women (30, 52, 53, 56-58, 263, 279), other studies did not find any significant associations between sex and multiple behavioural risk factors in adults (78, 280). Likewise in adolescents, a cross-sectional study conducted among a random sample of 4932 Canadian youth in grades 7-10 from Alberta found that females were 1.52 (95% CI: 1.33-1.73) times more likely to have two or more behavioural risk factors including occasional smoking, physical inactivity, poor diet quality, high fat intake and high BMI (238). In contrast, two cross-sectional studies, including a study of a representative sample of 6321 American youth aged 12-17 years (281) as well as a study of a random sample of 616 American adolescents aged 13-17

Table III. Studies investigating determinants of multiple chronic disease behavioural risk factors among youth and adults

Author (year)	Design	Sample (age)	Behavioural risk factors	Dependent variable	Data analysis	Independent correlates	Limitations
Raitakari OT et al. (1995)	Cross-sectional	Representative sample of 484 Finish adults (18-24 years)	Smoking daily Poor diet Physical inactivity Frequent inebriation	Multiple risk factor index[a]	Ordinal logistic regression	Men (+)[b] Past unemployment (+) Aggressiveness (+) ≥12 years of education (-)[c] High attention to health (-) Good self-perceived health (-) High sense of responsibility (-)	-Lack of theoretical framework -Lack of control for others' health behaviours and social relations
Diez-Roux A et al. (1999)	Cross-sectional	Population-based sample of 695 American adults living in Harlem (18-65 years)	Current smoking Physical inactivity Overweight Hypertension	0-2 risk factors *versus* 3-4 risk factors	Binary logistic regression	Older age (+) ≤$30 000 annual income (+) ≤12 years of education (+) Unemployment (+) Homelessness (+)	-Non-representative sample of American adults -Lack of theoretical framework
Rosal MC et al. (2001)	Cross-sectional	Sample of 496 American adult members of an HMO (20-70 years)	Current smoking High-fat diet Physical inactivity High alcohol intake	Multiple risk factor index	Ordinal logistic regression	Younger age (+) Less than college education (+) High depression (+) Poor self-perceived health (+)	-Non-representative sample of American adults -Lack of theoretical framework
Roberfroid D (2001)	Cross-sectional	Representative sample of 4394 Belgian adults (25-64 years)	Current smoking Heavy drinking Physical inactivity Unhealthy diet	0-2 risk factors *versus* ≥3 risk factors	Binary logistic regression	Men (+) Unmarried (+) Unemployed (+) ≤12 years of education (+) No religion (+)	-Lack of theoretical framework -Lack of control for environmental confounders

Table III. Studies investigating determinants of multiple chronic disease behavioural risk factors among youth and adults (continued)

Author (year)	Design	Sample (age)	Behavioural risk factors	Dependent variable	Data analysis	Independent correlates	Limitations
Laaksonen M et al. (2003)	Cross-sectional	Representative sample of 26 014 Finish adults (20-64 years)	Regular smoking High alcohol intake Physical inactivity Unhealthy diet	0-2 risk factors *versus* 3-4 risk factors	Binary logistic regression	Younger age (+) ≤12 years of education (+) Single (+) Divorced/Widowed (+)	-Lack of theoretical framework -Focused only on sociodemographic correlates
Fine LJ et al. (2004)	Cross-sectional	Representative sample of 29 183 American adults (≥18 years)	Current smoking High alcohol intake Physical inactivity Overweight	Multiple risk factor index	Multinomial logistic regression	Men (+), Younger age (+) Asian, Non-Hispanic black (-) <Bachelor's degree (+) Psychological distress (+) Divorced/Widowed (+) Never Married (-)	-Lack of theoretical framework -Lack of control for others' health behaviours and social relations
Emmons KM et al. (2005)	Cross-sectional	Sample of 1247 American patients with colorectal cancer (40-75 years)	Current smoking High alcohol intake Physical inactivity Low multivitamin intake Unhealthy diet	Multiple risk factor index	Ordinal logistic regression	Men (+) ≤ High school education (+) Poor health status (+)	-Non-representative sample -Lack of theoretical framework -Lack of control for others' behaviours
Galan I et al. (2005)	Cross-sectional	Random sample of 16 043 Spanish adults living in Madrid (18-64 years)	Current smoking High alcohol intake Physical inactivity Poor diet	0-2 risk factors *versus* 3-4 risk factors	Binary logistic regression	Men (+) Younger age (+) ≤12 years of education (+) for men	-Lack of theoretical framework -Lack of control for social confounders

Table III. Studies investigating determinants of multiple chronic disease behavioural risk factors among youth and adults (continued)

Author (year)	Design	Sample (age)	Behavioural risk factors	Dependent variable	Data analysis	Independent correlates	Limitations
Chiolero et al. (2006)	Cross-sectional	Representative sample of 18 005 Swiss adults (≥25 years)	Physical inactivity High alcohol intake Low fruits/vegetables	0-1 risk factor *versus* 2-3 risk factors	Binary logistic regression	Older age (+) <12 years of education (+) for men	-Lack of theoretical framework -Lack of control for income
Poortinga W (2007)	Cross-sectional	Representative sample of 11 492 English subjects (16-64 years)	Current smoking High alcohol intake Physical inactivity Low fruits/vegetables	Multiple risk factor index	Multinomial logistic regression	Men (+), Single (+) Younger age (+) Low social class (+) Unemployment (+)	-Lack of theoretical framework -Focused only on SES correlates
Kivimaki M et al. (2007)	Cross-sectional	Sample of 48 592 Finish public employees (17-65 years)	Ever smoking Binge drinking Physical inactivity Obesity	Multiple risk factor index	Multinomial logistic regression	Low income (+)	-Non-representative sample -Lack of theoretical framework
Sanchez A et al. (2008)	Cross-sectional	Convenience sample of 394 overweight American women (18-55 years)	Physical inactivity Sedentary behaviour Low fruits/vegetables High fat intake	Multiple risk factor index	Ordinal logistic regression	<12 years of education (+) Non-white (+) Low social support (+) Low use of physical activity change strategies (+)	-Non-representative sample -Lack of theoretical framework
Chou KL (2008)	Cross-sectional	Representative sample of 4812 adults from Hong Kong (≥60 years)	Current smoking Heavy drinking Physical inactivity Low fruits/vegetables	Multiple risk factor index	Multinomial logistic regression	Men (+) Older age (+) ≥High school education (+) Unemployment (+)	-Lack of theoretical framework -Focused only on SES correlates

Table III. Studies investigating determinants of multiple chronic disease behavioural risk factors among youth and adults (continued)

Author (year)	Design	Sample (age)	Behavioural risk factors	Dependent variable	Data analysis	Independent correlates	Limitations
Li FX et al. (2009)	Cross-sectional	Representative samples of Canadian subjects from the NPHS and the CCHS (≥12 years)	Current smoking Excessive alcohol intake Physical inactivity High BMI	Multiple risk factor index	Ordinal logistic regression	Female (-), Older age (+) Divorced/Widowed (+) Single/Never married (-) ≥12 years of education (-) ≥$50 000 annual income (-) Being an immigrant (-) Fair/poor general health (+)	-Lack of theoretical framework -Focused only on sociodemographic correlates -Lack of control for other confounders
Lowry R et al. (1996)	Cross-sectional	Representative sample of 6321 American youth (12-17 years)	Occasional smoking Physical inactivity Low fruits/vegetables High alcohol intake High fat intake	Multiple risk factor index	Linear regression	Older age (+) Black, Hispanic (-) Higher parent education (-) Higher family income (-)	-Lack of theoretical framework -Lack of psychosocial factors
Pronk NP et al. (2004)[d]	Cross-sectional	Random sample of 616 American adolescents (13-17 years), 1270 adults (≥18 years)	Non-smoking High diet quality Normal BMI Physical activity Non/low alcohol use	Multiple lifestyle index	Ordinal logistic regression	Non-depressed youth (+) Older aged adults (+) College degree for adults (+)	-Non-representative sample -Lack of theoretical framework
Lawlor DA et al. (2005)	Cross-sectional	Sample of 3613 Australian youth of a birth cohort examined at age 14 years	Ever smoking Sedentary behaviour Overweight High blood pressure	0-2 risk factor *versus* 3-4 risk factors	Binary logistic regression	<$25 999 annual family income (+) Low non-verbal reasoning (+)	-Lack of theoretical framework -Lack of control for parental education and family structure

Table III. Studies investigating determinants of multiple chronic disease behavioural risk factors among youth and adults (continued)

Author (year)	Design	Sample (age)	Behavioural risk factors	Dependent variable	Data analysis	Independent correlates	Limitations
Sanchez A et al. (2007)	Cross-sectional	Sample of 878 American youth recruited in care clinics (11-15 yr)	Physical inactivity High TV viewing High fat intake Low fruits/vegetables	Multiple risk factor index	Linear regression	Older age (+) Parental smoking (+) for females Parental healthy diet (-) for females	-Non-representative sample -Lack of theoretical framework -Lack of control for peer characteristics
Plotnikoff RC et al. (2009)	Cross-sectional	Random sample of 4932 Canadian youth in grades 7-10 from Alberta	Occasional smoking Physical inactivity Poor diet quality High fat intake High BMI	0-1 risk factor *versus* ≥2 risk factors	Binary logistic regression	Female (+) Older age (+)	-Non-representative sample -Lack of theoretical framework -Included only age and sex as variables
Mistry R et al. (2009)	Cross-sectional	Random sample of 4010 American youth from California (mean age: 14 years)	Current smoking Current drinking Physical inactivity Low fruits/vegetables	4 risk factor categories including a 0 risk category and a 4 risk category	Multinomial logistic regression	Older age (+) Depression (+) for females Living with a single parent (+) for females Parental supervision (-) Parental support (-) for males Presence of a role model (-)	-Non-representative sample -Lack of control for peer behaviours, peer-child relations and environmental confounders

[a] Subjects were assigned a total risk factor index or score based on the number of behavioural risk factors they had: those with zero risk factor (score=0), those with one risk factor (score=1), those with two risk factors (score=2), etc.
[b] Indicates a positive association.
[c] Indicates a negative (inverse) association.
[d] This study assessed correlates of multiple healthy lifestyle factors.

years who were members of a health plan (78), did not find any sex differences in the occurrence of multiple behavioural risk factors. Divergent findings of these studies may be due to use of different lifestyle risk factors, study populations and age groups.

Age: The association between age and multiple behavioural risk factors is more consistent among youth. A cross-sectional study of a representative sample of American youth aged 12-17 years found a positive association ($P < 0.001$) between age and the occurrence of multiple behavioural risk factors (281). Two other cross-sectional studies from the U.S. (66, 79) as well as a cross-sectional study from Alberta (238) reported similar results among youth aged between 11 to 17 years. Among adults, however, the direction of the association between age and multiple behavioural risk factors is less clear. Indeed, five studies found younger men tended to have more behavioural risk factors (52, 56, 57, 280, 282) and one study reported that older adults aged 50-64 years were 1.46 (95% CI: 1.04-2.05) times more likely to meet recommended guidelines for five healthy lifestyle factors (non-smoking, high diet quality, normal BMI, physical activity and non/moderate alcohol use) compared to those aged 18-49 years (78). On the other hand, four studies from the U.S. (283), Switzerland (54), Hong-Kong (263) and Canada (30) reported greater occurrence of multiple behavioural risk factors among middle-aged and older adults. These divergent findings could be partly explained by the diversity of study populations as well as the failure of some of the studies to include or control for other variables such as income (54) and psychosocial variables (56, 283).

Ethnicity: A study conducted among a representative sample of American adults aged 18 years and older found that Asian and Non-Hispanic Black subjects had, respectively, 70% and 30% lower odds of having three or four behavioural risk factors than Non-Hispanic Caucasian subjects (52). In contrast, a study conducted among a sample of overweight and obese American women aged 18-55 years reported that non-Caucasian women were 1.7 (95% CI: 1.08-2.67) times more likely to have higher number of behavioural risk factors (284). Similarly among adolescents, a cross-sectional study of a representative sample of American youth aged 12-17 years suggested that Black and Hispanic youth had higher number of risk factors compared to Caucasian youth ($P < 0.001$) (281). In turn, another

American cross-sectional study did not find any ethnic differences in the number of behavioural risk factors among California youth aged 11-15 years (66).

Immigration: A recent Canadian cross-sectional study using representative data from the NPHS and the CCHS reported that immigrant subjects aged 12 years or older were 30% less likely to have multiple lifestyle risk factors than non-immigrants (30). However, despite its large sample size (n = 89 341 in 2004/05) and representative data, this study focused only on sociodemographic correlates of multiple lifestyle risk factors and did not include or control for other potential factors such as psychosocial and environmental variables (30).

Socioeconomic status: Many studies suggest a positive association between low levels of education (30, 52, 53, 58, 78, 279, 280, 282-284) and unemployment (57, 58, 263, 279, 283) and the occurrence of multiple behavioural risk factors among adults. However, two studies reported significant positive associations between low levels of education (secondary school or less) and three or four behavioural risk factors only in men (54, 56). Another study conducted in a representative sample of older adults (≥60 years) from Hong Kong found that subjects with a secondary school education or more were at least 50% more likely to have two or more behavioural risk factors including current smoking, heavy drinking, physical inactivity and low fruits and vegetables intake compared to those with no formal education (263). However, the authors of this study acknowledged that their finding is inconsistent with the literature and stated that there is no clear explanation for the observed positive association between higher education and having multiple lifestyle risk factors in their study (263).

Personal income has been found to be correlated with the co-occurrence of behavioural risk in a study conducted among 48 592 Finnish public sector adult employees. In particular, men and women with lower income were found to be respectively, 3.32 (95% CI: 2.66-4.14) and 2.39 (95% CI: 2.03-2.82) times more likely to have three or four behavioural risk factors including ever smoking, binge drinking, physical inactivity and obesity (285). However, findings of this study may not be generalized to other populations because of its

sample which comprised Finish government worker who may have had healthier lifestyle habits than the general adult Finish population (285).

One study also reported an association between occupational category (or social class) and multiple behavioural risk factors among a representative sample of 11 492 English adults (57). Specifically, partly or unskilled manual workers were between 1.65 (95% CI: 1.47-1.85) to 2.40 (95% CI: 1.92-3.01) times more likely to have two or more behavioural risk factors including current smoking, high alcohol intake, physical inactivity and low fruits and vegetables intake compared to subjects with professional or intermediate type occupations (57).

Other sociodemographic correlates: Being single (57, 282), unmarried (279), divorced, separated or widowed (30, 52, 282) have been correlated with greater numbers of behavioural risk factors among adults. However, two cross-sectional studies from the U.S. (52) and Canada (30) found that adults who were never married were, respectively, 11% and 20% less likely to have multiple lifestyle risk factors compared to married subjects. A cross-sectional study conducted among 695 American adults from a predominately Black, poor urban community also reported that subjects with a history of homelessness were 2.2 (95% CI: 1.3-3.6) times more likely to have three or more unhealthy lifestyle risk factors compared to those with no history of homelessness (283). Lastly, adults with no religious affiliation have been reported to have increased odds (OR = 1.55, 95% CI: 1.21-1.99) of having three or more lifestyle risk factors including physical inactivity, unhealthy diet, having drinking and current smoking compared to subjects belonging to a religion (279).

Psychosocial factors

Psychological distress/depression/anxiety: Psychological distress defined as "a non-specific term that encompasses sadness, frustration, anxiety, and a number of other negative mood states" (286) including depression has been correlated with multiple lifestyle risk factors among adults. A study conducted among a representative sample of the American adult population found that subjects with psychological distress were 2.06 (95% CI: 1.65-2.58) times more likely to have three or four behavioural risk factors than those who did not report any distress (52). In this study, the association between psychological distress and

multiple behavioural risk factors persisted after controlling for age, sex, marital status and SES (52). Similarly, in another cross-sectional study from the U.S., adult members of a health maintenance organization with higher depression scores were found to have higher number of health risk behaviours including current smoking, high-fat diet, physical inactivity and heavy drinking (280). A cross-sectional study of a random sample of 616 American adolescents aged 13-17 years also reported increased odds (OR = 2.15, 95%: 1.30-3.53) of engaging in 4 *versus* 0-3 healthy behaviours among non-depressed youth (78). However, results of this study may have been subject to confounding because the authors did not control for any social characteristics such as family SES. In another cross-sectional study of a random sample of 4010 American youth from California (mean age: 14 years), only females with higher depression scores were found to be more likely (OR = 1.66, 95% CI: 1.09-2.54) to engage in four unhealthy lifestyle habits including current smoking, current drinking, physical inactivity and low fruits and vegetables intake (79). Although the authors of this study controlled for potential SES confounders in their models, the generalizability of their results may be limited to the youth population form the state of California.

Other psychosocial correlates: Two studies from the U.S. (53, 280) and one study from Finland (58) have found positive cross-sectional associations between fair or poor self-perceived health status and the occurrence of multiple behavioural risk factors among adults. Using representative data, Li et al. (2009) also reported that Canadian subjects aged 12 years and older with fair or poor general health status were up to 2.1 (95 CI%: 1.9-2.2) times more likely to engage in multiple unhealthy behaviours compared to those with excellent/very good/good health status (30). However, this study included only a few sociodemographic variables in their models and hence their findings may have been influenced by other unmeasured variables such as depression or anxiety. Aggressiveness, low sense of responsibility and low attention to personal health have been also reported to increase the likelihood of having multiple lifestyle risk factors in a sample of 484 Finish adults (58). Lastly, a cross-sectional study of a sample of 3613 Australian youth assessed at age 14 years reported higher odds (OR = 2.15, 95% CI (1.70-2.78) of having three or four risk factors including smoking, sedentary behaviour, overweight and high blood pressure

among youth with lower scores on a non-verbal reasoning ability test often used for psychological assessment in clinical and educational context (50).

Although poor academic achievement or performance has been shown to be correlated with several single behavioural risk factors including physical inactivity (69), sedentary behaviour (69), smoking (142), alcohol drinking (168) and overweight/obesity (202), no study has yet investigated its association with the occurrence of multiple behavioural risk factors in either children or adolescents. Similarly, several studies have linked lower self-esteem to increased likelihood of engaging in single behavioural risk factors such as physical inactivity (108), cigarette smoking (142), alcohol drinking (167) and obesity (196). However, no study has yet examined the potential variation in multiple chronic disease behavioural risk factors by sense of self among youth.

2.2.5.2 Social influences

Family SES

A small number of cross-sectional studies have found an association between low family/household income and the likelihood of having multiple behavioural risk factors. In a cross-sectional study of 695 adults aged 18 to 65 years living in Harlem, Diez-Roux et al. (1999) found that subjects with an annual household income of $30 000 or less were nearly four times more likely to have three or more unhealthy lifestyle risk factors compared to those with an annual income of over $30 000 (283). In a study of a representative sample of Canadian subjects aged 12 years and older, participants with an annual household income of $50 000-$79 999 and $80 000 or more were, respectively, 20% and 30% less likely to engage in multiple lifestyle risk factors than those with an annual household income of less than $30 000 (30). However, it should be noted that this study did not control for other social characteristics such as peer health-related behaviours which may also influence the co-occurrence of lifestyle risk factors. Among adolescents, Lowry et al. (1996) found an inverse association between higher family income (measured in units of $1000 increase) and the number of behavioural risk factors ($P < 0.001$) in a representative sample of 6321 American youth aged 12-17 years (281). Although this study used a large representative sample, the authors did not investigate the potential influence of several other potential factors such as psychosocial variables. In another cross-sectional study, Lawlor et al.

(2005) also reported greater co-occurrence (OR = 1.96, 95% CI: 1.47-2.65) of ever smoking, watching TV for more than five hours per day, overweight and high blood pressure, among 3613 Australian youth aged 14 years with an annual family income of less than $25 999 (50). Similar to the study of Lowry et al. (1996), this study included a very small number of covariates and did not control for other important family-related characteristics such as parental education and family structure.

Only two studies investigated the potential association between parental education and the occurrence of multiple behavioural risk factors among youth and their results were inconsistent. Lowry et al. (1996) found that American adolescents aged 12-17 years were less likely to engage in multiple lifestyle risk factors (including occasional smoking, physical inactivity, high alcohol use, high fat intake and low fruits and vegetables consumption) as years of education completed by the responsible adult increased (P = 0.001) (281). In contrast, Mistry et al. (2009) did not find an association between parental education and the likelihood of having two or more behavioural risk factors in a random sample of 4010 American youth (mean age: 14 years) from California (79). Nevertheless, living with a parent with a high school degree or more was found to be positively correlated with single behavioural risk factors including cigarette smoking, alcohol drinking and low fruits/vegetables consumption in the same study (79). Mistry et al. (2009) also reported that female adolescents living with a separated, divorced or widowed parent were more likely (OR = 2.25, 95% CI: 1.33-3.80) to engage in four unhealthy lifestyle behaviours than those living with a married parent (79). Indeed, studies of lone-parent families indicate that these families tend to have higher rates of joblessness, poverty and poor health compared to families with two parents (287, 288). In particular, lone-mother families are more likely to be socioeconomically disadvantaged than lone-father families (288). Given their low SES, lone-parent families are also less likely to have access to social and material resources that facilitate the adoption of healthy behaviours (such as access to fitness facilities, proximity to parks, walking and bicycle trails and access to quality foods) (289, 290). Thus, children living in lone-parent families are more likely to have adverse health behaviours than children living in two-parent families.

Parental (social) support/supervision

In their study, Mistry et al. (2009) found that male adolescents (mean age: 14 years) who received good parental support at home, such as the presence of an adult who cares, listens and talks to them about their problems, someone who wants the best for them or someone who expects them to follow rules, were less likely (OR = 0.74, 95% CI: 0.57-0.96) to engage in multiple unhealthy behaviours including smoking, drinking, physical inactivity and poor diet (79). Providing social support for healthy foods eating has been also correlated with decreased odds (OR = 0.96, 95% CI: 0.94-0.98) of having multiple lifestyle risk factors among a convenience sample of 394 overweight American women (284). The generalizability of this study is however limited because of its non-probability sampling. High parental supervision in terms of knowing what the adolescent is doing during his/her free times, at night, and afternoons has been also correlated with the co-occurrence of lifestyle risk factors among youth in the study of Mistry et al. (2009) (79). Lastly, American youth who reported having a role model (i.e., the presence of someone who the adolescent admires or would want to be like) were found to be less likely (OR = 0.54, 95% CI: 0.35-0.82 for males; OR = 0.39, 95% CI: 0.25-0.60 for females) to engage in multiple unhealthy behaviours than those who did not have a role model in the same study (79). Despite considering several individual and social characteristics, Mistry et al. (2009) did not examine the potential influence of peer-related characteristics such as peer-child relationships or peer health-related behaviours on the co-occurrence of behavioural risk factors among youth. In addition, the study by Mistry et al. (2009) did not control for potential environmental confounders such as school characteristics.

Parental/peer health behaviours

Only one cross-sectional study conducted in a sample of 878 American youth aged 11-15 years, and who were recruited through primary care clinics in San Diego, investigated the potential association between parental health-related behaviours and the occurrence of multiple lifestyle risk factors (66). In particular, a higher number of behavioural risk factors (including physical inactivity, high TV viewing, high fat intake and low fruits and vegetables consumption) was related to having a parent who was a former or current smoker (P = 0.01), and a parent who consumed less than five servings of fruits and vegetables per day (P = 0.007), but only in females (66). This may be due to lack of

controlling for other potential covariates such as peer health-related behaviours in this study.

2.2.5.3 Environmental influences

Socio-ecological theories of health behaviour state that influences external to the child, such as the school environment, contribute to behaviours (291, 292). Yet, no study has investigated the potential influence of environmental characteristics on multiple chronic disease behavioural risk factors in either children or adolescents. Youth are known to spend most of their time in school and many actually develop lifelong adverse health behaviours in that context including cigarette smoking, alcohol drinking, physical inactivity and overweight (293). The literature review of determinants of single chronic disease behavioural risk factors presented in Section 2.1 identified several school-related correlates of lifestyle risk factors including school type, the presence of a supportive school environment, the presence of rules, disciplines and policies at school as well as school connectedness and collective desire for success among school children. Despite this documented evidence, there is no published study investigating the potential relationship between school characteristics and the occurrence of multiple chronic disease behavioural risk factors in children and adolescents. This is an important gap in the literature of multiple behavioural risk factor research. This thesis addresses this gap by studying the potential associations between selected school characteristics and the co-occurrence of chronic disease behavioural risk factors in children and adolescents.

In summary, this section reviewed the literature on determinants of multiple chronic disease behavioural risk factors in children, adolescent and the adult populations. The most striking observation in this literature is that all studies conducted among youth or adults were cross-sectional, and thus only provided a snapshot of the potential associations between the variables under investigation and the occurrence of multiple behavioural risk factors among individuals. Another important finding of this literature review is that few studies investigated correlates or determinants of multiple behavioural risk factors exclusively among children and adolescents. In addition, findings of the studies reviewed were not always consistent in either youth or adults. Some of these inconsistencies may be related to use of different lifestyle risk factors, the use of different definitions and cutoffs to define

risk factor categories as well as the use of diverse study populations and age groups. Part of these inconsistencies may be also due to the lack of sufficient control for unmeasured factors such as family- and peer-related characteristics as well as social environmental variables.

Divergent findings may be also due to use of different analytic techniques for identifying correlates of multiple behavioural risk factors which included simple binary logistic regression, linear regression, multinomial regression and ordinal regression (Table III, *p.40*). While there is no single recommended analytic method to investigate factors possibly associated with multiple risk behaviours, ordinal regression modeling may be the most appropriate technique as it takes into account the ordinal nature of the dependent variable (i.e., multiple risk factor index or score) which is generally defined on an ordinal scale ranging from 0 risk factors to *X* number of risk factors (294). In this thesis, ordinal regression was used to identify potential correlates of multiple chronic disease behavioural risk factors among youth.

The studies conducted among youth focused on a limited number of sociodemographic and psychosocial correlates of multiple behavioural risk factors with no study investigating the potential influence of school characteristics on the co-occurrence of health risk behaviours. Of all the studies reviewed, only two American studies examined the potential associations between parental support/supervision (79) and parental health-related behaviours (66) and the occurrence of multiple behavioural risk factors among youth. This is a surprising observation and yet another important gap in this literature, especially given the presence of strong evidence for the association between parental characteristics, such as positive parenting styles and role-modeling, and the occurrence of single chronic disease behavioural risk factors among youth, as reviewed in Section 2.1.

Also, none of the studies reviewed herein investigated the potential influence of peer characteristics such as peer adverse lifestyle habits or peer-child relationships on the co-occurrence of unhealthy behaviours among youth. Yet, there is convincing evidence from the literature of single behavioural risk factors that peers are central in shaping the child and adolescent's behaviours particularly in mid adolescence (295). Peers influence youth in

both positive and negative ways; they influence academic achievement and prosocial behaviours as well as adverse behaviours including physical inactivity, alcohol use and cigarette smoking (295).

Lastly, studies of determinants of multiple behavioural risk factors have not consistently used a sound theoretical framework aimed at explaining or predicting multiple behavioural risk factors. Many of the studies reviewed did not even provide a rationale for the relationship between multiple behavioural risk factors and the independent variables under investigation. Only one study mentioned that a few explanatory variables including parental support, supervision, and role-modeling were selected because of their potential positive effects to enhance youth resiliency against engaging in adverse behaviours and outcomes such as smoking or alcohol drinking (79). This thesis used a novel and integrative conceptual framework to study the potential association between a large number of individual, social and school characteristics and the occurrence of multiple chronic disease behavioural risk factors in a nationally representative sample of children and adolescents.

THEORETICAL FRAMEWORKS

CHAPTER 3: THEORETICAL FRAMEWORKS

There are many theories used to explain or predict health behaviours in children and adolescents. Some of these theories focus on individual determinants of behaviour while others consider factors related to the social and physical environments of youth (296). Glanz et al. (1997) defined a theory as "a set of interrelated constructs (concepts), definitions, and propositions that presents a systematic view of phenomena by specifying relations among variables in order to explain and predict the phenomena" (296). This chapter first describes some of most influential theoretical frameworks used to explain or predict health behaviours including cognitive behavioural theories which focus on individual factors, social learning theories which address some aspects of the social environment, and ecological theories of health behaviour which emphasize the influence of social and physical environmental characteristics on health behaviour. This chapter then describes a contemporary theory which integrates elements of several previous theories of health behaviour, and which is applicable to the context of multiple behaviours. Finally, the conceptual framework used in this thesis is presented; this framework outlines the concepts and different types of potential determinants of multiple chronic disease behavioural risk factors among youth which are considered in this thesis.

3.1 Cognitive behavioural theories

One of the earliest and most widely used theories in the field of health education is the Health Belief Model (297, 298). According to this model, health behaviours are determined by two factors. The first factor is the degree to which the individual perceives a health threat (or risk behaviour) which is in turn determined by general health values and beliefs of vulnerability and consequences of disease. The second factor is the perception that a particular health practice will be effective in reducing that threat and is itself determined by the person's belief that the specific behaviour will be effective, and whether or not the cost of engaging in the health behaviour exceeds the benefits (297, 298). The Health Belief Model also suggests that demographic and psychosocial variables influence the individual's perceptions toward a health threat and his/her likelihood of taking recommended preventive health action (298). However, this model does not specifically address variables beyond the

individual such as factors related to his/her social environment which also affect one's likelihood of engaging in healthy or unhealthy behaviours.

The Theory of Reasoned Action by Ajzen and Fishbein (1980) provides a framework to study attitudes toward behaviours (299). According to this theory, the most important determinant of a person's behaviour is the individual's intention to perform the behaviour. This intention is, in turn, a function of the individual's attitudes toward the behaviour and his/her beliefs in how others will respond to the behaviour (i.e., subjective norm) (299). In 1985, Ajzen reformulated the Theory of Reasoned Action by adding an additional concept, the perceived behavioural control, which refers to the perceived ease or difficulty in performing the behaviour; this new theory was called the Theory of Planned Behaviour (300, 301). Although Theories of Reasoned Action and Planned Behaviour have been frequently used in the literature, neither specifically addresses factors related to SES or environmental characteristics of the individual as determinants of health behaviours (302).

Overall, the emphasis of cognitive behavioural theories is on understanding the cognitive psychology of the individual. In particular, these theories focus on the most immediate or *proximal* determinants of specific health behaviours including one's beliefs, attitudes, intentions or motivations to adopt or perform a given behaviour. As such these theories are considered behaviour-specific because proximal determinants are believed to be most directly linked to specific behaviours (303). Indeed, as stated by several authors, cognitive behavioural theories do not address all of the factors that affect one's behaviour, especially *distal* determinants such as characteristics of youth most intimate social support system (i.e., family and peers) which are thought to influence multiple behaviours because they are more distant from and not specific to a given behaviour compared to proximal determinants (304, 305).

3.2 Social learning theories

Several scholars including the sociologist Edward Sutherland suggested that besides individual factors (i.e., attitudes, beliefs, intentions), one must also consider factors related to the immediate social environment including the attitudes and behaviours of others for predicting one's behaviours (304). Bandura built upon this assertion and developed the

Social Learning Theory, which later became known as Social Cognitive Theory (306-308). The main concept behind Social Learning Theory is reciprocal determinism which suggests that the process of learning a behaviour is the result of a dynamic interaction between cognitive, social environmental and behavioural factors. Cognitive factors refer to one's beliefs, attitudes and knowledge that affect the learning process. Social environmental factors include the values, attitudes and behaviours of parents and peers, and behavioural factors refer to one's previous behaviour that can affect his/her likelihood of adopting or engaging in a specific behaviour (306).

The process of modeling in terms of observing and imitating others' behaviours is a key construct of Social Learning Theory (307). Indeed, several cross-sectional and longitudinal studies have consistently shown that parental and peer modeling of healthy eating (309), cigarette smoking (147), alcohol drinking (172) and exercising (121, 310) are associated with youth lifestyle choices. Self-efficacy is another important construct of Social Learning Theory. Self-efficacy refers to an individual's estimate of his/her ability to cope with a situation and outcome expectancy (311). A person's self-efficacy develops as a result of one's history of achievement in a particular area, from observations of others successes and failures and from one's own physiological state such as emotional arousal, nervousness, or anxiety while performing a behaviour (311).

Although social learning theories take on a slightly more distal approach to predict health behaviours than cognitive behavioural theories, by considering the attitudes and behaviours of role models, they fail to explain why some youth are more likely to imitate their parent's adverse behaviours or get involved with peers who engage in unhealthy lifestyles (304, 312). Indeed, there are other and even more distant factors (i.e., beyond social bonding and others' behaviours) that affect youth behaviours (304). These factors are known as *ultimate* determinants and include characteristics of the broader social and physical environments such as family SES, and social institutions such as school. These factors along with personality traits which are considered hard to modify are not addressed by either social learning theories or cognitive behavioural theories (304).

3.3 Ecological theories

Several authors have proposed more comprehensive approaches to study health behaviours by including factors of the broader social and physical environments (313, 314). One of these approaches is Bronfenbrenner's Ecological Systems Theory (291, 315). Bronfenbrenner's theory directs attention to both behaviour as well as its individual and environmental determinants in an ecological perspective (315). Specifically, this theory divides social and environmental influences on behaviour into different levels of influence including the micro-, meso-, exo-, and macrosystem levels. The microsystem represents the relationships and interactions that the child or adolescent has with his/her immediate surroundings, including his/her family, peers and school. The mesosystem refers to the interrelations between the structures of the child's microsystem, such as the relationship between the child's teacher and his/her parents. The exosystem defines the larger social system in which the child does not function directly which includes parental SES and community-based family resources. Lastly, the macrosystem refers to cultural beliefs and values that influence both the microsystem and the exosystem (315).

There are other ecological theories that have been used to explain health behaviours. Many of these theories are variations of the Bronfenbrenner's Ecological Systems Theory, including the Ecological Integration Framework of Belsky (1980) and the Ecological Theory for Health Promotion of McLeroy et al. (1988) (292, 316). The underlying basis of all these theories is the recognition that influences external to the child play important roles in explaining and predicting behaviours. Indeed, ecological frameworks differ from cognitive and social learning theories in that they emphasize the importance of the broader physical and social environments (i.e., *ultimate* determinants) on facilitating or constraining behaviours (317). More specifically, ecological theories recognize that youth require more than the appropriate knowledge, attitudes and skills to achieve a given behaviour. Children and adolescents also need a supportive environment such as supportive family and friends, supportive institutions and schools as well as the presence of public policies and safe communities (317). Despite their increased recognition among researchers, ecological theories do not articulate how and if different types of determinants (i.e., individual, social and environmental factors) influence the occurrence of multiple behaviours. In addition, ecological theories do not describe the contribution of different tiers or levels (in terms of

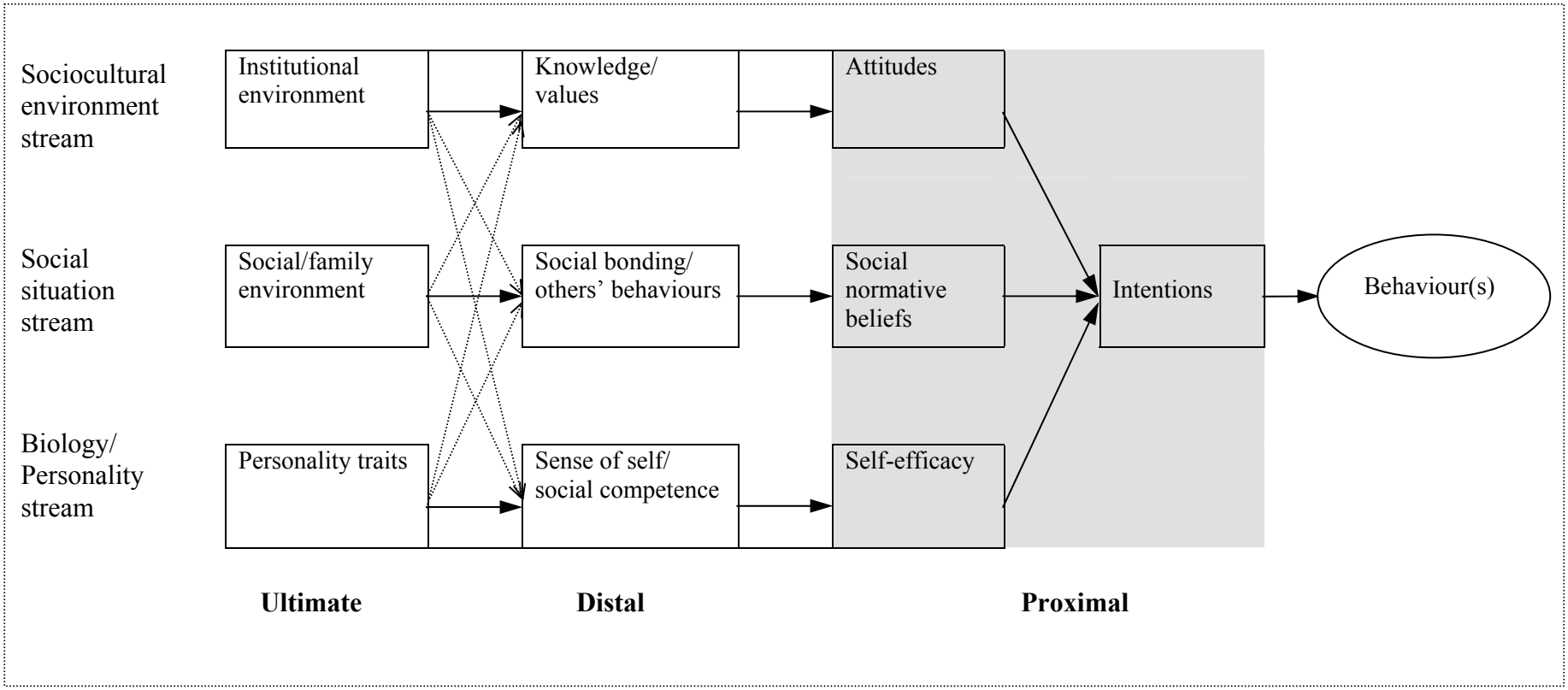
distance from behaviour) of constructs (i.e. proximal, distal and ultimate factors) on the co-occurrence of behaviours.

3.4 The Theory of Triadic Influence

Of all integrative theories of health behaviour, the Theory of Triadic Influence (TTI) (Figure 1, *p.61*) by Flay & Petraitis (1994) seems to be the most comprehensive one because not only it combines determinants of different types and tiers of constructs but it also supports the concept of the multidimensionality pattern of behaviours (303, 318). First, the TTI assembles determinants of behaviour into three distinct streams or types of influence called the biology/personality stream, the social situation stream and the sociocultural environment stream. The biology/personality stream includes one's inherited dispositions, personality traits and intrapersonal characteristics that affect his/her self-efficacy and intentions to perform a behaviour. The social situation stream includes characteristics of the child's social environment and interpersonal factors that affect the social pressures that a child or an adolescent may feel before engaging in a behaviour. The sociocultural environment stream includes broader environmental and cultural factors that affect one's attitudes toward engaging in a behaviour (318).

According to the TTI, each of these three types of influences (i.e., biology/personality, social situation, sociocultural environment) flows through three tiers of constructs before they have their final influence on behaviour. The tiers of constructs represent the ultimate, distal and proximal determinants of behaviour. Ultimate determinants include factors that are beyond the easy control of the child such as characteristics of the institutions and community of the child, his/her family situation as well as inherited traits (318). Because ultimate determinants are furthest from behaviour, in terms of distance, they are said to be not specific to a single behaviour. Indeed, according to the TTI, ultimate determinants tend to have general effects and because of this property they are thought to influence and predict multiple behaviours (303, 318). Distal determinants are at an intermediate distance from behaviour and include factors such as general values, social bonding with others, others' behaviours as well as sense of self. Distal determinants are also thought to have

Figure 1: The Theory of Triadic Influence (adapted from Flay & Petraitis, 1994)[318]



Dashed lines represent possible interstream pathways between the ultimate and the distal factors

general effects across behaviours (i.e., they are likely to predict multiple behaviours) (303). For example, less cohesive families and poor parent-child relationships are associated with various unhealthy behaviours including cigarette smoking (148), alcohol drinking (76) and obesity (211). Lastly, proximal determinants (grey area in Figure 1, *p.60*) refer to the most immediate predictors of behaviour including the attitudes, beliefs, self-efficacy and intentions of the individual in performing a behaviour (318). Proximal determinants are thought to be strong predictors of single behaviours, compared to distal or ultimate determinants (303, 319). In fact, empirical evidence from a prospective study conducted among 702 high school American students (mean age: 16 years) at high risk of drug abuse found that one's intentions to use drugs, a proximal determinant was a strong predictor of substance abuse compared to prosocial coping and anger coping (distal determinants of the biology/personality stream), as well as compared to depression (ultimate determinant of the biology/personality stream) (319). Thus, proximal determinants are thought to be less likely to predict multiple behaviours.

The TTI also recognizes that there are possible interstream pathways between the ultimate and distal determinants. For example, the TTI assumes that one's intelligence (ultimate determinant of the biology/personality stream) might have its primary influences on one's sense of self and social competence (distal determinants of the biology/personality stream) but it might also to a lesser degree influence how well one bonds with others (distal determinant of the social situation stream) (318).

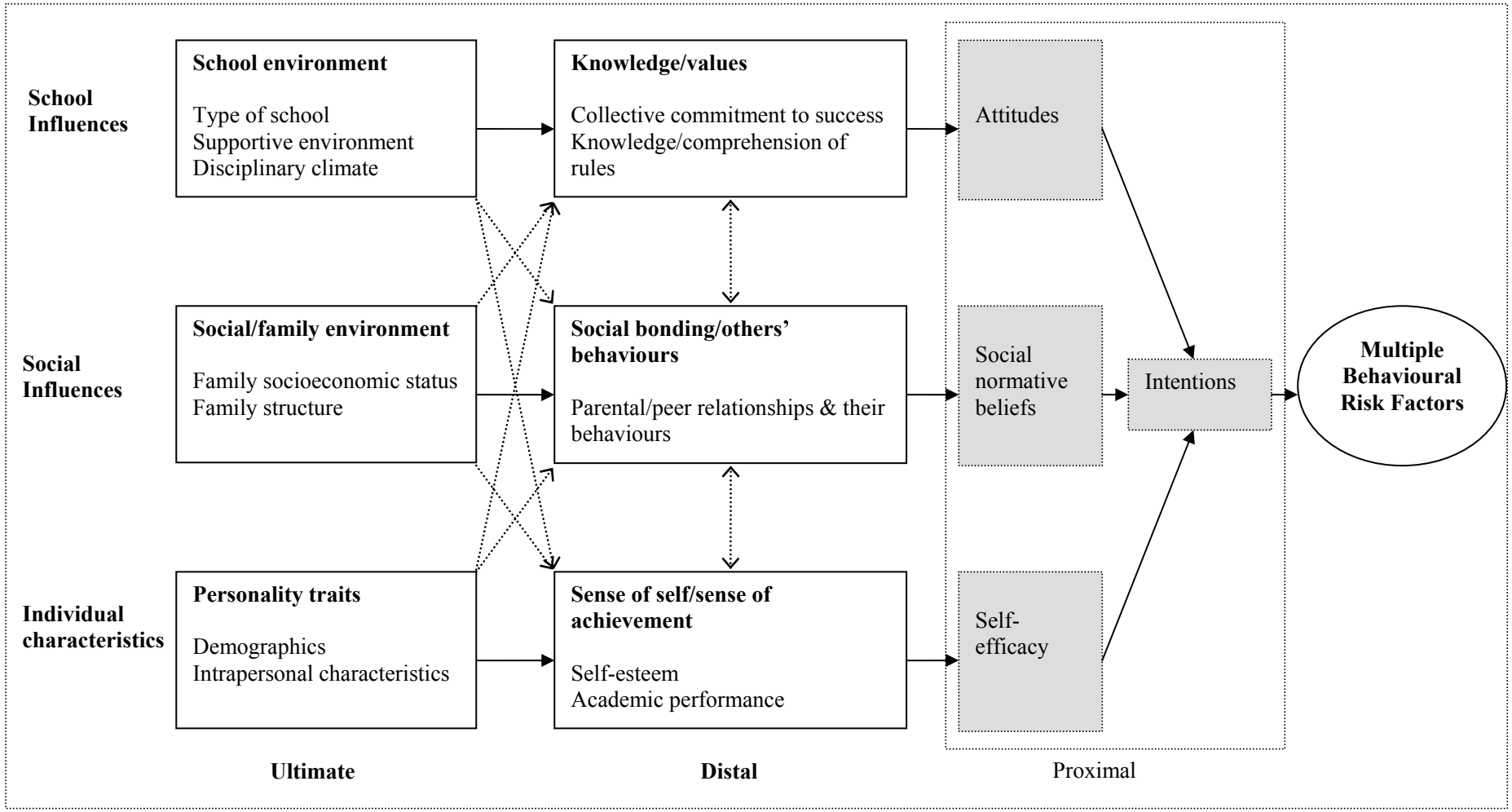
In short, the TTI is a comprehensive framework which addresses determinants of both single and multiple behaviours. In particular, the TTI suggests that all behaviours tend to have common sets of determinants defined by distal and ultimate factors. Thus, contrary to proximal determinants that are behaviour-specific, distal and ultimate determinants are thought to transcend specific behaviours. For instance, according to Flay (2002), attitudes toward alcohol drinking (a proximal determinant) would be a predictor of alcohol drinking, but a weaker predictor of physical inactivity (303). In contrast, characteristics of school or home environment (ultimate determinants) would be associated with a variety of behaviours affecting youth mental and physical well-being (303). Indeed, empirical evidence shows that a supportive school and home environment can reduce the likelihood

of engaging in several unhealthy behaviours including cigarette smoking, alcohol drinking and physical inactivity among children and adolescents (73, 113, 144, 152).

3.5 Conceptual framework

The conceptual framework used in this thesis (Figure 2, *p.64*) is based on the TTI which proposes a general framework for mapping out the relationships between several different types of determinants and multiple behaviours. First, the conceptual framework of this thesis focused on ultimate and distal determinants as they are believed to be predictors of multiple behaviours (303). Proximal factors are only presented in Figure 2 to suggest a pathway through which selected determinants might influence multiple health risk behaviours. Second, based on the review of the literature of single and multiple chronic disease behavioural risk factors (Section 2.1 and Section 2.2), the TTI's three different streams were adapted to categories that describe more specifically the selected factors that are thought to influence multiple behavioural risk factors considered in this thesis (i.e., physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking and overweight) among children and adolescents. Specifically, the biology/personality stream, the social situation stream and the sociocultural environment stream of the TTI were operationalized as individual characteristics, social influences and school influences, respectively. As per the TTI, individual characteristics include demographic and intrapersonal factors (ultimate), and sense of self and sense of achievement (distal). Social influences include family socioeconomic status and family structure (ultimate), and parental/peer relationships with the child as well as their behaviours (distal). Finally, school influences include the type of school and characteristics of the school environment (ultimate), and collective commitment to success and knowledge/comprehension of school rules (distal). Consistent with the TTI, we assume that there are possible interstream pathways between the distal and the ultimate determinants as well as possible pathways between the distal determinants. This conceptual framework provides a comprehensive basis linking a large number of individual, social and school characteristics to multiple chronic disease behavioural risk factors in children and adolescents. This framework along with the review of the literature of multiple chronic disease behavioural risk factors led to the elaboration of this thesis' rationale and specific objectives.

Figure 2: Conceptual framework used in this thesis (adapted from the Theory of Triadic Influence)[318]



Dashed lines represent possible interstream pathways between the ultimate and the distal factors

3.6 Rationale and objectives

Physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking, and overweight account for a substantial proportion of the burden of chronic diseases and disability throughout the world. These behavioural risk factors are prevalent among children and adolescents and tend to co-occur. Although much is known about the prevalence and determinants of single chronic disease behavioural risk factors, little is known about the prevalence, clustering patterns and potential determinants of multiple chronic disease behavioural risk factors in children and adolescents. Many studies have reported only pairwise associations between behavioural risk factors and only a limited number have investigated associations between three or more behavioural risk factors in children and adolescents. The existing evidence of potential determinants of multiple chronic disease behavioural risk factors is of cross-sectional nature and generally inconsistent among children and adolescents. In addition, previous studies have been carried out without a sound theoretical framework applicable to multiple behaviours. The conceptual framework of this thesis emphasizes that understanding determinants of multiple behavioural risk factors requires consideration of influences of different types (i.e., individual, social and school characteristics) and of different tiers of constructs (distal and ultimate factors). No study has yet investigated the distribution, clustering patterns and the influence of a large number of individual, social and school variables on the rate of occurrence of multiple chronic disease behavioural risk factors among Canadian youth. Documenting the prevalence, clustering patterns and potential determinants of multiple unhealthy behaviours considered in this thesis will provide valuable information for developing effective interventions targeted at children and adolescents who are likely to have multiple behavioural risk factors.

Therefore, the specific objectives of this thesis are:

1. To describe the prevalence and clustering patterns of multiple chronic disease behavioural risk factors in Canadian children and adolescents aged 10-17 years;

2. To explore potential individual, social and school correlates of multiple chronic disease behavioural risk factors in Canadian children and adolescents;

3. To assess the longitudinal influence of a set of conceptually-related distal and ultimate variables on the rate of occurrence of multiple chronic disease behavioural risk factors in Canadian children and adolescents.

3.7 Hypotheses

1. Chronic disease behavioural risk factors will be expected to co-occur frequently among Canadian children and adolescents. These behavioural risk factors will also cluster in multiple combinations among Canadian youth and the clustering patterns will differ between males and females;

2. Several individual, social and school characteristics will be correlated with multiple chronic disease behavioural risk factors in Canadian children and adolescents;

3. Both distal and ultimate variables will influence the rate of co-occurrence of chronic disease behavioural risk factors in Canadian children and adolescents. Ultimate determinants will be expected to exert a stronger influence on the rate of occurrence of multiple chronic disease behavioural risk factors, compared to distal determinants, due to their potentially broader effects.

METHODS

CHAPTER 4: METHODS

This chapter provides a general overview of the methods that are common to all thesis objectives including a description of the source of data, recruitment and sampling, the study population, data collection procedures and measures of interest. It also provides information about the steps I took to acquire and prepare the datasets for the analysis. Finally, details regarding the analytic methods used to address the thesis objectives that could not be covered in the three manuscripts included in Chapter 5, due to space limitations of scientific journals, are presented in this chapter.

4.1 Source of data

The three objectives of this thesis were addressed using data from the National Longitudinal Survey of Children and Youth (NLSCY). The NLSCY is a large nationally representative longitudinal survey of Canadian children that follows their development and well-being from birth to early adulthood. The survey is designed to collect information about factors influencing a child's social, emotional and behavioural development and to monitor the impact of these factors on the child's development over time. The survey covers a comprehensive range of topics including the health of children, their physical, social and motor development, health behaviours and their social environment. The NLSCY began in 1994 and is jointly conducted by Statistics Canada and Human Resources and Social Development Canada. Because of its representative sample, wealth of information and longitudinal design, this survey offered a unique opportunity to investigate the prevalence, clustering patterns and potential determinants of multiple chronic disease behavioural risk factors in Canadian children and adolescents.

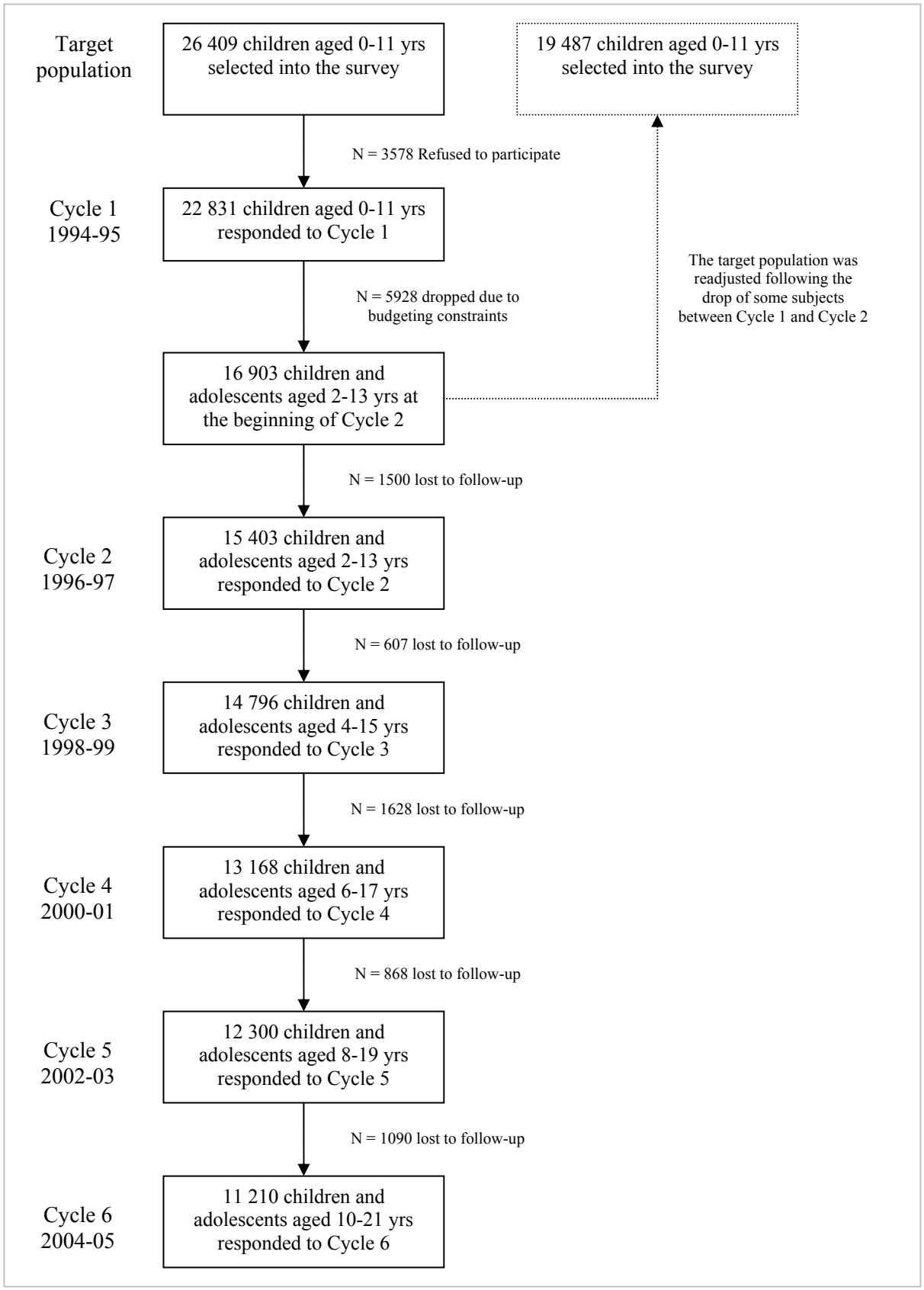
4.2 Recruitment and sampling

The sampling frame for the original cohort of children in Cycle 1 (1994-1995) of the NLSCY was drawn from Statistics Canada's Labour Force Survey, which is a monthly household survey representative of Canada's population. The Labour Force Survey uses a probability sample that is based on a stratified multi-stage design. Each province is first divided into large geographic stratum. The first stage of sampling consists of selecting smaller geographic areas, called clusters, from within each large stratum. The second stage

of sampling consists of selecting dwellings from within each selected cluster (320). For the NLSCY, one or two children were selected per dwelling, and the child, not the dwelling, was the unit of analysis. In 1994, a total of 15 502 dwellings which included 26 409 children aged 0-11 years were selected for the first cycle of the NLSCY. Of the 15 502 dwellings, 13 439 responded (86.7% response rate) and included 22 831 children who originally comprised the sample of the first cycle (Figure 3, *p.70*). These children were then followed every two years since the first cycle. However, between Cycle 1 and Cycle 2, some children were dropped from the sample for budgeting reasons as well as to reduce the burden on households. This resulted in an overall sample of 16 903 children at the beginning of Cycle 2. Of these 16 903 children, 15 403 (aged 2-13 years) responded to Cycle 2, 14 796 (aged 4-15 years) responded to Cycle 3, 13 168 (aged 6-17 years) responded to Cycle 4, 12 300 (aged 8-19 years) responded to Cycle 5 and 11 210 (aged 10-21 years) responded to Cycle 6 (321). Indeed, as per every longitudinal survey, the original cohort of the NLSCY suffered some attrition over the years. The rate of sample attrition was on average 5% per cycle, and resulted from multiple circumstances including inability to trace the children or their parents, older children or their parents refusing to participate in the survey, and children moving outside of the country (320). The cumulative longitudinal response rates for Cycles 2, 3, 4, 5 and 6 were respectively 79.1%, 76.0%, 67.8%, 63.1% and 57.6%. These response rates were calculated based on a starting readjusted target population of 19 487 children (instead of the original 26 409 children) in Cycle 1 due to the reduction of the sample size at the beginning of Cycle 2, as explained above (321).

Statistics Canada accounted for sample attrition in the NLSCY at the time of computing the survey's sampling weights which are used for making population-level inferences. The NLSCY weighting strategy involved a series of adjustments including an adjustment made to account for possible nonresponse errors due to attrition and a post-stratification adjustment. First, the nonresponse in the NLSCY was addressed by adjusting the sampling weights so that the respondents represent the nonrespondents. More precisely, the goal of the nonresponse adjustment was to inflate the NLSCY design weights of the respondents so that their nonresponse adjusted weights add up to the sum of the NLSCY design weights for everyone in the original sample. To do this, Statistics Canada created a series of response homogenous groups (i.e., individuals with the same likelihood of response). An

Figure 3: Flow chart of the evolution of the NLSCY study cohort from Cycle 1 to Cycle 6



adjustment factor was then computed for each response homogenous group such that the weights of respondents would compensate for the nonrespondents having similar predicted likelihood to respond, where this predicted likelihood to respond was based on previously collected characteristics such as education level and type of dwelling, and was determined by logistic regression models (320). Statistics Canada also employed a post-stratification adjustment factor to ensure consistency between the estimates produced by the NLSCY sampling weights and Statistics Canada's population estimates by age, sex and province. The reference population for the sample of children selected in Cycle 1 was the population of all children aged 0 to 11 years as of December 31, 1994. In computing the survey weights, Statistics Canada made a final adjustment to account for households with more than one child selected for the NLSCY (25, 320).

Because of the complex sample design of the NLSCY and the multiple series of adjustments made to the survey weights, it is extremely important to compute an estimate of the sampling variance as a means to describe the variability of the point estimates obtained using data from the NLSCY (320). To do this, Statistics Canada strongly recommends the use of bootstrapping technique which provides a series of estimates of the sampling variance by re-sampling a large number of times the sample of interest (320). For the NLSCY, Statistics Canada provides a set of 1000 bootstrap weights which can be used to estimate the sampling variance of a point estimate. Similar to use of a set of survey weights which yields one estimate, 1000 set of bootstrap weights yield 1000 estimates. The computed variance of these 1000 bootstrap estimates is precisely the estimate of the sampling variance of the point estimate. In this thesis, both survey weights and bootstrap weights were used in all analyses, as recommended by Statistics Canada (320).

4.3 Study population

The NLSCY follows a representative sample of Canadian children, aged 0 to 11 years at the time of their selection in Cycle 1, to adulthood, with data collection occurring at two-year intervals. The original study population comprised the non-institutionalized civilian population in Canada's 10 provinces. The survey excludes children living on Indian reserves or Crown lands, residents of institutions, full-time members of the Canadian Armed Forces, and residents of some remote regions. In addition to the original

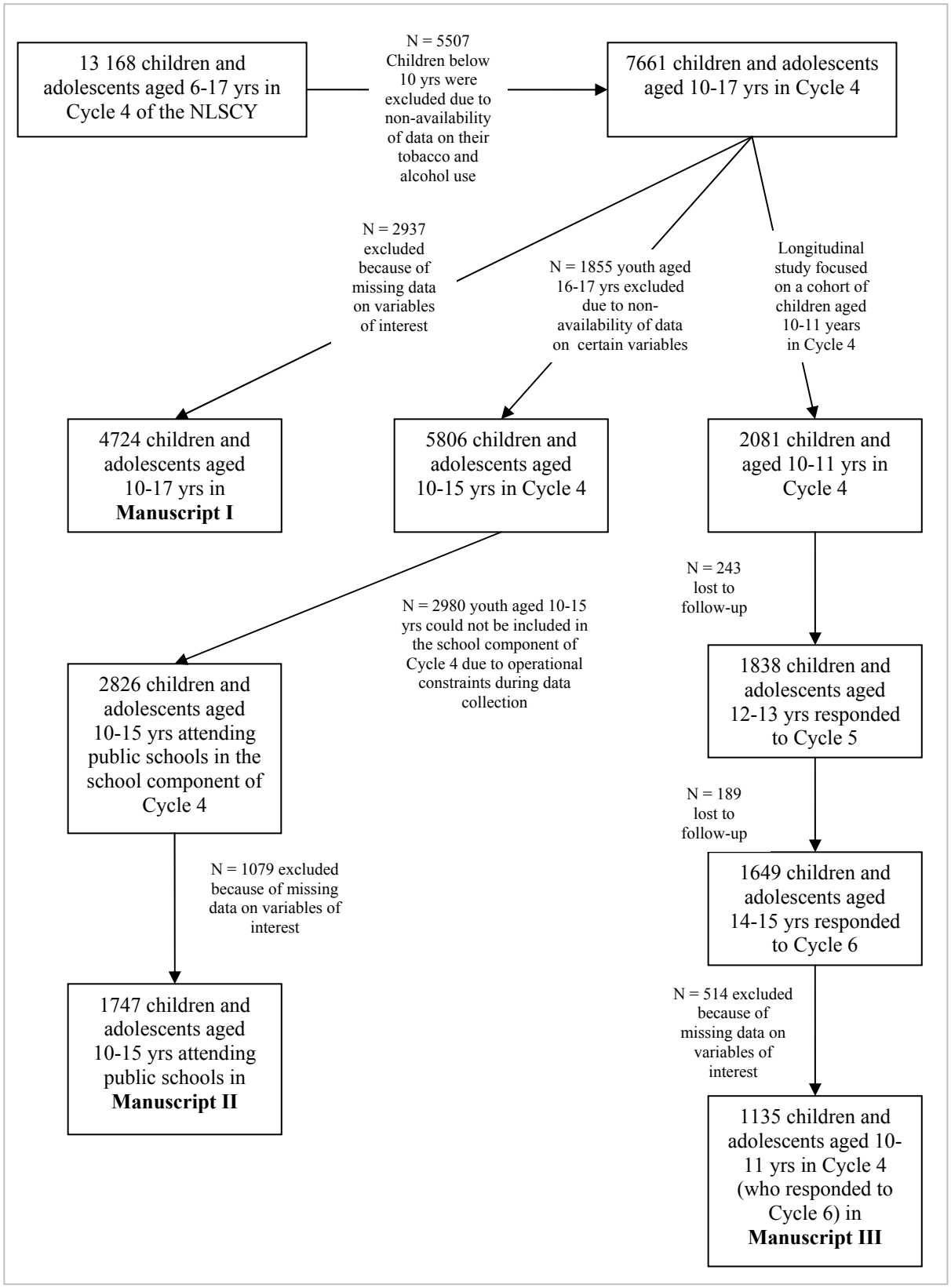
longitudinal panel of children now aged 10 to 23 years in Cycle 7, the survey has continued to add and follow a new sample of children aged 0 to 1 year at each cycle.

The first two objectives of this thesis were addressed using cross-sectional data from Cycle 4 of the NLSCY. Cycle 4 was conducted in 2000-2001 and included 13 168 children and adolescents aged 6 to 17 years (of the original cohort) (Figure 4, *p.73*). Cycle 4 contained data on variables of interest such as school characteristics that were not available in the succeeding cycles of the NLSCY. Indeed, Cycle 4 was the most recent and the last cycle that included a school component addressing the school environment of children and adolescents aged 6 to 15 years. Of 7661 children and adolescents aged 10 to 17 years in Cycle 4, analyses for the first objective of the thesis were based on 4724 youth aged 10 to 17 years with complete data on lifestyle variables and covariates under investigation. Children below 10 years of age were not included in this thesis due to the absence of information regarding their tobacco consumption and alcohol use in the NLSCY.

There were 5806 children and adolescents aged 10 to 15 years in Cycle 4 of the NLSCY. However, because of operational constraints including a heavier than anticipated workload, increased costs and the respondent burden experienced during data collection, the school component of Cycle 4, used for the purpose of the second objective of this thesis, included a sub-sample of youth attending public schools only. As a result of these operational constraints, a reduced sample of 2826 youth aged 10 to 15 years (attending public schools) was included in the school component of Cycle 4. Of these 2826 youth, analyses for the second objective of the thesis were based on 1747 children and adolescents in Cycle 4 aged 10 to 15 years with complete data on lifestyle and explanatory variables of interest, attending public schools. Adolescents aged 16 and 17 years could not be included as part of the second objective of this thesis due to non-availability of data on several variables of interest for these youth including measures of anxiety, parent-child relationship and school characteristics.

Lastly, the third objective of this thesis was addressed using longitudinal data from Cycle 4 (2000-2001), Cycle 5 (2002-2003) and Cycle 6 (2004-2005) of the NLSCY. Of 2081 children and adolescents aged 10 to 11 years in Cycle 4, analyses for the third objective

Figure 4: Flow chart of the evolution and selection of the study populations for the three manuscripts



were based on 1135 children who were then followed until the age of 14-15 years in Cycle 6, and who had complete data on the outcome and independent variables under investigation. Data on several variables of interest, as explained above, precluded the inclusion of youth aged 16 and 17 years as part of the third objective of this thesis. For each of the three objectives/analyses of this thesis, characteristics of youth in the study population were compared to those of youth lost to follow-up or excluded because of incomplete/missing data. Details of these analytic comparisons are provided in each of the three manuscripts included in Chapter 5.

4.4 Data collection

The NLSCY combines computer-assisted interviewing methods and the use of paper questionnaires for its data collection.[4] Depending on the composition of the household and the nature of the required components, the interview is conducted partly or completely by telephone and/or field visit. The NLSCY collects a wide array of information including children/adolescents' sociodemographic characteristics, height and weight, physical activities, adverse health behaviours, relationships with peers and parents and school characteristics. All questionnaires were developed in coordination by Statistics Canada, Human Resources and Social Development Canada, and an expert advisory group. All instruments were tested in focus groups and pilot surveys were conducted prior to data collection (320).

Data collection for Cycle 4 of the NLSCY took place between the fall of 2000 and the spring of 2001. There were two main settings under which data were collected in Cycle 4: the household and the school. In the household collection, the primary respondent referred to as the Person Most Knowledgeable (PMK) was asked to complete two questionnaires: a

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[4] Due to their large size, the NLSCY questionnaires were not included in the appendices. Instead, they are available online on Statistics Canada's website at the following addresses:

Cycle 4: http://www.statcan.gc.ca/rdc-cdr/nlcsy-elnej-cycle4-eng.htm

Cycle 5: http://www.statcan.gc.ca/cgi-bin/imdb/p2SV.pl?Function=getInstrumentLink&SurvId=4450&SurvVer=1&InstaId=16044&InstaVer=5&lang=en&db=IMDB&adm=8&dis=2

Cycle 6: http://www.statcan.gc.ca/cgi-bin/imdb/p2SV.pl?Function=getInstrumentLink&SurvId=4450&SurvVer=1&InstaId=16044&InstaVer=6&lang=en&db=IMDB&adm=8&dis=2

parent questionnaire and a child questionnaire. The parent questionnaire gathered information on family SES and parent's adverse health behaviours, while the child's questionnaire was used to obtain the child's height and weight (for children below the age of 12 years). Adolescents aged 12 years or more self-reported their height and weight. Information on youth lifestyle behaviours and social relations with parents and peers were collected through age-specific self-administered questionnaires for children aged 10 years or more at home. The school component consisted of a questionnaire for the teacher and a questionnaire for the school principal that collected information about the school environment and resources.

Data for Cycle 5 of the NLSCY were collected between the fall of 2002 and the spring of 2003, using similar questionnaires and instruments as in Cycle 4. However, starting in Cycle 5, the school component (for children aged 6 years or older) was dropped due to operational constraints including increased costs and respondent burden during data collection. Data for Cycle 6 of the NLSCY were collected between the fall of 2004 and spring of 2005, also using similar tools and questionnaires as in Cycles 4 and 5.

4.5 Measures

This section describes the various measures used in this thesis to address the three thesis objectives.

4.5.1 Behavioural risk factors

Physical inactivity was measured using two closed questions adapted from the Health Behaviour in School-aged Children (HBSC) survey: 1) "During the past 12 months, how often have you played sports or done physical activities without a coach or an instructor (biking, skateboarding, etc.)?"; 2) "During the past 12 months, how often have you played sports with a coach or an instructor, other than gym class (swimming lessons, baseball, hockey, etc.)?"(322). Response choices included "never", "less than once a week", "1 to 3 times a week" and "4 or more times a week". Because the Canadian Physical activity Guides for Children (95) and Youth (96) recommend daily participation in physical activities, physical inactivity was defined as engaging in less than four times of organized/unorganized activities per week. The physical activity questions have been

validated by means of the Multistage Fitness Test (323), a field measure of aerobic fitness, and were shown to have acceptable validity (92). The intra-class correlation coefficient for the reliability of this measure was 0.74, in the targeted age group (92).

Sedentary behaviour was measured using a closed question adapted from the HBSC survey: "On average, about how many hours a day do you watch television or videos?" (322). Responses choices included: "I don't watch TV or videos", "less then 1 hour a day", "1 or 2 hours a day", "3 or 4 hours a day", "5 or 6 hours a day" and "7 or more hours a day". Because the American Academy of Pediatrics guidelines recommend limiting screen viewing to 2 hours per day or less (128), sedentary behaviour was defined as watching television or videos for more than 2 hours per day. The sedentary behaviour measure has been validated using a 7-day television viewing diary. Spearman correlation coefficients ranged from 0.36 to 0.54 (324). Test-retest intra-class correlation scores for the reliability of this measure ranged from 0.76 to 0.81, in the targeted age group (322, 324).

Alcohol drinking for children aged 10 and 11 years in the NLSCY was assessed using a closed question: "Have you ever had a drink of alcohol". Response choices included: "Yes, at least one drink", "I have only had a few sips" and "No" (25). For adolescents 12 years or older, alcohol drinking was assessed using a closed question adapted from the HBSC survey: "Which of the following best describes your experience with drinking alcohol?"(322). Responses choices included: "I have never had a drink of alcohol", "I have only had a few sips", "I only tried once or twice (at least one drink)", "I do not drink alcohol anymore", "a few times a year", "about once or twice a month", "about 1-2 days a week", "about 3-5 days a week" and "about 6-7 days a week". In order to use a standard definition for alcohol drinking across age groups, alcohol drinking was defined as ever drinking, that is having ever had at least one drink of alcohol or more for both children and adolescents (156). A previous study of multiple behavioural risk factors has also used the measure of ever drinking among children and adolescents aged 11 to 18 years (258). Longitudinal studies have shown that children who start drinking (more than just a few sips) as early as 11 years of age are at increased risk of becoming problem and heavy drinkers later in life (325, 326).

Cigarette smoking was assessed by a closed question adapted from the HBSC survey: "Which of the following best describes your experience with smoking cigarettes?" (322). Response choices included: "I have never smoked", "I have only had a few puffs", "I do not smoke anymore", "a few times a year", "about once or twice a month", "about 1-2 days a week", "about 3-5 days a week" and "about 6-7 days a week". In this thesis, cigarette smoking was defined according to Health Canada's definition of ever smoking, that is, having ever tried a cigartte, even a few puffs (133). This definition was chosen because several studies indicate that any cigarette use during childhood is associated with greater risk for subsequent use and children who begin smoking at an early age are more likely to develop severe nicotine dependence than those who start later (327, 328). In addition, use of a lifetime measure of smoking (i.e., ever smoking) has been shown to be both a meaningful and an informative measure in a primary prevention context (329), and has been used in other studies of multiple behavioural risk factors among children and adolescents (50, 258).

High BMI (weight (kg)/height $(m)^2$) was defined as overweight or obese, according to Cole et al.'s (178) international age- and sex-specific cutoffs for children and adolescents, corresponding to body mass indices of 25 and 30, respectively, at age 18 years.

4.5.2 Independent variables

As per the conceptual framework of this thesis, potential determinants (i.e., the independent variables) of multiple chronic disease behavioural risk factors can be grouped into three major categories: individual characteristics, social influences and school influences.

Individual characteristics were classified into ultimate and distal variables. Individual ultimate variables referred to demographic and intrapersonal characteristics of youth, while individual distal variables referred to one's sense of self and sense achievement.

Selected individual ultimate variables included:

Sex was determined by a closed question (binary variable; male, female) (25).

Age was determined by an open question assessing the subject's age in years (25). In the analyses describing the prevalence of multiple behavioural risk factors by age, and the analyses assessing correlates of multiple behavioural risk factors, age was expressed as a categorical variable: 10-11 years, 12-13 years, 14-15 years, and 16-17 years.

Anxiety in children and adolescents aged 10 to 15 years was assessed using seven questions adapted from the Ontario Child Health Survey assessing degree of nervousness, anxiety, and depression (330). Based on subjects' responses, the NLSCY computed a global score ranging from 0 to 14, with higher scores indicating the presence of greater anxiety (continuous variable). This measure has been validated through factor analyses and has been shown to have good construct validity. Its reliability was also satisfactory (Cronbach's $\alpha = 0.76$) in the NLSCY (25).

Selected individual distal variables included:

Self-esteem was measured using four items adapted from the General Self-Scale of the Marsh Self-Description Questionnaire assessing the child's and youth general sense of self (331). Each item was rated on a 5-point scale ranging from 1 (false) to 5 (true). A global score ranging from 0 to 16 was computed in the NLSCY, with higher scores indicating positive self-esteem (continuous variable). This measure has been shown to have high convergent validity (factor intercorrelation = 0.76) (332). Its reliability was also satisfactory (Cronbach's $\alpha = 0.73$) in the NLSCY (25).

Academic performance was assessed using a closed question in the NLSCY: "how well do you think you are doing in your school work?"(25). Responses choices included: "very well", "well", "average", "poor" and "very poor". In the analyses, the response categories "poor" and "very poor" were combined to ensure adequate cell sizes (categorical variable).

Social influences were classified into ultimate and distal variables. Social ultimate variables referred to characteristics of the child's immediate social environment such as family SES and family structure, while social distal variables pertained to child's social relations wither others as well as behaviours of influential role models.

Selected social ultimate variables included:

Family structure (i.e., single parent *versus* two parents) was determined using a closed question indicating if the child lives in a family of two parents or one parent (25) (binary variable).

Parental level of education for the first and the second thesis objectives was determined using a closed question enquiring about the highest level of education attained by the PMK and/or the spouse, if applicable (25, 26, 66). Response choices included: "less than secondary", "secondary school graduation", "some post-secondary" and "college or university degree (including trade)". In the analyses, the first two categories were combined to ensure adequate cell sizes (categorical variable). For the third thesis objective (i.e., the longitudinal analysis), the NLSCY reported inconsistencies in the categorical measure of parental education between Cycles 4 through 6. In particular, the level of parental education using this variable seemed to decrease over time, while it was expected to remain stable or increase over the three cycles. Indeed, the questionnaires flow for this particular measure changed in such a way that returning parents or guardians were asked about their highest level of education at each interview/cycle instead of being asked if they had attended a school, college or university since the last interview. Therefore, to avoid any inconsistencies, the level of parental education for the third objective was assessed instead using an open question enquiring about the number of years of education completed by the parent (25), and defined as low education (<12 years of schooling) *versus* high education (≥12 years of schooling), as defined elsewhere (333).

Household income was assessed using an open question, recording the total household income in the past 12 months (25). In the analyses, household income was presented in quartiles: <$30,000, $30,000-59,999, $60,000-89,999 and ≥$90,000 (334) (categorical variable).

Selected social distal variables included:

PMK smoking status was assessed using a closed question: "At present time do you smoke cigarettes daily, occasionally or not at all?" (25). Responses choices included:

"daily", "occasionally" and "not at all". Subjects reporting that they smoked "daily" or "occasionally" were considered smokers (binary variable).

PMK drinking status was determined using a closed question: "During the past 12 months, how often did you drink beer, wine, liquor or any other alcoholic beverage?" (25). Response choices included: "every day", "4-6 times a week", "2-3 times a week", "once a week", 2-3 times a month", "once a month", "less than once a month" and "never". Subjects reporting that they consumed alcohol at least once a week or more often were considered drinkers (335) (binary variable).

Parent-child relationship was assessed using the Parental Nurturance Scale which comprised seven questions adapted from the Western Australia Child Health Survey evaluating the child's perception of the parents' degree of attention, appreciation and affection (25). A global score ranging from 0 to 28 was computed in the NLSCY, with higher scores indicating better parent-child relationships (continuous variable). The reliability of this scale was excellent (Cronbach's $\alpha = 0.88$) in the NLSCY (25).

Peer smoking was assessed using a closed question: "How many of your close friends smoke cigarettes"? (25). Response choices included "none", "a few", "most" and "all". In the analyses, the response categories "most" and "all" were combined to ensure adequate cell sizes (categorical variable).

Peer drinking were assessed using a closed questions: "How many of your close friends drink alcohol"? (25). Response choices included "none", "a few", "most" and "all". In the analyses, the response categories "most" and "all" were combined to ensure adequate cell sizes (categorical variable).

Peer-child relationships were assessed using the Friends Scale which comprised four items from the Ontario Child Health Study evaluating how well the child feels he/she gets along with his/her peers (330). A global score ranging from 0 to 16 was computed in the NLSCY, with higher scores indicating better relationships with peers. The reliability of this scale was satisfactory (Cronbach's $\alpha = 0.78$) in the NLSCY (25).

School influences were classified into ultimate and distal variables. School ultimate variables referred to characteristics of the school environment, while school distal variables pertained to subjects' commitments to general rules and values at school.

Selected school ultimate variables included:

Type of school was determined by a closed question from the principal's questionnaire (binary variable: public school with religious affiliation *versus* public school with no religious affiliation).

Supportive school environment was assessed through the teacher's questionnaire and using the Supportive School Environment Scale constructed from five questions that measured the level of positive feedback provided to students and teachers. The internal consistency of this measure was excellent (Cronbach's $\alpha = 0.91$) in the NLSCY (25). A total score ranging from 0 to 20 was computed, with a higher score indicating a highly supportive school environment (continuous variable).

Disciplinary climate in the school was determined through the teacher's questionnaire and using the Disciplinary Climate Scale consisting of four questions that evaluated the extent of disciplinary policies in the school. A global score ranging from 0 to 16 was computed, with a higher score indicating the presence of a strong disciplinary climate in the school (continuous variable). The reliability of this measure was satisfactory (Cronbach's $\alpha = 0.81$) in the NLSCY (25)

Selected distal school variables included:

Pupils' degree of cooperation was used as a proxy for collective commitment to success at school (336, 337), and was measured through the teacher's questionnaire and using a closed question assessing how well students worked together in group activities. Response choices included "never", "rarely", "sometimes", "often" and "always". In the analyses, the first two response categories were combined to ensure adequate cell sizes (categorical variable).

Pupils' understanding of school rules was measured with a closed question assessing the extent to which teachers agreed or disagreed that students understood school rules. Response choices included "strongly disagree", "disagree", "neither agree nor disagree", "agree" and "strongly agree". In the analyses, the first two response categories were combined to ensure adequate cell sizes (categorical variable).

4.6 Preparation of datasets for the analysis

Before going into details of the analytic methods used in this thesis, it is important to highlight the steps I took to acquire and prepare the NLSCY datasets for the analysis. As mentioned earlier in this chapter, the NLSCY has been carried out jointly by Statistics Canada and Human Resources and Social Development Canada. In order to gain access to any data (Full Master Files) from Statistics Canada, a researcher must first obtain a permission to use the data from the Social Sciences and Humanities Research Council of Canada. I prepared an application for the purpose of this research for which I was granted the permission to use the NLSCY data at the Quebec Inter-University Centre for Social Statistics in Montreal. All data from Statistics Canada's surveys are stored and available to use only at Research Data Centres (such as the Quebec Inter-University Centre for Social Statistics) throughout Canada. As stated earlier, the NLSCY is a large nationally representative longitudinal survey of Canadian children and adolescents which is conducted every two years. As such, the NLSCY comprises a large number of questionnaires, tools, data files (e.g., a parent, a child, an adolescent and a school data file) and supplementary materials that the researcher needs to review, understand and be able to manage before beginning any type of analysis. In addition, there is a multitude of specific confidentiality rules and requirements that apply to use of data from Statistics Canada that the researcher must adhere to at all times while conducting data analysis at Research Data Centres. I read, studied and became knowledgeable of all materials and requirements related to the NLSCY and complex national surveys at the Quebec Inter-University Centre for Social Statistics before proceeding with the data analysis. I also applied and was awarded a Canadian Institutes of Health Research operating grant in the open competition for this research project (grant NRF-84288).

With regard to preparing the datasets for the analysis, I performed several tasks that are important to highlight. First, for each of the three analyses, the accuracy of data was inspected using descriptive statistics. For continuous variables, the minimum and maximum values and means and standard deviations were checked for plausibility. For discrete/categorical variables, the presence of any out-of-range numbers was inspected but none were found. For both continuous and categorical variables, the presence of potential outliers was inspected using the Statistical Analysis System (SAS) Univariate procedure and histograms. No extreme values were detected. Data were also screened for missing values. Several variables in the NLSCY including physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking, overweight, anxiety, self-esteem, academic performance, parent-child relationship and peer-child relationships comprised missing values (ranging from 2% to 23% of the cases). When dealing with missing data, the pattern of missingness is more important than the amount of data missing (338). If data are missing at random, that is if missingness is not related to the dependent variable, decisions of how to handle missing data are not so critical. In this thesis, a dummy variable with two groups (cases with missing and nonmissing values) was constructed for each variable and differences in the proportions of the outcome (number of behavioural risk factors) were tested between the groups (338). In addition, characteristics of subjects with missing data were compared to those of subjects with complete data. Overall, differences between the two groups were modest suggesting that missing data were likely occurring at random in the dataset. If data are likely missing at random, then listwise deletion of data (i.e., removal of cases with missing values) is considered acceptable (338). I also considered the use of a sophisticated missing data handling procedure called multiple imputation to impute missing values. Multiple imputation is considered the gold standard approach for dealing with missing data as it has the advantage of not requiring data to be missing at random and can be used for nearly any form of analysis. Unfortunately, multiple imputation is often difficult to implement and does not provide the full richness of output even when it works (338). Multiple imputation involves creating multiple imputed datasets (usually 5 sets) for a dataset with missing values. The statistical analysis is then performed on each of the newly created datasets; the multiple analyses are then combined to yield average parameter estimates from the multiple runs in the results (338).

I considered using multiple imputation for each of the three analyses of this thesis using the statistical software SAS and Survey Data Analysis (SUDAAN). However, as mentioned in Section 4.2 of this chapter, one of the most important requirements for making valid inferences using the NLSCY data is to use the bootstrap weights provided by the Statistics Canada to obtain correct estimates of the sampling variance for the parameter estimates computed. While the bootstrap weights were successfully combined with each of the five multiply imputed datasets for the analyses in this thesis, SUDAAN was unable to successfully combine results of all five datasets to yield final average parameter estimates and estimates of the sampling variance of the estimators. The apparent underlying cause for these unsuccessful runs in SUDAAN was likely related to the exhaustive amount of computations that was required to yield final parameter and variance estimates. In particular, each set of analysis included 1000 bootstrap weights (which is equivalent to 1000 variables) for every of the five multiply imputed datasets, and where each imputed dataset contained several thousands of subjects. I was nevertheless able to run the analyses using the multiple imputation procedure but without the bootstrap weights; however these results were not reported because the design of the NLSCY was ignored in these analyses due to the absence of the bootstrap weights. Final parameter estimates (but not estimates of the variance) obtained using the imputed and nonimputed datasets were found to be similar. Therefore, in this thesis because missing data was likely occurring at random and because the bootstrap weights could not be successfully used in conjunction with the multiple imputation procedure, it seemed appropriate to conduct the analyses using the nonimputed datasets containing subjects with complete data on all variables of interest (i.e., with no missing data).

For all three analyses, the collinearity diagnostics in SAS were used to assess multicollinearity between the variables under investigation (338). The collinearity diagnostics in SAS is a powerful procedure which provides several indicators for detecting collinearity between independent variables. Tolerance is defined as 1 – SMC, where SMC is the squared multiple correlation of an independent variable regressed on the remaining independent variables. Low values of Tolerance (generally less than 0.1) indicate high multivariate correlation (338). The Variance Inflation Factor is 1 / Tolerance, and indicates how much the variance of an estimator is inflated due to collinearity. Although there is no

formal cutoff value for the Variance Inflation Factor to determine multicollinearity, a value exceeding 10 (equivalent to a Tolerance < 0.1) is often regarded as indicating multicollinearity (339). The values of the Variance Inflation Factor for the variables used in this thesis were lower than 2 (and values of the Tolerance were higher than 0.5) indicating the absence of multicollinearity. Examination of other indicators such as a high Condition Index (a measure of dependency of a variable on other variables computed using values of a rescaled crossproduct matrix of variables) in combination with high values of variance proportions for the parameter estimates (used to identify the variables that contribute to the instability of the estimation process associated with inverting the crossproduct matrix of variables) also showed absence of multicollinearity. Generally, a Condition Index greater than 30 for a given component/factor (i.e., row of a crossproduct matrix) coupled with variance proportions greater than 0.5 for at least two different variables indicate the presence of multicollinearity (338). These criteria were not met for any of the three analyses confirming the absence of multicollinearity in the datasets.

4.7 Data analysis

This section provides a general overview of the analytic methods used to address each objective and comprises information that could not be included in the manuscripts due to space limitations, such as a more thorough description of the methods as well as a discussion of underlying assumptions. All statistical analyses in this thesis were performed using SAS, version 9.1 (SAS Institute Inc., Cary, North Carolina) and SUDAAN, version 9.01 (RTI International, Research Triangle Park, North Carolina).

4.7.1 Objective 1

The first objective of this thesis aimed to describe the prevalence and clustering patterns of multiple chronic disease behavioural risk factors in Canadian children and adolescents aged 10-17 years. Cross-sectional data from Cycle 4 of the NLSCY were used to address this objective.

Descriptive statistics were used to characterize the sample. Characteristics of the study population were compared to those of subjects excluded because of incomplete data using the chi-squared test. In order to measure the observed prevalence of single behavioural risk

factors, each behavioural risk factor was coded binary (yes = 1, no = 0). The observed prevalence of multiple behavioural risk factors was computed using a risk factor index approach where individual risk factor scores were summed to yield a multiple risk factor index ranging from 0 to 5 (0 = no risk factors, 5 = all five risk factors). The prevalence of single and multiple chronic disease behavioural risk factors by sex and age were estimated using cross-sectional weights supplied by Statistics Canada so that results would be representative of the Canadian children and adolescent populations. The distribution of single and multiple behavioural risk factors was also described by selected socioeconomic characteristics of youth including the highest level of education reported by the PMK, total annual household income and region of residence. Region of residence was used only in this study as a background variable to describe the distribution of behavioural risk factors by four territorial regions (Atlantic, Quebec, Ontario and West). Differences in the distribution of single and multiple behavioural risk factors by selected characteristics of youth were tested using the chi-squared test. Ninety five percent CIs for the estimated proportions were computed using bootstrap weights supplied by Statistics Canada to account for the complex sampling design of the NLSCY.

The clustering of chronic disease behavioural risk factors was assessed using the O/E ratio method described in Section 2.2.2. First, the observed proportions of all possible combinations of behavioural risk factors (i.e., $2^5 = 32$ different combinations, based on the 5 behavioural risk factors under study) were estimated using weighted methods. Then, the expected proportions of all 32 combinations of risk factors were calculated following the laws of probability by assuming independence of the behavioural risk factors and multiplying the individual probabilities of each risk factor based on their occurrence in the study population, for males and females separately. For example, if the prevalence of smoking is 30% and the prevalence of drinking is 40%, then the joint prevalence of smoking and drinking is 12%. There is empirical evidence to support the use of the assumption of mutual independence of risk factors in the computation of their expected proportions (340). The ratio of the O/E proportions was used to assess the clustering of behavioural risk factors as demonstrated in other studies reviewed in Section 2.2.4. Similar to any other point estimate, the O/E ratio has little meaning if it is not presented with an interval estimate which measures its precision. Conventional methods of estimating CIs

assume that the statistics or the point estimate has a normal distribution where the estimated CI is symmetric about the point estimate and its lower limit can become negative (264). However, an O/E ratio cannot be negative and its distribution is not symmetric. In fact, its lowest theoretical value is 0 when the observed prevalence of a risk factor is 0 and its highest value can be relatively large depending on the observed prevalence of a risk factor. Hence, the interval estimate of an O/E ratio should not be computed using conventional methods. An efficient method of computing CIs for O/E ratios is by using the bootstrap technique which requires no distributional assumptions about the statistic (264) and has the additional advantage of providing strong control of type I error rates due to the multiple-comparison problem (341, 342). Therefore, in this thesis, the 95% CIs for the O/E ratios were calculated by the bootstrap technique which also accounted for the complex sample design of the NLSCY.

4.7.2 Objective 2

The second objective of this thesis aimed to explore potential individual, social and school correlates of multiple chronic disease behavioural risk factors in Canadian children and adolescents. Cross-sectional data from Cycle 4 of the NLSCY were used to address this objective.

Descriptive statistics were used to characterize the sample and report the distribution of behavioural risk factors. Each behavioural risk factor was coded binary (yes = 1, no = 0). The dependent variable representing multiple behavioural risk factors corresponded to a multiple risk factor index created by summing individual risk factor scores and ranging from 0 to 5 (0 = no risk factors, 5 = all five risk factors). To ensure adequate cells sizes, the multiple risk factor index was combined into four levels based on the overall sample distribution: level I (subjects with 0 or 1 risk factor), level II (subjects with 2 risk factors), level III (subjects with 3 risk factors) and level IV (subjects with 4 or 5 risk factors) (284). The potential cross-sectional associations between selected individual, social and school characteristics and multiple behavioural risk factors were first examined using univariate analyses. Specifically, differences in selected characteristics between behavioural risk factor levels I, II, III and IV were tested using the chi-squared test for categorical variables and analysis of variance for continuous variables. All variables significant at $P \leq 0.20$ were

then included in the multivariate analyses (343). Stepwise ordinal logistic regression modeling was used to assess the associations between significant independent variables, as described above, and levels I to IV of behavioural risk factors. To test the possibilities of interaction by sex and age, interaction terms were included in the models. All variables initially not retained in the multivariate analyses (i.e. $P > 0.20$) were also entered one by one into regression models to identify possible confounders. The results of models with and without possible confounders were the same. Our final multivariate model was adjusted for all potential covariates (i.e., individual, social and school variables). As per Statistics Canada's guidelines, sampling weights and bootstrap weights were used in all analyses to adjust for sample selection and nonresponse.

The ordinal logistic regression analysis used to address this objective is an extension of the binary logistic regression analysis which is designed to handle ordinal response variables such as the number or levels of multiple behavioural risk factors. Ordinal regression models provide several advantages over binary logistic models where the dependent variable is dichotomized often based on some arbitrary cutoffs; this practice leads to substantial loss of information. In ordinal regression, the model takes advantage of the ordinal nature of the response variable which leads to a more sensitive, powerful and efficient analysis of data (294). Ordinal regression models are also superior to multinomial logistic regression models because the latter ignore the ordering of the categories of the dependent variable, if the dependent variable is an ordinal variable. The ordinal regression model is also called the cumulative odds model or the proportional odds model. The cumulative odds property indicates that the model is defined by the logit (i.e., log odds) of the cumulative probabilities formed over a series of successive incremental cutoffs or levels (294). The cumulative odds ratio is therefore a summary of the binary logistic odds ratios representing each of the levels of the response variable. However, because the cutoff-specific estimates (i.e., odds ratios) are not independent, the cumulative odds ratio is not a simple weighted average of these estimates, but instead is based on maximization of a specific likelihood function (294, 344). Ordinal regression models assume homogeneity of effects across levels of the outcome variable. This is referred to as the proportional odds assumption where the model estimates separate intercepts for each logit but constrains the relationship between each independent variable and the dependent variable to be constant in each logit (294). For

example in this analysis, the sum of behavioural risk factors was used as the dependent variable with 4 levels (Level I: 0-1 risk factor, Level II: 2 risk factors, Level III: 3 risk factors, and Level 4: 4-5 risk factors). The ordinal logistic model estimated three logits as follows:

$$1)\ log\ odds \left(\frac{\text{2-5 risk factors}}{\text{0-1 risk factor}} \right) = \alpha_1 + \beta X_i$$

$$2)\ log\ odds \left(\frac{\text{3-5 risk factors}}{\text{0-2 risk factors}} \right) = \alpha_2 + \beta X_i$$

$$3)\ log\ odds \left(\frac{\text{4-5 risk factors}}{\text{0-3 risk factors}} \right) = \alpha_3 + \beta X_i$$

The first logit estimated the log odds of having two to five behavioural risk factors compared to having zero to one risk factor; the second logit estimated the log odds of having three to five risk factors compared to having zero to two risk factors; and the third logit estimated the log odds of having four to five risk factors compared to having zero to three risk factors. It can be seen from the above equations that each logit had its own intercept (α_1, α_2 and α_3), but all logits had the same coefficient (β). This means that the odds of having two to five risk factors *versus* zero to one risk factor may have been different then the odds of having three to five risk factors *versus* zero to two risk factors or the odds of having four to five risk factors *versus* zero to three risk factors. However, the effect of an independent variable (X) was assumed to be the same for the three logits in the proportional odds model. This assumption was tested using a chi-squared score test and was found to be nonsignificant (P = 0.18), indicating that the proportional odds regression model was appropriate for the data. In addition, the likelihood ratio test of the final multivariate model showed a significant difference between the constant-only model and the full model

(Likelihood ratio = 356.43, degrees of freedom = 30, $P < 0.001$), indicating a good model fit with the set of independent variables.

4.7.3 Objective 3

The third objective of this thesis aimed to assess the longitudinal influence of a set of conceptually-related distal and ultimate variables on the rate of occurrence of multiple chronic disease behavioural risk factors in Canadian children and adolescents. To address this objective, longitudinal data from Cycle 4, Cycle 5 and Cycle 6 of the NLSCY were used.

First, the representativeness of the study cohort was tested by comparing baseline characteristics of youth in the cohort to those of subjects lost to follow-up or excluded because of missing data; the chi-squared test was used to test differences in proportions of categorical variables, and the t-test was used to test differences in means of continuous variables. The prevalence and 95% CIs of single and multiple behavioural risk factors by sex at each cycle were estimated using sampling and bootstrap weights. Single behavioural risk factors were coded binary (yes = 1, no = 0). The dependent variable representing multiple behavioural risk factors corresponded to a multiple risk factor score constructed by summing individual risk factor scores and ranging from 0 to 5 (0 = no risk factors, 5 = all 5 risk factors). Sex-specific time trends in the prevalence of single and multiple behavioural risk factors were examined using polynomial trend tests in SUDAAN (345, 346). The independent variables consisted of all individual and social characteristics of youth considered in this thesis. School characteristics were not included in this analysis since they were not related to multiple behavioural risk factors in the second analysis. Sex and age at baseline in Cycle 4 (10-11 years) were the only time-independent variables. All other independent variables were time-dependent and were assessed at each cycle. The distribution of multiple behavioural risk factors by selected categorical covariates was examined by estimating the mean number of risk factors by selected covariates across time. The distribution of multiple risk factors by selected continuous covariates was described by estimating correlations between the multiple risk factor score and selected covariates across time.

Longitudinal Poisson regression models, within a generalized estimating equations (GEE) framework were used to assess the longitudinal association between selected distal and ultimate independent variables and the rate of multiple risk factor score. First, a set of longitudinal Poisson models was constructed to assess the direct influence of individual ultimate and individual distal variables on the rate of multiple risk factor score, as per our conceptual framework. We then built a second set of longitudinal Poisson models to assess the direct influence of social ultimate and social distal variables on the rate of multiple risk factor score, as per our conceptual framework. A final set of multivariate models was then constructed to assess the independent longitudinal influence of individual distal/ultimate and social distal/ultimate variables on the rate of multiple risk factor score. The log-likelihood ratio statistic was used to assess the contribution of each block of variable to the models. Interaction terms were added to the models to test possible interactions between each covariate and sex as well as between each covariate and time. The final multivariate model included adjustments for all potential covariates (i.e., all distal and ultimate variables) to account for potential confounding. Sampling and bootstrap weights were used in all analyses to adjust for sample selection and nonresponse, as per Statistics Canada's guidelines.

The longitudinal Poisson analysis used to address this objective is an extension of the ordinary Poisson regression analysis with the difference being that the longitudinal analysis uses GEE to account for within-subject correlations between repeated measurements over time in a longitudinal design. The longitudinal (GEE) Poisson regression analysis is also referred to as longitudinal log-linear analysis because it uses a *log link* function to model the outcome count variable (347). The GEE Poisson models were used to address this objective for several reasons. First, the GEE Poisson analysis is designed to handle count outcome variables, such as the multiple risk factor score used herein which has a discrete and non-negative nature; this type of outcome variable is inherently a non-normal variable (i.e., it does not follow a normal distribution). Indeed, because GEE Poisson models estimate the average value of the outcome variable among all subjects in relation to covariates they are not restricted by any distributional assumptions including the assumption of normality required by most other approaches to longitudinal data analysis, such as repeated measures analysis of variance (347, 348). Second, GEE Poisson models

provided a compelling choice for the estimation of mean effects as well as the estimation of the longitudinal influence of selected blocks of distal and ultimate variables on the rate of multiple risk factor score which was the focus of the present analysis (347, 348). Third, although GEE models require the researcher to specify a working correlation structure for the repeated measurements of the dependent variable, they provide robust parameter and standard error estimates even if the working correlation structure is misspecified (348-350). Consistent with a previous longitudinal analysis of a count outcome variable (347), the current analysis employed an exchangeable working correlation structure in which correlations between subsequent measurements were assumed to be the same irrespective of the length of the time interval. A comparison of regression coefficients and standard errors using different working correlation structures including exchangeable, independent and unstructured forms in the context of a count outcome variable (i.e., multiple biological risk factor score) and equally spaced time intervals, similar to the current analysis, found almost identical values for the regression coefficients and standard errors for different forms of the working correlation structure (347). In the present analysis, all statistical tests were based on the robust (empirical) standard error computed by the bootstrap technique which automatically adjusted for possible overdispersion (i.e., the variance of the dependent variable exceeding its mean) in the GEE Poisson model and thus reducing any concern about the correct specification of the working correlation structure (348). Fourth, by using the GEE Poisson analysis in SUDAAN, it was possible to account for the complex sample design of the NLSCY through the use of the bootstrap technique which is critical in obtaining efficient estimates of variance for the regression coefficients, as recommended by Statistics Canada and described in Section 4.2 of this chapter. Finally, the GEE Poisson models provided direct estimates of rate ratios indicating the longitudinal relationship between the multiple risk factor score and both time-dependent and time-independent covariates along the entire follow-up period (347). A general form of the longitudinal (GEE) Poisson model used in the present analysis can be written as follows:

$$log\,(\mu_{it}) = \beta_0 + \sum_{j=1}^{J} \beta_{1j} X_{ijt} + \sum_{k=1}^{K} \beta_{2k} Z_{ikt} + \beta_3 t + \mathrm{CORR}_{it} + \varepsilon_{it}$$

where μ_{it} was the dependent variable (i.e., multiple risk factor score) for subject i at time t, β_0 was the intercept, X_{ijt} was the time-independent variable j for subject i at time t, β_{1j} was the regression coefficient for time-independent variable j, J was the number of time-independent variables, Z_{ikt} was the time-dependent variable k for subject i at time t, β_{2k} was the regression coefficient for time-dependent variable k, K was the number of time-dependent variables, t was time, β_3 was the regression coefficient for time, $CORR_{it}$ was the working correlation structure, and ε_{it} was the "error" for subject i at time t. A likelihood ratio test of the final multivariate longitudinal Poisson model showed a significant difference between the constant-only model and the full model (Likelihood ratio = 480.32, degrees of freedom = 22, $P < 0.001$), indicating a good model fit with the set of independent variables.

4.8 Ethical considerations

All three analyses were conducted using previously collected data from the NLSCY. As a result, I was not in any contact with the respondents of the NLSCY. Data provided by Statistics Canada for the purposes of this research was kept fully confidentiality throughout the analyses. Statistics Canada is prohibited by law from releasing any data which would divulge information obtained under the Statistics Act that relates to any identifiable person, business or organization without the prior knowledge or the consent in writing of that person, business or organization. Various confidentiality rules were applied to all data that are released or published to prevent the publication or disclosure of any information deemed confidential. Suppression of direct identifiers (name, address, etc.) and indirect identifiers (combination of variables identifying a respondent) was used. This study received approval from the Ethics Committee on Research on Human Subjects of the Faculty of Medicine of Université de Montréal. The certificate of ethics approval is included in Appendix 1.

RESULTS

MANUSCRIPT I

MANUSCRIPT II

MANUSCRIPT III

CHAPTER 5: RESULTS

This chapter presents the results of the thesis in the form of three manuscripts. Manuscript I addresses objective 1, Manuscript II addresses objective 2 and Manuscript III addresses objective 3 of the thesis. I wrote and was the first author of all three manuscripts. The co-author played a critical supervisory role with regard to the writing of the manuscripts. Details regarding the contribution of co-authors are provided in the following paragraphs. I also disseminated the research results through presentations and posters at several local, national and international conferences.[5]

Manuscript #1:

CLUSTERING OF CHRONIC DISEASE BEHAVIORAL RISK FACOTRS IN CANADIAN CHILDREN AND ADOLESCENTS

Published in *Preventive Medicine*, volume 48, number 5, pages 493-499, May 2009. A copyright waiver from Elsevier Limited, publisher of *Preventive Medicine* and copyrights holder of the manuscript, is included in Appendix 2.

Arsham Alamian, Ph.D. Candidate: Designed and conceived the study, carried out statistical analyses, interpreted the data and wrote the manuscript.

Gilles Paradis, MD, MSc, FRCPC: Contributed to data interpretation, provided comments on the manuscript and reviewed the final version for important intellectual content and quality.

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[5] The results of the thesis were presented at the following scientific meetings: Canadian Public Health Association Annual Conference (CPHA), Halifax, NS (June 1-4, 2008); XVIII IEA World Congress of Epidemiology, Porto Alegre, Brazil (September 20-24, 2008); American Public Health Association (APHA) 136th Annual Meeting, San Diego, CA (October 25-29, 2008); 4th Symposium of the Association of Public Health Students of the Université de Montréal, Montréal, QC (February 20, 2009); Quebec Inter-University Centre for Social Statistics 2009 New Scholars Conference, Montreal, QC (March 13, 2009); 78th Annual Congress of Association francophone pour le savoir (ACFAS), Montréal, QC (May 10-14, 2010).

Manuscript #2:

CORRELATES OF MULTIPLE CHRONIC DISEASE BEHAVIORAL RISK FACTORS IN CANADIAN CHILDREN AND ADOLESCENTS

Published in the *American Journal of Epidemiology*, volume 170, number 10, pages 1279-1289, November 2009. A copyright waiver from Oxford University Press, publisher of the *American Journal of Epidemiology* and copyrights holder of the manuscript, is included in Appendix 3.

Arsham Alamian, Ph.D. Candidate: Designed and conceived the study, carried out statistical analyses, interpreted the data and wrote the manuscript.

Gilles Paradis, MD, MSc, FRCPC: Contributed to data interpretation, provided comments on the manuscript and reviewed the final version for important intellectual content and quality.

Manuscript #3:

INDIVIDUAL AND SOCIAL DETERMINANTS OF MULTIPLE BEHAVIORAL RISK FACTORS AMONG YOUTH

Submitted to *Social Science & Medicine*.

Arsham Alamian, Ph.D. Candidate: Designed and conceived the study, carried out statistical analyses, interpreted the data and wrote the manuscript.

Gilles Paradis, MD, MSc, FRCPC: Contributed to data interpretation, provided comments on the manuscript and reviewed the final version for important intellectual content and quality.

5.1 MANUSCRIPT I

CLUSTERING OF CHRONIC DISEASE BEHAVIORAL RISK FACOTRS IN CANADIAN CHILDREN AND ADOLESCENTS

Preamble

Behavioural risk factors including physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking and overweight/obesity are linked to adverse health and social consequences throughout the life course (41, 42, 46, 159). When these adverse behaviours co-occur, risks of chronic diseases morbidity and mortality increase substantially (244). Since lifestyle risk factors track from childhood to adulthood (17, 20), early identification of the prevalence and clustering patterns of behavioural risk factors among youth may help curb the future increased burden of chronic diseases. The literature review of studies investigating the prevalence and distribution of multiple chronic disease behavioural risk factors (Chapter 2, Section 2.2.3) indicated that only a few studies were conducted among children and adolescents (65, 66, 78, 238, 246, 265), including the absence of any Canadian report of both the sex- and age-specific prevalence of multiple behavioural risk factors in a nationally representative sample of youth (Table I, Chapter 2, Section 2.2.3, *p.27*). The review of the literature of Section 2.2.4 further demonstrated the paucity of evidence on clustering patterns of behavioural risk factors for chronic diseases among youth. The few studies that investigated clustering of behavioural risk factors were not based on nationally representative samples (50, 79, 258), and no other study had determined whether chronic disease behavioural risk factors cluster among Canadian youth (Table II, Chapter 2, Section 2.2.4, *p.32*), prior to the publication of Manuscript I presented herein. The present study is therefore among the first to address these important gaps in the literature by determining both the prevalence and clustering patterns of multiple chronic disease behavioural risk factors in a large nationally representative sample of Canadian children and adolescents aged 10 to 17 years.

Knowing the prevalence and distribution of multiple chronic disease behavioural risk factors among Canadian youth would help to inform health prevention and promotion efforts across multiple settings including public health departments and agencies as well as primary health clinics. The information generated by this study regarding clustering of behavioural risk factors would be of great importance to support the planning of strategies aimed at preventing the occurrence of multiple behavioural risk factors among youth.

Clustering of chronic disease behavioral risk factors in Canadian children and adolescents

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Footnotes

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Abstract

Objective: We assessed the prevalence, socioeconomic distribution and clustering of five major chronic disease behavioral risk factors (physical inactivity, sedentary behavior, tobacco smoking, alcohol drinking and high body mass index) in a representative sample of Canadian children and adolescents aged 10-17 years.

Methods: Cross-sectional data (n = 4724) from Cycle 4 (2000/2001) of the National Longitudinal Survey of Children and Youth were used. Clustering was assessed using an observed to expected ratio method.

Results: Overall, 65% of Canadian youth had two or more behavioral risk factors compared to only 10% with none of the five risk factors. The prevalence of having multiple behavioral risk factors was greater among older youth and those from low socioeconomic status families. Behavioral risk factors clustered in multiple combinations. Specifically, the simultaneous occurrence of all five risk factors was 120% greater in males (Observed/Expected ratio: 2.20; 95% CI: 1.31-3.09) and 94% greater in females (Observed/Expected ratio: 1.94; 95% CI: 1.24-2.64) than expected. Ever smoking and ever drinking showed the strongest association among the pairwise clusters.

Conclusions: Multiple chronic disease behavioral risk factors are frequent and occur more often than expected among Canadian children and adolescents. Early prevention programs targeting clusters of behavioral risk factors in youth are needed.

Keywords: Epidemiology, Chronic diseases, Clustering, Health behaviors, Children; Adolescents

5.1.1 Introduction

Chronic diseases, including cardiovascular diseases, cancer, chronic obstructive lung disease, and diabetes are the leading causes of death and disability worldwide (World Health Organization, 2001). Although these conditions occur in adulthood, there is convincing evidence that the precursors of these diseases manifest in childhood and adolescence. First, autopsy evidence confirms that pathological processes involved in the development of atherosclerosis originate in the first two decades of life (Tracy et al., 1995). Second, chronic disease risk factors and behaviors including, obesity (Webber et al., 1991), physical inactivity (Dennison et al., 1988; Kelder et al., 1994; Hallal et al., 2006), sedentary behavior (Janz et al., 2000), tobacco smoking (Kelder et al., 1994) and alcohol drinking (Andersen et al., 2003) track from childhood to adulthood (Mikkila et al., 2005; Cullen et al., 1999), and are linked to adult diseases (Freedman et al., 1999; Centers for Disease Control and Prevention, 1994). Third, chronic disease behavioral risk factors are prevalent in children and adolescents and are associated with adverse health and social consequences (Boyce, 2004; Canada Fitness and Lifestyle Research Institute, 2005).

Despite the increasing literature on single behavioral risk factors, less is known about the prevalence and distribution of multiple behavioral risk factors in youth. Many of the previous research studies have reported pairwise associations (Laaksonen et al., 2002; Bien and Burge, 1990; Pate et al., 1996) and only a few studies investigated the association of three or more behavioral risk factors related to chronic diseases. The majority of these studies have been conducted in adults (Galan et al., 2005; Fine et al., 2004; Schuit et al., 2002; Chiolero et al., 2006; Raitakari et al., 1995), and only a limited number focused on children and adolescents (Lawlor et al., 2005; Sanchez et al., 2007). Investigating the clustering of behavioral risk factors in youth could help define the future burden of disease and identify targets for early prevention programs (Baranowski et al., 1997; Tercyak and Tyc, 2006). Using a large dataset, we assessed the prevalence, distribution and clustering of physical inactivity, sedentary behavior, tobacco smoking, alcohol drinking, and high body mass index (BMI) in a representative sample of Canadian children and adolescents aged 10-17 years.

5.1.2 Methods

Study population

Cross-sectional data from the second release (December 2004) of Cycle 4 (2000/2001) of the National Longitudinal Survey of Children and Youth (NLSCY) were used. The NLSCY is a large nationally representative survey of Canadian children and adolescents that follows their development and well-being from birth into adulthood. Of 7661 eligible children and adolescents aged 10 to 17 years, analyses were based on 4724 youth (62% of the initial sample) who had complete data on selected lifestyle and socioeconomic variables. This study was approved by the Ethics Committee on Research on Human Subjects of the Faculty of Medicine of the University of Montreal.

Data collection

The Person Most Knowledgeable, most often the mother, was asked to complete a parent questionnaire and a child questionnaire. The parent questionnaire gathered information about parents' socioeconomic status (SES), while the child questionnaire (for children below the age of 12 years old) gathered information about the child's social relationships as well as height and weight. Information regarding the youth's health behaviors and height and weight (for adolescents aged 12 years and over) was assessed through self-administered questionnaires.

Measures

Risk factors

Physical inactivity was measured using two closed questions adapted from the World Health Organization Health Behavior in School-aged Children (HBSC) survey: 1) "During the past 12 months, how often have you played sports or done physical activities without a coach or an instructor (biking, skateboarding, etc.)?"; 2) "During the past 12 months, how often have you played sports with a coach or an instructor, other than gym class (swimming lessons, baseball, hockey, etc.)?" (Wold et al., 1993). Response choices included "never", "less than once a week", "1 to 3 times a week" and "4 or more times a week". Because the Canadian Physical activity Guide for Children and Youth recommends daily participation in moderate and vigorous activities (Public Health Agency of Canada and Canadian Society

for Exercise Physiology, 2002), we defined physical inactivity as engaging in less than four times of organized/unorganized activities per week. The intra-class correlation coefficient for the original physical activity questions was 0.74, in the targeted age group (Booth et al., 2001).

Sedentary behavior was measured using a closed question from the HBSC: "On average, about how many hours a day do you watch TV or videos?" (Wold et al., 1993). Because the American Academy of Pediatrics guidelines recommend limiting screen viewing at ≤2 h/day (American Academy of Pediatrics, 2001), we defined sedentary behavior as watching TV or video >2 h/day. Test-retest intra-class correlation scores for the original measures of TV viewing ranged from 0.76 to 0.81, in the targeted age group (Wold et al., 1993; Vereecken et al., 2006).

Ever smoking was assessed by a closed question from the HBSC asking youth about their past experience with cigarette smoking (Wold et al., 1993). We used Health Canada's definition of *ever* smoking that is, having ever tried a cigarette, even a few puffs (Health Canada, 2005). The original measures of cigarette smoking were previously tested and validated in the targeted age group (Wold et al., 1993; Brener et al., 2003).

Ever drinking was measured by a closed question from the HBSC inquiring about youth's past experience with drinking alcohol (Wold et al., 1993). Ever drinking was defined as ever having had at least one drink (Dubé and Pica, 2005). The original questions of alcohol drinking were previously piloted and validated (Wold et al., 1993; Brener et al., 2003).

High BMI was defined, as overweight or obese, according to Cole et al.'s international age- and sex-specific BMI cut-offs for children and adolescents that pass through a BMI of 25 and 30 kg/m^2 at age 18 (Cole et al., 2000). BMI was calculated as weight (kg) / height (m^2).

Socioeconomic variables

Family educational level was assessed as the highest level of education, reported by the Person Most Knowledgeable. In the analyses, a categorical variable with three levels was created: "high school or less", "some post-secondary" and "post-secondary degree".

Household income was estimated using an open question, recording the total household income from all sources in the past 12 months. In these analyses, household income was presented in quartiles: "<$30,000", "$30,000-59,999", "$60,000-89,999", "≥$90,000".

Region of residence was defined by combining the ten Canadian provinces into four distinct territorial regions: "Atlantic", "Quebec", "Ontario" and "West".

Statistical analyses

We described the observed prevalence of single behavioral risk factors coded as a binary variable (Yes = 1; No = 0). Then, the observed prevalence of multiple behavioral risk factors was estimated using a risk factor index approach where individual risk factor scores were summed to yield a multiple risk factor index ranging from 0 to 5 (0 = no risk factor, 5 = all risk factors) based on the overall sample distribution (Galan et al., 2005; Schuit et al., 2002; Laaksonen et al., 2003). The age- and sex-specific proportions of youth, in each of the single and multiple behavioral risk factor categories, was estimated using cross-sectional weights supplied by Statistics Canada so that results would be representative of the Canadian children and adolescent populations (Statistics Canada and Human Resources Development Canada, 2003). The prevalence of single and multiple behavioral risk factors was also described by selected socioeconomic variables. Ninety five percent confidence intervals were constructed for the estimated proportions using bootstrap weights supplied by Statistics Canada to account for the complex sampling design of the NLSCY (Statistics Canada and Human Resources Development Canada, 2003).

We then studied the clustering of behavioral risk factors. We defined clustering as an observed proportion of a combination of risk factors in excess of its expected proportion (Schuit et al., 2002). The observed proportions of 32 different combinations of behavioral risk factors were estimated using weighted methods (Statistics Canada and Human Resources Development Canada, 2003). The expected proportions were calculated by multiplying the individual probabilities of each risk factor based on their occurrence in the study population for males and females separately. For example, suppose that the five risk factors have the following prevalences among males: physical inactivity = 60%; sedentary behavior = 40%; ever smoking = 30%; ever drinking = 65% and high BMI = 25%. Then,

the expected prevalence of having all five risk factors among males would be: 0.6 x 0.4 x 0.3 x 0.65 x 0.25 = 0.0117 (1.17%). The expected prevalence of having physical inactivity, sedentary behavior, ever smoking and ever drinking, but not having high BMI among males would be: 0.6 x 0.4 x 0.3 x 0.65 x 0.75 = 0.0351 (3.51%), and so on. The ratio of the observed over expected (O/E) proportions was used to assess the clustering of behavioral risk factors (Schuit et al., 2002; Galan et al., 2005). Ninety five percent confidence intervals were calculated for the ratios by bootstrap techniques (Statistics Canada and Human Resources Development Canada, 2003). All statistical analyses were performed using SUDAAN, version 9.01. Significance was judged at the $P<0.05$ level, with Bonferroni correction for multiple comparison tests used for interpreting differences in the prevalence of single and multiple behavioral risk factors by region of residence.

5.1.3 Results

Characteristics of the study population are presented in Table 1. Analyses comparing youth in the study population and those excluded due to missing data showed no differences between the two groups with respect to age, education, income and region of residence. There were slightly more females among youth in the study population than among those excluded (52.4% Vs. 48.7%; $p = 0.05$).

Single behavioral risk factors

The most common single behavioral risk factor was physical inactivity with a prevalence of 62% (Table 2). Sedentary behavior was the second most common risk factor (45%), followed by ever drinking (40%), ever smoking (37%) and high BMI (25%). Across most age groups, females were significantly more physically inactive than males ($p<0.0001$) while males were significantly more likely to be overweight/obese than females ($p<0.0001$). Physical inactivity ($p<0.0001$), ever smoking ($p<0.0001$) and ever drinking ($p<0.0001$) also showed strong positive trends with increasing age, for both males and females.

Among females, ever smoking ($p=0.0004$), ever drinking ($p=0.0626$) and high BMI ($p=0.0122$) showed consistent inverse trends with higher levels of family education (Table

3). Among males, only the prevalence of sedentary behavior decreased with higher education (p=0.0001). Sedentary behavior (p=0.0001) and ever smoking (p=0.0181) also tended to decrease with higher household income, but mainly in females. Ever drinking increased with household income in males (p=0.0115). According to the multiple comparison tests, the prevalence of sedentary behavior was higher in the Atlantic region (p=0.0004) and in Quebec (p=0.0055) compared to Western Canada, especially among males. Ever smoking was also higher in the Atlantic region compared to Ontario (p=0.0089) and higher in Quebec compared to Ontario (p<0.0001) and to Western Canada (p=0.0001), mainly among females. The proportion of males with high BMI was greater in the Atlantic region compared to those in Western Canada (p=0.0032), while the proportion of females with high BMI was higher in the Atlantic region compared to those in Quebec (p=0.0020) and to those in Ontario (p=0.0030).

Multiple behavioral risk factors

Only one out of ten Canadian youth aged 10-17 years had none of the five risk factors (Table 4). Twenty-five percent had one risk factor, 28% had two risk factors, 23% had three risk factors and 14% had four or five risk factors. The prevalence of having three risk factors, and four or five risk factors increased with age while the prevalence of having zero or one risk factor decreased with age, for both males (p<0.0001) and females (p<0.0001). The prevalence of multiple behavioral risk factors did not differ by sex (p=0.2744).

The prevalence of having zero or one risk factor was on average greater among youth from families with high education (p=0.0001), particularly among females (Table 5). In contrast, the proportion of youth with four or five risk factors tended to be higher among those from families with low education and low household income, mainly in females (p=0.0001). According to the multiple comparison tests, the prevalence of having four or five risk factors was higher in Quebec compared to Western Canada, for males (p=0.0084), and higher in the Atlantic region compared to Ontario, for females (p=0.0019). Overall, Western Canada exhibited a healthier risk profile (higher proportion of youth with zero risk factor) than the Atlantic region (p=0.0003) and Quebec (p=0.0029).

The combination of all five risk factors showed clustering with an O/E ratio of 2.20 (95% CI: 1.31-3.09), for males, and an O/E ratio of 1.94 (95% CI: 1.24-2.64), for females (Table 6). This indicates that the proportion with which the five risk factors occur was 120% greater in males and 94% greater in females than the proportion that would be expected had the five risk factors occurred independently. The greatest degree of clustering occurred in females in a four-behavior pattern comprised of physical inactivity (P), ever smoking (T), ever drinking (A) and high BMI (B) (O/E ratio: 2.58; 95% CI: 1.69-3.47). Among males, the simultaneous combination of (P), sedentary behavior (S), (T) and (A) showed the highest degree of clustering with a ratio of 2.36 (95% CI: 1.74-2.99). Four of the three-behavior patterns clustered in males (PSB, PTA, STA and TAB) while only the (PTA) combination was more prevalent than expected in females. Among the two-behavior patterns, (TA) clustered in both males and females while the O/E ratios for (PS) and (SB) were higher than expected in females.

5.1.4 Discussion

This is the first report of the prevalence, clustering and socioeconomic distribution of multiple chronic disease behavioral risk factors in a representative sample of Canadian children and adolescents aged 10-17 years. The results indicate that 65% of Canadian youth had two or more behavioral risk factors, including 37% with at least three risk factors. Only 10% of youth did not have any of the five risk factors.

To our knowledge, only a few studies have described the prevalence of multiple lifestyle risk factors in youth. These studies included different risk factors, used various definitions and cut-offs, and focused on different age groups and a variety of populations. Hence, it is difficult to compare the results of these studies. Nevertheless, our finding that nearly two-thirds of Canadian youth aged 10-17 years have multiple behavioral risk factors is similar to that of a recent study conducted in adolescents aged 11-15 years in San Diego, CA. In that study, nearly 80% of adolescents were sedentary, physically inactive and did not meet dietary guidelines for fat and fruits/vegetables intake (Sanchez et al., 2007). The prevalence of having four or five risk factors in our study is also comparable to a study conducted among 14 year old Australians in which 10% of participants reported having three or four

risk factors including, tobacco smoking, high levels of TV viewing, overweight and high blood pressure (Lawlor et al., 2005).

In our study, the proportion of multiple behavioral risk factors was similar between males and females, a finding that is consistent with a study conducted among Australian adolescents (Lawlor et al., 2005), as well as with results of two studies conducted in adults (Schuit et al., 2002; Chiolero et al., 2006). The prevalence of having three or more risk factors was higher among older adolescents. This finding is also concordant with results of a study in American adolescents (Sanchez et al., 2007) and those of three studies conducted in adults where younger adults (18-39 year olds) reported having a higher number of risk factors than middle-aged or older adults (Laaksonen et al., 2003; Fine et al., 2004; Galan et al., 2005).

The prevalence of having four or five behavioral risk factors was greater in youth from families with low household income and most notably low levels of education. These results corroborate those of previous studies where low education and low income predicted having three or more unhealthy behaviors, in both the paediatric (Lawlor et al., 2005) and the adult population (Schuit et al., 2002; Raitakari et al., 1995; Fine et al., 2004; Laaksonen et al., 2003; Pronk et al., 2004). Several socio-ecological theories of health behavior highlight the importance of youth's social environment on behavior change (Bronfenbrenner, 1977). Youth from families with low levels of education may be less informed about the importance of engaging in healthy behaviors while those from low income families may perceive less social support from friends, consume more unhealthy diets and live in unsafe and less cohesive neighbourhoods (Jeffery and French, 1996; Gordon-Larsen et al., 2000). Thus, special programs may be required targeting youth from low SES families.

The proportion of youth with four or five behavioral risk factors was higher in the Atlantic region (females) and in Quebec (males) compared to Ontario and Western Canada, respectively. Analyses of other Canadian national surveys have consistently reported higher prevalences for physical inactivity (Gilmour, 2007) and smoking (Shields, 2005), as single risk factors, in Quebec, and for the same risk factors and obesity (Shields and Tjepkema,

2006) in the Atlantic regions, compared to Western Canada. In the United States, a recent analysis of the 2003 National Survey of Children's Health also found higher prevalences of at risk for overweight or overweight school-aged children in southeastern states, compared to northwestern states (Tudor-Locke et al., 2007). Possible explanations for these regional differences include different rates of walking or bicycling as means of transportation, discrepancies in opportunities for exercise and higher rates of immigrant settlements in large cities (Gilmour, 2007; Shields and Tjepkema, 2006).

The five behavioral risk factors clustered in multiple combinations in both males and females. Previous studies have only presented the observed prevalence of combinations of lifestyle risk factors without describing the degree of clustering nor the intensity of the relationships between three or more risk factors (Sanchez et al., 2007; Klein-Geltink et al., 2006; Pronk et al., 2004). Using the O/E ratio method, we found significant clustering of risk factors among youth with four or five risk factors confirming results from an Australian adolescent study (Lawlor et al., 2005), as well as from other studies conducted in adults (Raitakari et al., 1995; Galan et al., 2005; Schuit et al., 2002).

The most common unhealthy behaviors which clustered were ever smoking and ever drinking. In fact, except for the combination of physical inactivity, sedentary behavior and high BMI, all three- and four-behavior patterns that showed clustering, included both ever smoking and ever drinking. In addition, ever smoking and ever drinking showed the strongest association among the pairwise combinations. Finally, ever smoking and ever drinking were less prevalent than expected, as single risk factors. Thus, public health programs might need to focus on joint tobacco and alcohol use prevention or cessation among youth rather than focusing on individual behavior change.

This study had limitations. First, high BMI may not be viewed as a behavioral risk factor. Nevertheless, overweight is a risk factor for several chronic diseases and its immediate determinants include several behaviors, including imbalance between dietary energy intake and energy expenditure through physical activity. Indeed, as depicted in Table 6, high BMI clustered with sedentary behavior among females (O/E ratio: 1.64; 95% CI: 1.02-2.27); it also tended to cluster with physical inactivity in both males and females (reflected by the

O/E ratios >1). Although other risk behaviors did show clustering independent of high BMI, if high BMI was excluded from the analysis, the overall degree of clustering, particularly that of sedentary behavior with other risk factors, would have been lower.

Second, height and weight were self-reported in the NLSCY. Though correlations for objective *versus* self-reported measures among adolescents have been reported in the range of 0.87-0.94 for body mass and 0.82-0.91 for height (Strauss, 1999), young females are more likely to underreport body mass than young males (Strauss, 1999; Elgar and Stewart, 2008). This may explain the sex differences observed in the prevalences of high BMI in this study, where high BMI was identified more often in males than in females. The assessment of other behaviors was also based on self-reports which may be subject to social desirability bias. This may have led to an underestimation of the true prevalences of multiple behavioral risk factors. Furthermore, behavioral risk factors were dichotomized which may lead to a loss of information when categories are collapsed. However, because health behaviors were measured on different scales, and because we aimed to describe the clustering pattern of risk factors, dichotomization using standard national/international cut-offs was considered appropriate.

In this study, the five risk factors were summed up to create a multiple risk factor index. While some authors have questioned use of such additive indices where risk factors are attributed equal weights (Slater and Linder, 1988; Dean and Salem, 1998), there is theoretical and empirical evidence that use of equally weighted risk factor indices results in the identification of very similar at risk population sub-groups than those identified by unequally weighted risk factor indices (Piacentini et al., 1992; Miller and Bauman, 2005). Several methods were used to account for possible nonresponse errors, including weight adjustments to minimize the effect of errors due to total nonresponse. For partial nonresponse, characteristics of respondents were compared to those of non-respondents. Although no significant differences emerged from this comparison, differences between respondents and non-respondents beyond the reported demographic characteristics and hence the potential influence of unmeasured variables on observed relationships remain unknown. Lastly, the cross-sectional nature of this study precludes making causal claims.

Conclusions

The information generated by this study has important implications. Traditionally, most health promotion strategies have addressed single behavioral risk factors. Yet, as the findings of this study suggest, chronic disease behavioral risk factors are prevalent and they tend to co-occur more often than expected among youth. Since the co-existence of behavioral risk factors predisposes individuals to greater risks of chronic disease and mortality (Yusuf et al., 1998), early prevention programs may be required to target a range of behavioral risk factors rather than focusing on single risk factors in youth. In particular, special efforts may be required targeting older adolescents and youth from low SES families.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

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Table 1
Characteristics of youth in the study population and those excluded due to missing data, (2000/2001)[a]

	Study population		Subjects excluded		*p*-value[d]
	n[b]	%[c]	*n*[b]	%[c]	
Sex					0.05
Male	945,445	47.6	647,242	51.3	
Female	1,042,079	52.4	614,439	48.7	
Age					0.11
10-11	506,896	25.5	320,467	25.4	
12-13	438,682	22.1	306,588	24.3	
14-15	511,321	25.7	315,420	25.0	
16-17	530,625	26.7	319,206	25.3	
Education					0.27
High school or less	499,156	25.1	328,037	26.0	
Some post-secondary	451,176	22.7	293,972	23.3	
Post-secondary	1,037,192	52.2	639,672	50.7	
Income					0.09
<$30,000	254,998	12.8	185,467	14.7	
$30,000-59,999	654,586	32.9	415,093	32.9	
$60,000-89,999	582,093	29.3	362,102	28.7	
≥$90,000	495,847	25.0	299,019	23.7	
Region of residence					0.08
Atlantic	162,222	8.2	98,411	7.8	
Quebec	473,516	23.8	281,355	22.3	
Ontario	784,898	39.5	490,794	38.9	
West	566,888	28.5	391,121	31.0	

[a] National Longitudinal Survey of Children and Youth, Cycle 4.
[b] Weighted frequencies expressed in terms of frequency of Canadian youth aged 10-17 years.
[c] Weighted percentage expressed in terms of percentage of Canadian youth aged 10-17 years.
[d] *p*-value from the chi-square test.

Table 2
Prevalence (% (95%CI)) of single behavioral risk factors in Canadian youth aged 10-17 years, by sex and age, (2000/2001)[a]

Risk factors	Total (n = 1,987,524)	Males (*n* = 945,445)				Females (*n* = 1,042,079)			
		Age groups (years)				Age groups (years)			
	10-17	10-11	12-13	14-15	16-17	10-11	12-13	14-15	16-17
Physical inactivity[b]	62 (59-64)	47 (41-53)	45 (38-51)	57 (51-63)	65 (58-70)	59 (53-65)	65 (59-71)	72 (66-77)	77 (72-78)
Sedentary behavior[c]	45 (43-47)	46 (40-52)	56 (50-62)	47 (40-53)	47 (41-54)	40 (34-46)	52 (45-58)	42 (36-48)	35 (30-41)
Ever smoking[d]	37 (35-39)	5 (3-8)	20 (15-25)	44 (38-51)	66 (60-71)	5 (3-8)	24 (19-29)	51 (45-57)	71 (66-76)
Ever drinking[e]	40 (38-42)	7 (4-10)	16 (12-21)	49 (43-56)	76 (69-81)	7 (4-11)	17 (13-22)	57 (50-63)	82 (77-87)
High BMI[f]	25 (23-27)	29 (23-35)	28 (22-34)	28 (23-34)	33 (27-40)	25 (20-31)	16 (12-21)	17 (13-21)	22 (17-27)

Note. Prevalences were computed using weighted methods and expressed in terms of percentage of Canadian youth aged 10-17 years. Confidence intervals were computed by bootstrap techniques to account for the complex sampling design of the National Longitudinal Survey of Children and Youth.
[a] National Longitudinal Survey of Children and Youth, Cycle 4.
[b] Physical inactivity: engaging in less than four times of organized / unorganized activities per week.
[c] Sedentary behavior: watching TV or videos more than 2 h per day.
[d] Ever smoking: ever smoked a cigarette, even a few puffs.
[e] Ever drinking: ever had a standard drink of alcohol.
[f] High BMI: overweight/obese defined by cut-off points from Cole et al. (2000).

Table 3
Prevalence (%) of single behavioral risk factors in Canadian youth aged 10-17 years, by sex and socioeconomic variables, (2000/2001)[a]

	Males (n = 945,445)					Females (n = 1,042,079)				
	Risk factors					Risk factors				
	Physical inactivity[b]	Sedentary behavior[c]	Ever smoking[d]	Ever drinking[e]	High BMI[f]	Physical inactivity[b]	Sedentary behavior[c]	Ever smoking[d]	Ever drinking[e]	High BMI[f]
Family Education										
High school or less	55	63	40	38	29	72	47	49	48	23
Some post-secondary	55	51	34	35	33	73	48	36	43	22
Post-secondary degree	52	41	32	39	28	65	36	35	39	16
p-value[g]	0.6961	0.0001	0.1624	0.6071	0.3063	0.0394	0.0071	0.0004	0.0626	0.0122
Household income										
<$30,000	52	53	44	31	30	72	52	51	46	21
$30,000-59,999	56	56	32	34	34	70	46	37	39	21
$60,000-89,999	56	44	32	37	30	71	43	39	44	20
≥$90,000	50	42	37	47	22	63	30	35	42	17
p-value[g]	0.4699	0.0055	0.1469	0.0115	0.0134	0.2617	0.0001	0.0181	0.5025	0.7660
Region of residence										
Atlantic	50	51	34	37	35	68	47	43	44	28
Quebec	56	57	43	45	29	71	40	48	46	18
Ontario	55	49	31	32	32	70	45	34	37	18
West	50	41	33	40	25	64	37	36	46	23
p-value[g]	0.3021	0.0024	0.0238	0.0122	0.0209	0.2349	0.0480	0.0005	0.0320	0.0066

Table 3
Prevalence (%) of single behavioral risk factors in Canadian youth aged 10-17 years, by sex and socioeconomic variables, (2000/2001)[a] (Continued)

Note. Prevalences were computed using weighted methods and expressed in terms of percentage of Canadian youth aged 10-17 years.
[a] National Longitudinal Survey of Children and Youth, Cycle 4.
[b] Physical inactivity: engaging in less than four times of organized / unorganized activities per week.
[c] Sedentary behavior: watching TV or videos more than 2 hours per day.
[d] Ever smoking: ever smoked a cigarette, even a few puffs.
[e] Ever drinking: ever had a standard drink of alcohol.
[f] High BMI: overweight (includes obese) defined by cut-off points from Cole et al. (2000).
[g] *p*-value from the chi-square test.

Table 4
Prevalence (% (95%CI)) of multiple behavioral risk factors in Canadian youth aged 10-17 years, by sex and age, (2000/2001)[a]

No. of risk factors[b]	Total (n = 1,987,524)	Males (*n* = 945,445)				Females (*n* = 1,042,079)			
		Age groups (years)				Age groups (years)			
	10-17	10-11	12-13	14-15	16-17	10-11	12-13	14-15	16-17
0	10 (9-12)	23 (18-29)	17 (12-22)	6 (4-12)	2 (1-4)	14 (11-19)	11 (8-16)	8 (5-13)	3 (1-6)
1	25(23-26)	33 (28-39)	31 (25-37)	22 (17-27)	11 (8-15)	47 (41-53)	32 (26-38)	16 (12-22)	7 (6-11)
2	28 (26-30)	31 (26-37)	30 (24-31)	30 (25-36)	21 (16-26)	29 (23-34)	36 (30-44)	27 (21-33)	22 (17-28)
3	23 (21-25)	11 (8-16)	16 (12-23)	26 (21-32)	37 (31-44)	8 (5-13)	14 (10-19)	29 (24-35)	38 (33-44)
4 or 5	14 (13-16)	2 (1-3)	6 (4-9)	16 (12-21)	29 (24-35)	2 (1-5)	7 (5-10)	20 (16-24)	30 (24-35)

Note. Prevalences were computed using weighted methods and expressed in terms of percentage of Canadian youth aged 10-17 years. Confidence intervals were computed by bootstrap techniques to account for the complex sampling design of the National Longitudinal Survey of Children and Youth.
[a] National Longitudinal Survey of Children and Youth, Cycle 4.
[b] Risk factors include: Physical inactivity (engaging in less than four times of organized / unorganized activities per week); Sedentary behavior (watching TV or videos more than 2 hours per day); Ever smoking (ever smoked a cigarette, even a few puffs); Ever drinking (ever had a standard drink of alcohol); and High BMI (overweight/obese defined by cut-off points from Cole et al. (2000)).

Table 5
Prevalence (%) of multiple behavioral risk factors in Canadian youth aged 10-17 years, by sex and socioeconomic variables, (2000/2001)[a]

	Males (n = 945,445)						Females (n = 1,042,079)					
	Number of risk factors[b]						Number of risk factors[b]					
	0	1	2	3	4 or 5	*p*-value[c]	0	1	2	3	4 or 5	*p*-value[c]
Family Education						0.0856						0.0001
High school or less	8	19	29	29	15		5	21	27	23	24	
Some post-secondary	12	23	28	21	16		6	23	30	27	14	
Post-secondary degree	13	27	27	22	11		12	28	28	21	11	
Household income						0.2463						0.0001
<$30,000	13	25	21	25	16		4	22	25	26	23	
$30,000-59,999	12	20	27	26	15		9	26	27	22	16	
$60,000-89,999	10	29	28	22	11		8	26	27	22	17	
≥$90,000	14	22	31	20	13		13	25	31	24	7	
Region of residence						0.0215						0.0286
Atlantic	8	28	27	25	12		8	22	24	26	20	
Quebec	10	18	26	27	19		6	26	27	23	18	
Ontario	11	26	29	21	13		9	26	29	25	11	
West	16	24	28	22	10		12	24	28	20	16	

Note: Prevalences were computed using weighted methods and expressed in terms of percentage of Canadian youth aged 10-17 years.
[a] National Longitudinal Survey of Children and Youth, Cycle 4.
[b] Risk factors include: Physical inactivity (engaging in less than four times of organized/unorganized activities per week); Sedentary behavior (watching TV or videos more than 2h per day); Ever smoking (ever smoked a cigarette, even a few puffs); Ever drinking (ever had a standard drink of alcohol); and High BMI (overweight/obese defined by cut-off points from Cole et al. (2000)).
[c] *p*-value from the chi-square test.

Table 6
Clustering pattern of behavioral risk factors in Canadian youth aged 10-17 years, (2000/2001)[a]

No.	P	S	T	A	B		Males			Females		
							Observed %	Expected %	O/E ratio (95% CI)[b]	Observed %	Expected %	O/E ratio (95% CI)[b]
0	-	-	-	-	-		11.96	6.82	**1.75 (1.44-2.06)**	8.99	5.15	**1.75 (1.39-2.10)**
						Total	11.96	6.82	**1.75 (1.44-2.06)**	8.99	5.15	**1.75 (1.39-2.10)**
1	+	-	-	-	-		10.14	7.93	1.28 (1.02-1.54)	14.87	11.28	1.32 (1.10-1.53)
1	-	+	-	-	-		8.01	6.47	1.24 (1.00-1.47)	5.71	3.69	1.54 (1.18-1.91)
1	-	-	+	-	-		0.94	3.59	0.26 (0.14-0.38)	0.82	3.28	0.25 (0.13-0.37)
1	-	-	-	+	-		1.84	4.17	0.44 (0.29-0.59)	1.41	3.76	0.37 (0.21-0.54)
1	-	-	-	-	+		2.90	2.83	1.02 (0.66-1.39)	2.34	1.29	1.82 (1.11-2.52)
						Total	23.83	24.99	0.95 (0.85-1.05)	25.15	23.30	1.08 (0.97-1.19)
2	+	+	-	-	-		8.71	7.53	1.16 (0.90-1.42)	11.45	8.10	**1.41 (1.12-1.71)**
2	+	-	+	-	-		0.88	4.17	0.21 (0.08-0.34)	1.38	7.18	0.19 (0.11-0.27)
2	+	-	-	+	-		3.39	4.84	0.70 (0.43-0.97)	3.52	8.25	0.43 (0.29-0.56)
2	+	-	-	-	+		3.65	3.29	1.11 (0.76-1.46)	3.47	2.83	1.23 (0.85-1.61)
2	-	+	+	-	-		1.42	3.40	0.42 (0.23-0.60)	1.04	2.35	0.44 (0.19-0.69)
2	-	+	-	+	-		1.20	3.96	0.30 (0.17-0.44)	0.60	2.70	0.22 (0.11-0.34)
2	-	+	-	-	+		2.99	2.69	1.11 (0.79-1.44)	1.52	0.93	**1.64 (1.02-2.27)**
2	-	-	+	+	-		4.22	2.19	**1.93 (1.33-2.52)**	4.20	2.40	**1.75 (1.25-2.26)**
2	-	-	+	-	+		0.48	1.49	0.32 (0.05-0.59)	0.29	0.82	0.36 (0.00-0.84)
2	-	-	-	+	+		0.86	1.73	0.50 (0.22-0.78)	0.45	0.94	0.48 (0.05-0.91)
						Total	27.80	35.29	0.79 (0.71-0.86)	27.92	36.50	0.77 (0.69-0.84)

Table 6
Clustering pattern of behavioral risk factors in Canadian youth aged 10-17 years, (2000/2001)[a]

No.	P	S	T	A	B		Males			Females		
							Observed %	Expected %	O/E ratio (95% CI)[b]	Observed %	Expected %	O/E ratio (95% CI)[b]
3	+	+	+	-	-		2.18	3.96	0.55 (0.30-0.80)	1.72	5.15	0.33 (0.20-0.47)
3	+	+	-	+	-		1.63	4.60	0.36 (0.23-0.48)	2.12	5.92	0.36 (0.19-0.53)
3	+	+	-	-	+		4.82	3.12	**1.54 (1.01-2.08)**	3.19	2.03	1.57 (0.93-2.21)
3	+	-	+	+	-		4.74	2.55	**1.86 (1.35-2.38)**	11.70	5.25	**2.23 (1.87-2.58)**
3	+	-	+	-	+		0.46	1.73	0.26 (0.00-0.57)	0.27	1.80	0.15 (0.05-0.26)
3	+	-	-	+	+		1.53	2.01	0.76 (0.44-1.08)	0.60	2.07	0.29 (0.08-0.50)
3	-	+	+	+	-		3.68	2.08	**1.77 (1.27-2.27)**	2.29	1.72	1.33 (0.87-1.79)
3	-	+	+	-	+		1.44	1.41	1.02 (0.21-1.83)	0.21	0.59	0.36 (0.02-0.70)
3	-	+	-	+	+		0.79	1.64	0.48 (0.20-0.76)	0.34	0.68	0.51 (0.00-1.01)
3	-	-	+	+	+		1.82	0.91	**2.00 (1.01-2.98)**	0.51	0.60	0.85 (0.36-1.33)
						Total	23.09	24.01	0.96 (0.84-1.08)	22.95	25.81	0.89 (0.79-0.99)
4	+	+	+	+	-		5.71	2.42	**2.36 (1.74-2.99)**	8.14	3.77	**2.16 (1.73-2.59)**
4	+	+	+	-	+		1.09	1.64	0.66 (0.27-1.05)	0.48	1.29	0.37 (0.17-0.58)
4	+	+	-	+	+		1.11	1.91	0.58 (0.15-1.01)	0.54	1.48	0.36 (0.11-0.62)
4	+	-	+	+	+		1.49	1.06	1.41 (0.84-1.98)	3.40	1.32	**2.58 (1.69-3.47)**
4	-	+	+	+	+		1.70	0.86	**1.97 (1.07-2.86)**	0.60	0.43	1.40 (0.66-2.13)
						Total	11.10	7.89	**1.41 (1.15-1.66)**	13.16	8.29	**1.59 (1.35-1.82)**
5	+	+	+	+	+		2.20	1.00	**2.20 (1.31-3.09)**	1.83	0.94	**1.94 (1.24-2.64)**
						Total	2.20	1.00	**2.20 (1.31-3.09)**	1.83	0.94	**1.94 (1.24-2.64)**

Table 6
Clustering pattern of behavioral risk factors in Canadian youth aged 10-17 years, (2000/2001)[a] (Continued)

P: physical inactivity; S: sedentary behavior; T: ever smoking; A: ever drinking; B: high BMI; +: risk factor present; -: risk factor absent. Note: O/E ratio (95% CI) in bold indicate significant clustering of risk factors.
[a]National Longitudinal Survey of Children and Youth, Cycle 4.
[b]Confidence intervals were computed by bootstrap techniques to account for the complex sampling design of the NLSCY.

5.2 MANUSCRIPT II

CORRELATES OF MUTLIPLE CHRONIC DISEASE BEHAVIORAL RISK FACTORS IN CANADIAN CHILDREN AND ADOLESCENTS

Preamble

Findings of Manuscript I indicated that the five behavioural risk factors considered in this thesis (i.e., physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking and high BMI) cluster more often than expected by chance among Canadian children and adolescents. In addition, nearly two-thirds of Canadian youth were found to have at least two or more behavioural risk factors while only one in ten Canadian youth had none of the five studied risk factors. These results might have implications for the planning of interventions aimed at reducing the burden of multiple health risk behaviours among youth. Manuscript II examines the factors associated with multiple health risk behaviours among youth to inform the development of tailored-specific interventions.

The review of the literature of Section 2.2.5 indicated that very few studies have investigated correlates of multiple chronic disease behavioural risk factors among children and adolescents (Table III, Chapter 2, Section 2.2.5, *p.40*). This is surprising in light of the growing evidence suggesting that multiple behavioural risk factors co-occur among youth, and that the co-occurrence of unhealthy behaviours increases risks of morbidity and mortality later in life (243). Of seven previous studies conducted among youth and reviewed in Section 2.2.5, five were based on non-representative samples (50, 66, 78, 79, 238); in addition, all seven studies lacked sufficient control of several potential factors including psychosocial variables, family characteristics, peer characteristics and environmental variables (30, 281). In fact, prior to the publication of Manuscript II presented herein, little was known regarding the potential associations between parental and peer characteristics and the presence of multiple chronic disease behavioural risk factors among youth. In addition, no other study had investigated the potential relation between school characteristics and multiple unhealthy behaviours among children or adolescents. The present study was therefore conducted to explore several individual, social and school correlates of multiple chronic disease behavioural risk factors in a representative sample of Canadian children and adolescents. Findings of Manuscript II would help public health professionals to develop more efficient early prevention strategies by targeting specific individual, social or school characteristics of Canadian youth.

Correlates of multiple chronic disease behavioral risk factors in Canadian children and adolescents

Running Title:
Multiple Behavioral Risk Factor Correlates in Youth.

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Published in the *American Journal of Epidemiology*

Footnotes

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Abstract

The authors assessed individual, social, and school correlates of multiple chronic disease behavioral risk factors (physical inactivity, sedentary behavior, tobacco smoking, alcohol drinking and high body mass index) in a representative sample of Canadian youth aged 10-15 years (mean = 12.5 years), attending public schools. Cross-sectional data (n = 1,747) from cycle 4 (2000-2001) of the National Longitudinal Survey of Children and Youth were used. Ordinal regression models were constructed to investigate associations between selected covariates and multiple behavioral risk-factor levels (0/1, 2, 3 or 4/5 risk factors). Older age (odds ratio (OR) = 1.95, 95% confidence interval (CI): 1.21, 3.13), caregiver smoking (OR = 1.49, 95% CI: 1.09, 2.03), reporting that most/all of one's peers smoked (OR = 7.31, 95% CI: 4.00, 13.35) or drank alcohol (OR = 3.77, 95% CI: 2.18, 6.53), and living in a lone-parent family (OR = 1.94, 95% CI: 1.31, 2.88) increased the likelihood of having multiple behavioral risk factors. Youth with high self-esteem (OR = 0.92, 95% CI: 0.85, 0.99) and youth from families with post-secondary education (OR = 0.58, 95% CI: 0.41, 0.82) were less likely to have a higher number of risk factors. Although several individual and social characteristics were associated with multiple behavioral risk factors, no school-related correlates emerged. These variables should be considered when planning prevention programs.

Keywords: adolescent; child; chronic disease; health behavior; risk factors

Abbreviations: CI, confidence interval; HBSC, Health Behavior in School-aged Children; NLSCY, National Longitudinal Survey of Children and Youth; OR, odds ratio; PMK, person most knowledgeable.

5.2.1 Introduction

Modifiable lifestyle risk factors, including tobacco smoking, alcohol drinking, physical inactivity, and overweight, are major contributors to the development of chronic diseases such as cardiovascular disease, cancer and type 2 diabetes (1). Though chronic conditions manifest in adulthood, their precursors are often established earlier in life (2). Indeed, childhood and adolescence are critical periods when youth begin to experiment with or engage in unhealthy behaviors, including tobacco smoking, alcohol drinking, and physical inactivity, which often persist into adulthood (3, 4). There is also increasing evidence that many youth engage in multiple risky behaviors (5-8). This is of special concern because the risk of adverse health outcomes increases with increasing number of unhealthy behaviors (9). Furthermore, the occurrence of 2 or more behavioral risk factors reduces life expectancy considerably (10).

The observed increase in harmful health effects associated with multiple behavioral risk factors has led to the emergence of several studies investigating their occurrence and distribution among different populations (8, 11-14). Despite this rising concern, only a few investigators have studied potential correlates of multiple behavioral risk factors, especially among youth (5, 6, 15). Most of these reports have focused on sociodemographic characteristics of youth, with those having multiple risk factors more often being older (6, 7) and living in lone-parent (15) and low-income (5) families. However, socioecological theories postulate that influences external to the child, such as characteristics of the social and school environment, play important roles in constraining or facilitating behaviors (16). Although relations between single behavioral risk factors and social characteristics—such as parents' and peers' health-related behaviors (17-19) and school characteristics (20) and policies (21)—have been documented, few reports have examined the associations between individual, social, and school characteristics and multiple behavioral risk factors in youth. Identifying characteristics of youth with multiple behavioral risk factors could lead to more targeted prevention programs. Hence, we aimed to identify correlates of multiple chronic disease behavioral risk factors in a representative sample of Canadian youth aged 10-15 years who attended public schools.

5.2.2 Materials and methods

Study population

The study population was drawn from the second release (December 2004) of cycle 4 (2000-2001) of the National Longitudinal Survey of Children and Youth (NLSCY). The NLSCY is a large, nationally representative survey of Canadian youth that follows their development and well-being from birth to adulthood. The NLSCY uses a stratified, multistage probability sample design based on an area frame (22). Of 2,826 eligible youth aged 10-15 years, analyses were based on 1,747 subjects with complete data on selected lifestyle variables and covariates. Table 1 shows the characteristics of youth included in the study population and of those excluded because of incomplete data. This study was approved by the Ethics Committee on Research on Human Subjects of the Faculty of Medicine of the University of Montreal.

Data collection

Data were collected for 2 main settings: the household and the school. In the household component, the person most knowledgeable (PMK) about the young person, most often the mother, completed both a parent questionnaire and a child questionnaire. The parent questionnaire gathered information on family socioeconomic status and PMK adverse health behaviors, while the child questionnaire gathered information about the child's social relations, as well as height and weight (for children below age 12 years). For adolescents aged 12 years or more, information regarding youth behaviors and social relations, as well as height and weight, was assessed through an age-specific self-administered youth questionnaire completed at home. The school component consisted of a questionnaire for the teacher and a questionnaire for the school principal that collected information about the school environment and resources.

Measures

Risk factors. Physical inactivity was measured using 2 closed questions adapted from the World Health Organization Health Behavior in School-aged Children (HBSC) survey: 1) "During the past 12 months, how often have you played sports or done physical activities without a coach or an instructor (biking, skateboarding, etc.)?"; 2) "During the past 12

months, how often have you played sports with a coach or an instructor, other than gym class (swimming lessons, baseball, hockey, etc.)?" (23). Response choices included "never," "less than once a week," "1 to 3 times a week" and "4 or more times a week". Because the Canadian *Physical activity Guide for Children and Youth* (24) recommends daily participation in physical activities, we defined physical inactivity as engaging in organized/unorganized activities fewer than 4 times per week. The physical activity questions have been validated by means of the Multistage Fitness Test (25), a field measure of aerobic fitness, and have been shown to have acceptable validity. The intraclass correlation coefficient for the reliability of this measure was 0.74, in the targeted age group (26).

Sedentary behavior was measured using a closed question from the HBSC survey: "On average, about how many hours a day do you watch television or videos?" (23). Because the American Academy of Pediatrics guidelines recommend limiting screen viewing to 2 hours per day or less (27), we defined sedentary behavior as watching television or videos for more than 2 hours per day. The sedentary behavior measure has been validated using a 7-day television viewing diary. Spearman correlation coefficients ranged from 0.36 to 0.54 (28). Test-retest intraclass correlation scores for the reliability of this measure ranged from 0.76 to 0.81, in the targeted age group (23, 28).

Ever smoking was assessed by means of a closed question from the HBSC survey asking youth about their past experience with cigarette smoking (23). We used Health Canada's definition of ever smoking—that is, having ever tried a cigarette, even a few puffs (29). The original measures of cigarette smoking were previously tested and validated in the targeted age group (23, 30).

Ever drinking was measured by means of a closed question from the HBSC survey inquiring about past experience with alcohol consumption (23). Ever drinking was defined as ever having had at least 1 alcoholic drink (31). The original questions on alcohol drinking were previously piloted and validated (23, 30).

High body mass index (weight (kg)/height $(m)^2$) was defined, as being overweight or obese, according to Cole et al.'s (32) international age- and sex-specific body mass index cutoffs for children and adolescents, corresponding to body mass indices of 25 and 30, respectively, at age 18 years.

Independent variables. The independent variables considered in this study were selected from the literature on single and multiple behavioral risk factors and are presented in 3 categories.

Individual characteristics included sex, age (10-11, 12-13, or 14-15 years), anxiety, self-esteem, and academic performance.

Anxiety was measured using 7 questions from the Ontario Child Health Study assessing degree of nervousness, anxiety, and depression (33). Based on the responses, a global score ranging from 0 to 14 was calculated, with higher scores indicating the presence of greater anxiety. This measure has been validated through factor analyses and has been shown to have good construct validity. Its reliability was also satisfactory (Cronbach's $\alpha = 0.76$) in the NLSCY (22).

Self-esteem was measured using 4 items from the General Self-Scale of the Marsh Self-Description Questionnaire (34). Each item was rated on a 5-point scale ranging from 1 (false) to 5 (true). A global score ranging from 0 to 16 was computed, with higher scores indicating positive self-esteem. This measure has been shown to have high convergent validity (factor inter-correlation = 0.76) (35). Its reliability was also satisfactory (Cronbach's $\alpha = 0.73$) in the NLSCY (22).

Academic performance was assessed using a closed question: "How well do you think you are doing in your school work?" (22). Response choices included: "very well", "well", "average", "poor" and "very poor". In the analyses, the response categories "poor" and "very poor" were combined to ensure adequate cell sizes.

Social characteristics included family structure (2 parents, 1 parent); highest level of education attained by the PMK or the spouse (if applicable), defined as high school or less, some postsecondary education, or a post-secondary degree) (36, 37), total annual household income (<Can$30,000, Can$30,000-59,999, Can$60,000-89,999, or ≥Can$90,000) (38); PMK smoking status; PMK drinking status; quality of the parent-child relationship; peer smoking; peer drinking; and quality of peer-child relationships.

PMK smoking status was assessed using a closed question: "At the present time, do you smoke cigarettes daily, occasionally, or not at all?" (22). Subjects reporting that they smoked "daily" or "occasionally" were considered smokers. PMK drinking status was also determined using a closed question: "During the past 12 months, how often did you drink beer, wine, liquor or any other alcoholic beverage?" (22). Subjects reporting that they consumed alcohol at least once a week or more often were considered drinkers (39).

The parent-child relationship was assessed using 7 questions from the Western Australia Child Health Survey evaluating the child's perception of the parents' degree of attention, appreciation, and affection (22). A global score ranging from 0 to 28 was computed, with higher scores indicating better parent-child relationships. The reliability of this scale was excellent (Cronbach's $\alpha = 0.88$) in the NLSCY (22).

Peer smoking and peer drinking were assessed using 2 closed questions: "How many of your close friends smoke cigarettes"? and "How many of your close friends drink alcohol"? (22). Response choices included "none", "a few", "most," and "all". In the analyses, the response categories "most" and "all" were combined to ensure adequate cell sizes.

Peer-child relationships were assessed using 4 items from the Ontario Child Health Study evaluating how well the child feels he/she gets along with his/her peers (33). A global score ranging from 0 to 16 was computed, with higher scores indicating better relationships with peers. The reliability of this scale was satisfactory (Cronbach's $\alpha = 0.78$) in the NLSCY (22).

School characteristics included type of school (public religious, public nonreligious), supportive environment, disciplinary climate, pupils' level of cooperation, and pupils' understanding of school rules.

The presence of a supportive school environment was assessed using a scale constructed from 5 questions that measured the level of positive feedback provided to students and teachers. The internal consistency of this measure was excellent (Cronbach's $\alpha = 0.91$) in the NLSCY (22). A total score ranging from 0 to 20 was computed, with a high score indicating a highly supportive school environment.

The disciplinary climate in the school was determined using a disciplinary climate scale consisting of 4 questions that evaluated the extent of disciplinary policies in the school. A global score ranging from 0 to 16 was computed, with a high score indicating the presence of a strong disciplinary climate in the school. The reliability of this measure was satisfactory (Cronbach's $\alpha = 0.81$) in the NLSCY (22).

Pupils' level of cooperation was measured using a closed question assessing how well students worked together in group activities. Response choices included "never", "rarely", "sometimes", "often," and "always". In the analyses, the first 2 response categories were combined to ensure adequate cell sizes.

Pupils' understanding of school rules was measured with a closed question assessing the extent to which teachers agreed or disagreed that students understood school rules. Response choices included "strongly disagree", "disagree", "neither agree nor disagree", "agree," and "strongly agree". In the analyses, the first 2 response categories were combined to ensure adequate cell sizes.

Statistical analyses

Descriptive statistics were used to characterize the sample and determine the prevalence of behavioral risk factors. Each risk factor was coded as a binary variable (yes = 1, no = 0). We then created a multiple risk factor index by summing individual risk factor scores; the index ranged from 0 to 5 (0 = no risk factors, 5 = all 5 risk factors). The multiple risk factor

index was further stratified into 4 levels based on the overall sample distribution: level I, 0 or 1 risk factor; level II, 2 risk factors; level III, 3 risk factors; and level IV, 4 or 5 risk factors (40). Differences in individual, social and school characteristics between the behavioral risk factor levels were tested using the chi-squared test and analysis of variance. All variables significant at $P \leq 0.20$ were included in the multivariate analyses. Stepwise ordinal logistic regression modeling was used to assess the associations between significant independent variables, as described above, and levels I-IV of the behavioral risk factors. To test the possibilities of interaction by sex and age, we included interaction terms in the models. All variables initially not retained in the multivariate analyses (i.e., $P > 0.20$) were also entered one by one into regression models to identify possible confounders. The results of models with and without possible confounders were the same. Our final multivariate model included adjustment for all potential covariates (i.e., individual, social and school variables). We tested the proportional odds assumption using the score test and found it to be nonsignificant, indicating that the regression model was appropriate for the data.

As per Statistics Canada's guidelines, sampling weights and bootstrap weights were used in all analyses to adjust for sample selection and nonresponse (22). All statistical tests were 2-sided, and the analyses were performed using SAS, version 9.1 (SAS Institute Inc., Cary, North Carolina), and SUDAAN, version 9.01 (RTI International, Research Triangle Park, North Carolina).

5.2.3 Results

Study population

A comparison of youth in the study population and those who were excluded because of incomplete data showed no significant differences between the 2 groups with respect to individual, social, or school characteristics (Table 1). Youth who were excluded were slightly more likely to be from families with a low level of education ($P = 0.04$) and a low income ($P = 0.05$) than those included in the study population.

Youth in the study population were aged 10-15 years (mean = 12.5 years; standard error, 0.1 years). Seventy-two percent of youth reported performing well or very well at school

(Table 1). Eighty-three percent of youth were living with 2 parents, 75% were from families with at least some postsecondary education, and 53% lived in families with an annual household income of Can$60,000 or more. Seventy-four percent of the youth attended a public nonreligious school. Seventy percent often/always worked well together at school, and 83% understood school rules and policies.

Distribution of single and multiple chronic disease behavioral risk factors

Fifty-seven percent of these Canadian youth were physically inactive (Table 2). Fifty percent of them engaged in sedentary behavior, 26% were ever smokers, 24% were ever drinkers, and 23% were overweight/obese. Females were significantly more physically inactive than males ($P < 0.001$), while males were significantly more likely to be overweight/obese than females ($P = 0.002$).

Twenty-six percent of the youth had 3 or more risk factors (Table 2). Thirty percent had 2 risk factors, 32% had 1 risk factor, and 12% had none of the 5 behavioral risk factors. The prevalence of multiple behavioral risk factors did not differ by sex ($P = 0.08$).

Correlates of multiple chronic disease behavioral risk factors

Univariate analyses. Among the individual characteristics, being aged 12-13 years, being aged 14-15 years, and having higher anxiety scores were associated with the presence of multiple behavioral risk factors (Table 3). In contrast, youth with high self-esteem and youth with high academic performance were less likely to have multiple behavioral risk factors.

Of the 9 selected social characteristics, 7 were related to multiple behavioral risk factors in the univariate analyses. Specifically, living in a lone-parent family, PMK smoking, and having reported that a few or most/all of one's peers smoked or drank increased the odds of having a higher number of risk factors. In contrast, youth from families with a postsecondary education and a household income of Can$90,000 or more, as well as youth who perceived a good parental relationship, were less likely to have a higher risk factor level. None of the school-related characteristics were associated with multiple behavioral risk factors.

Multivariate analyses. In the final multivariate ordinal logistic regression model, 7 variables were found to be associated with multiple behavioral risk factors (Table 4). Among the individual characteristics, age and self-esteem were associated with behavioral risk factor levels. Specifically, youth aged 14-15 years were 1.95 times more likely to have multiple risk factors than those aged 10-11 years (95% confidence interval (CI): 1.21, 3.13). Self-esteem was inversely associated with risk factor levels (odds ratio (OR) = 0.92, 95% CI: 0.85, 0.99). Among the social characteristics, PMK smoking (OR = 1.49, 95% CI: 1.09, 2.03), having reported that a few or most/all of one's peers smoked (a few—OR = 2.23, 95% CI: 1.44, 3.47; most/all—OR = 7.31, 95% CI: 4.00, 13.35) or drank (a few—OR= 2.03, 95% CI: 1.28, 3.20; most/all—OR = 3.77, 95% CI: 2.18, 6.53), and living in a lone-parent family (OR = 1.94, 95% CI: 1.31, 2.88) increased the likelihood of having multiple behavioral risk factors. Youth from families with postsecondary education (OR = 0.58, 95% CI: 0.41, 0.82) were less likely to have a higher number of risk factors.

5.2.4 Discussion

This study assessed correlates of multiple chronic disease behavioral risk factors in Canadian youth aged 10-15 years. Among the individual characteristics considered in this study, older age, particularly being aged 14-15 years, was associated with the presence of multiple behavioral risk factors. This finding is consistent with 3 studies conducted among American youth aged 10-16 years (6, 7, 15), as well as studies conducted in the United Kingdom (13) and Spain (14), where youth aged 16-24 years were more likely to have multiple behavioral risk factors than older adults. These data suggest that adolescence is a critical period in which youth begin to engage in multiple adverse health behaviors. Our results also suggest that youth with high self-esteem are less likely to have multiple behavioral risk factors. Indeed, several studies have shown that high self-esteem is associated with regular physical activity (41), lower smoking rates (42), and lower body weight (43) among youth. High self-esteem is believed to contribute to overall health by mediating the relation between stress and psychological adjustment (44), and by enhancing one's capacity to cope with behavioral problems and interpersonal relationships (45).

The associations observed in this study between family and peer characteristics and multiple behavioral risk factors highlight the importance of the social environment in determining health behaviors (16, 46). First, living in a lone-parent family was associated with increased odds of having multiple behavioral risk factors. This finding corroborates results of 4 studies in which youth from lone-parent families were found more often to be physically inactive (47), to be obese (48), to smoke cigarettes (49), and to watch television (50) than youth living with 2 parents. Indeed, it has been shown that youth living in lone-parent families experience less parental support and bonding, which are important factors in adolescent development and may protect against unhealthy behaviors (51).

Youth from families with a postsecondary education were less likely to have a higher number of risk factors. We also found a univariate association between high household income and multiple behavioral risk factors which disappeared in multivariate analyses. This is in agreement with at least 2 other studies (14, 52) in which education rather than income was found to be associated with multiple behavioral risk factors. This may be because education is a more stable and more accurate indicator of socioeconomic status than income (53). Since youth from families with a low educational level may be less informed about lifestyle risk factors and their potential consequences, special prevention efforts may be required for low socioeconomic status families.

Youth whose caregivers reported being smokers were more likely to have multiple behavioral risk factors. In addition, having friends who smoked cigarettes or drank alcohol was strongly associated with the presence of multiple risk factors. This is consistent with existing evidence from a study of multiple lifestyle risk factors among American youth (6) and several studies investigating the associations between parental (or peer) risk factors and youth risk factors, such as physical inactivity (47), cigarette smoking (17), alcohol drinking (54), and obesity (55). These findings emphasize the influence of parents and peers as role models and in providing social support for the behavior and for shaping outcome expectations among youth, as suggested by the social cognitive theory (46).

Although the school environment may have an impact on specific lifestyle risk factors (56), none of the school characteristics considered in this study were associated with multiple

behavioral risk factors. To our knowledge, no study has yet assessed the potential relations between school characteristics and multiple behavioral risk factors in either children or adolescents. This makes it difficult to compare the results of this study with those of other relevant reports. Nevertheless, several studies have linked characteristics of the school climate, such as attitudes about discipline (57), school health promotion policies, and school rules (58) with cigarette smoking (21) and alcohol consumption (58) and have linked school physical education programs with physical inactivity (59) and obesity (60). In contrast, other studies have found weak associations (61) or no associations (62) between school characteristics and single lifestyle risk factors. These divergent findings emphasize the need for more research on the effect of school characteristics on behavioral risk factors among youth.

Limitations of this study include its cross-sectional nature, which precludes our making causal claims. Some measurement bias may have occurred. First, the physical activity questions did not measure the intensity or duration of activities. Although objective measures are preferred, the questions used herein were previously validated using a field measure of aerobic fitness (26). Second, our measure of sedentary behavior included only television and video viewing. Because other types of sedentary activities (such as computer use or computer games) were not assessed, the extent of sedentary behavior in our study may have been underestimated. Some investigators may not view body mass index as a behavioral risk factor; however, overweight is a risk factor for several chronic diseases, and its immediate determinants include several behaviors, including an imbalance between dietary energy intake and energy expenditure through physical activity. Furthermore, since we did not have information on dietary habits, the inclusion of body mass index may have partially reflected dietary practices. Height and weight were self-reported in the NLSCY. Although self-reported measures are strongly correlated with objective measures, females tend to underestimate their weight and males tend to overestimate their height, which may have led to underestimation of body mass index (63). Other behaviors were also self-reported and hence subject to social desirability and recall bias.

Selection bias may have occurred in this study mainly due to nonparticipation or the exclusion of subjects because of missing data. However, several methods were used to

account for possible nonresponse errors, including weight adjustments to minimize the effect of errors due to total nonresponse. For partial nonresponse, characteristics of participants were compared with those of nonparticipants. Although no significant differences emerged from this comparison, differences between participants and nonparticipants beyond the reported characteristics and hence the potential influence of unmeasured variables on observed relations remain unknown. In addition, residual confounding remains possible, since other factors not included in the study could partly explain the observed associations between selected variables and multiple behavioral risk factors.

In this study, we aggregated the 5 risk factors to create a multiple risk factor index. To create this index, we dichotomized the behavioral risk factor values. Dichotomization may lead to loss of information and reduced statistical power. However, because the behaviors were measured on different scales, dichotomization using standard national/international cutoff points was deemed appropriate. Finally, because of operational constraints, including a heavier-than-anticipated workload, increased costs, and the respondent burden experienced during the data collection, the school component of the NLSCY included only youth attending public schools. Therefore, the findings of this study may apply only to youth attending public schools.

The present study contributes new knowledge about correlates of multiple chronic disease behavioral risk factors among children and adolescents. In particular, the findings point to a range of individual and social variables which could be used as potential targets in lifestyle intervention strategies aimed at changing multiple behavioral risk factors among youth. Though more research is needed to determine the effectiveness of multiple behavioral interventions in primary prevention settings (64), this study provides evidence that older youth, those with low self-esteem, those living in a lone-parent family or a family with low education, those whose parents/friends smoke cigarettes, and those whose friends drink alcohol may be the most at risk and might require special attention.

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Table 1. Characteristics of the study population and of subjects excluded because of incomplete data, National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001

	Study Population, %[a] (*n* = 1,747)	**Subjects Excluded, %[a] (*n* = 1,079)**	***P* Value[b]**
Individual characteristics			
Sex			0.06
Female	51	48	
Age, years			0.21
10-11	36	33	
12-13	32	33	
14-15	32	34	
Anxiety, mean (SE)[c]	3.4 (0.1)	3.5 (0.1)	0.22
Self-esteem, mean (SE)[d]	13.3 (0.1)	13.2 (0.1)	0.37
Academic performance			0.27
Poor/Very poor	4	5	
Average	24	26	
Well	41	39	
Very well	31	30	
Social characteristics			
Family structure			0.07
2 parents	83	82	
1 parent	17	18	
Education			0.04
High school or less	25	29	
Some postsecondary education	22	24	
Postsecondary degree	53	47	
Annual household income, Canadian dollars			0.05
<30,000	13	16	
30,000-59,999	34	33	
60,000-89,999	29	28	
≥90,000	24	23	

Table 1. Characteristics of the study population and of subjects excluded because of incomplete data, National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001 (continued)

	Study Population, %[a] (*n* = 1,747)	Subjects Excluded, %[a] (*n* = 1,079)	*P* Value[b]
PMK smoking status			0.63
Tobacco smoker	28	28	
PMK drinking status			0.26
Alcohol drinker	32	30	
Parent-child relationship, mean (SE)[e]	21.4 (0.2)	21.4 (0.2)	0.94
Peer smoking			0.34
No peers	71	73	
A few peers	22	19	
Most/all peers	7	8	
Peer drinking			0.35
No peers	67	68	
A few peers	21	19	
Most/all peers	12	13	
Peer-child relationship, mean (SE)[f]	13.3 (0.1)	13.1 (0.1)	0.15
School characteristics			
Type of school			0.91
Public religious	26	27	
Public nonreligious	74	73	
Supportive environment, mean (SE)[g]	14.2 (0.1)	14.0 (0.2)	0.62
Disciplinary climate, mean (SE)[h]	10.6 (0.1)	10.5 (0.1)	0.64
Pupils work well together			0.85
Never/rarely	5	5	
Sometimes	25	26	
Often	55	54	
Always	15	15	
Pupils understand school rules			0.22
Strongly disagree/disagree	5	5	
Neither agree nor disagree	12	11	
Agree	63	63	
Strongly agree	20	21	

Table 1. Characteristics of the study population and of subjects excluded because of incomplete data, National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001 (continued)

Abbreviations: PMK, person most knowledgeable; SE, standard error.
[a] Weighted percentage expressed in terms of the proportion of Canadian youth aged 10-15 years.
[b] *P* value from a chi-squared test or *t* test. All tests were 2-sided.
[c] Anxiety was assessed using a global score ranging from 0 to 14, with higher scores indicating the presence of greater anxiety.
[d] Self-esteem was assessed using a global score ranging from 0 to 16, with higher scores indicating positive self-esteem.
[e] The parent-child relationship was assessed using a global score ranging from 0 to 28, with higher scores indicating a better relationship between parents and child.
[f] Peer-child relationships were assessed using a global score ranging from 0 to 16, with higher scores indicating a better relationship between the child and his/her peers.
[g] Supportive environment was assessed using a global score ranging from 0 to 20, with a higher score indicating a highly supportive school environment.
[h] Disciplinary climate was assessed using a global score ranging from 0 to 16, with a higher score indicating the presence of a strong disciplinary climate in the school.

Table 2. Distribution of single and multiple chronic disease behavioral risk factors in Canadian youth aged 10-15 years, National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001

	Total (n[a] = 612,000)		Males (n[a] = 301,024)		Females (n[a] = 310,976)	
	%[b]	95% CI[c]	%[b]	95% CI[c]	%[b]	95% CI[c]
Risk Factors						
Physical inactivity[d]	57	53, 60	50	45, 55	63	58, 68
Sedentary behavior[e]	50	47, 54	54	48, 59	47	42, 51
Ever smoking[f]	26	23, 29	23	19, 27	28	25, 32
Ever drinking[g]	24	21, 27	22	18, 26	26	22, 29
High body mass index[h]	23	20, 26	28	23, 32	19	16, 22
No. of risk factors						
0	12	10, 15	15	11, 19	10	7, 13
1	32	29, 35	28	24, 33	36	32, 41
2	30	27, 33	33	29, 39	27	23, 31
3	17	14, 19	16	13, 20	17	14, 20
4	8	7, 10	7	5, 9	9	7, 12
5	1	1, 2[i]	1	1, 2[i]	1	1, 2[i]

Abbreviation: CI, confidence interval.
[a] Weighted frequencies were computed using sampling weights supplied by Statistics Canada and expressed in terms of the number of Canadian youth aged 10-15 years.
[b] Weighted percentage expressed in terms of the proportion of Canadian youth aged 10-15 years.
[c] CIs were computed using bootstrap techniques to account for the complex sampling design of the National Longitudinal Survey of Children and Youth.
[d] Engaging in organized/unorganized activities fewer than 4 times per week.
[e] Watching television or videos for more than 2 hours per day.
[f] Ever smoked a cigarette, even a few puffs.
[g] Ever having a standard drink of alcohol.
[h] Being overweight/obese, as defined by the cutoff points of Cole et al. (32).
[i] Rounded 95% CIs; the actual 95% CIs were from left to right: 0.7, 1.7; 0.6, 1.9; and 0.6, 2.1, respectively.

Table 3. Individual, social, and school characteristics of Canadian youth aged 10–15 years according to behavioral risk factor level, National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001

	Behavioral risk factor levels[a], %[b]				Odds Ratio[d]	95% Confidence Interval[e]	*P* Value[f]
	Level I (n^c = 270,779)	Level II (n^c = 183,871)	Level III (n^c = 100,456)	Level IV (n^c = 56,894)			
Individual characteristics							
Sex							0.09
Female	46	26	17	11	1	Referent	
Male	42	34	16	8	1.02	0.81, 1.28	
Age, years							<0.001
10-11	59	33	7	1	1	Referent	
12-13	49	31	13	7	1.66	1.20, 2.28	
14-15	23	26	30	21	6.57	4.71, 9.17	
Anxiety, mean (SE)[g]	3.1 (0.2)	3.3 (0.2)	3.8 (0.3)	4.2 (0.4)	1.10	1.04, 1.16	0.01
Self-esteem, mean (SE)[h]	13.9 (0.1)	13.2 (0.2)	12.7 (0.2)	12.4 (0.3)	0.84	0.79, 0.89	<0.001
Academic Performance							<0.001
Poor/Very poor	31	37	19	13	1	Referent	
Average	28	28	23	21	1.44	0.70, 2.98	
Well	47	31	17	5	0.54	0.26, 1.12	
Very well	55	29	11	5	0.38	0.18, 0.80	

Table 3. Individual, social, and school characteristics of Canadian youth aged 10–15 years according to behavioral risk factor level, National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001 (Continued)

	Behavioral risk factor levels[a], %[b]				Odds Ratio[d]	95% Confidence Interval[e]	*P* Value[f]
	Level I (n^c = 270,779)	Level II (n^c = 183,871)	Level III (n^c = 100,456)	Level IV (n^c = 56,894)			
Social characteristics							
Family structure							0.004
2 parents	47	29	16	8	1	Referent	
1 parent	32	35	18	15	1.71	1.25, 2.33	
Education							0.001
High school or less	34	34	16	16	1	Referent	
Some postsecondary education	39	32	20	9	0.79	0.56, 1.12	
Postsecondary degree	51	27	15	7	0.51	0.38, 0.69	
Annual household income, Canadian dollars							0.01
<30,000	39	29	18	14	1	Referent	
30,000-59,999	42	28	20	10	0.87	0.55, 1.38	
60,000-89,999	41	35	16	8	0.81	0.51, 1.27	
≥90,000	55	27	10	8	0.50	0.30, 0.83	
PMK smoking status							<0.001
Nonsmoker	48	30	14	8	1	Referent	
Smoker	34	30	22	14	1.89	1.44, 2.47	

Table 3. Individual, social, and school characteristics of Canadian youth aged 10–15 years according to behavioral risk factor level, National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001 (Continued)

	Behavioral risk factor levels[a], %[b]				Odds Ratio[d]	95% Confidence Interval[e]	*P* Value[f]
	Level I (n^c = 270,779)	Level II (n^c = 183,871)	Level III (n^c = 100,456)	Level IV (n^c = 56,894)			
PMK drinking status							0.25
Nondrinker	42	31	18	9	1	Referent	
Drinker	49	28	14	9	0.78	0.59, 1.05	
Parent-child relationship, mean (SE)[i]	22.9 (0.2)	21.2 (0.3)	19.5 (0.5)	18.7 (0.6)	0.90	0.88, 0.92	<0.001
Peer smoking							<0.001
No peers	55	33	10	2	1	Referent	
A few peers	25	28	27	20	5.15	3.60,7.37	
Most/all peers	1	6	46	47	34.21	22.08, 53.00	
Peer drinking							<0.001
No peers	56	32	11	1	1	Referent	
A few peers	26	29	25	20	5.08	3.50, 7.36	
Most/all peers	7	22	35	36	16.75	11.46, 24.48	
Peer-child relationship, mean (SE)[j]	13.4 (0.2)	13.2 (0.2)	13.2 (0.2)	13.6 (0.3)	1.00	0.95, 1.05	0.67
School characteristics							
Type of school							0.13
Public religious	50	28	12	10	1	Referent	
Public non-religious	42	31	18	9	1.27	0.93, 1.74	

Table 3. Individual, social, and school characteristics of Canadian youth aged 10–15 years according to behavioral risk factor level, National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001 (Continued)

	Behavioral risk factor levels[a], %[b]				Odds Ratio[d]	95% Confidence Interval[e]	*P* Value[f]
	Level I (n^c = 270,779)	Level II (n^c = 183,871)	Level III (n^c = 100,456)	Level IV (n^c = 56,894)			
Supportive environment, mean (SE)[k]	14.4 (0.2)	14.5 (0.3)	13.9 (0.3)	13.7 (0.5)	0.98	0.94, 1.01	0.17
Disciplinary climate, mean (SE)[l]	10.8 (0.2)	10.6 (0.3)	10.4 (0.3)	10.5 (0.3)	0.98	0.94, 1.02	0.69
Pupils worked well together							0.49
Never/rarely	40	34	18	8	1	Referent	
Sometimes	43	31	16	10	0.95	0.55, 1.64	
Often	48	28	16	8	0.80	0.46, 1.38	
Always	35	33	18	14	1.33	0.71, 2.47	
Pupils understood school rules							0.41
Strongly disagree/disagree	38	36	18	8	1	Referent	
Neither agree nor disagree	41	27	20	12	1.07	0.58, 1.97	
Agree	43	30	17	10	0.92	0.58, 1.46	
Strongly agree	51	30	12	7	0.64	0.39, 1.05	

Table 3. Individual, social, and school characteristics of Canadian youth aged 10–15 years according to behavioral risk factor level, National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001 (Continued)

Abbreviations: PMK, person most knowledgeable; SE, standard error.
[a] Behavioral risk factor levels: Level I, 0 or 1 risk factor; level II, 2 risk factors; level III, 3 risk factors; level IV, 4 or 5 risk factors.
[b] Weighted percentage expressed in terms of the proportion of Canadian youth aged 10–15 years.
[c] Weighted frequencies were computed using sampling weights supplied by Statistics Canada and expressed in terms of the number of Canadian youth aged 10-15 years.
[d] Cumulative odds ratio from univariate ordinal logistic regression analyses.
[e] Confidence interval from univariate ordinal logistic regression analyses.
[f] *P* value from a chi-squared test or analyses of variance. All tests were 2-sided.
[g] Anxiety was assessed using a global score ranging from 0 to 14, with higher scores indicating the presence of greater anxiety.
[h] Self-esteem was assessed using a global score ranging from 0 to 16, with higher scores indicating positive self-esteem.
[i] The parent-child relationship was assessed using a global score ranging from 0 to 28, with higher scores indicating a better relationship between parents and child.
[j] Peer-child relationships were assessed using a global score ranging from 0 to 16, with higher scores indicating a better relationship between the child and his/her peers.
[k] Supportive environment was assessed using a global score ranging from 0 to 20, with a higher score indicating a highly supportive school environment.
[l] Disciplinary climate was assessed using a global score ranging from 0 to 16, with a higher score indicating the presence of a strong disciplinary climate in the school.

Table 4. Independent correlates of multiple behavioral risk factors in Canadian youth aged 10–15 years (n = 1,747), National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001[a]

	Cumulative Odds Ratio[b]	95% Confidence interval[c]
Individual characteristics		
Sex		
Female	1	Referent
Male	1.23	0.93, 1.62
Age, years		
10-11	1	Referent
12-13	1.06	0.74, 1.52
14-15	1.95	1.21, 3.13
Anxiety[d]	1.03	0.97, 1.09
Self-esteem[e]	0.92	0.85, 0.99
Social characteristics		
Family structure		
2 parents	1	Referent
1 Parent	1.94	1.31, 2.88
Education		
High school or less	1	Referent
Some postsecondary education	0.92	0.63, 1.35
Postsecondary degree	0.58	0.41, 0.82
PMK smoking status		
Nonsmoker	1	Referent
Smoker	1.49	1.09, 2.03
Peer smoking		
No peers	1	Referent
A few peers	2.23	1.44, 3.47
Most/all peers	7.31	4.00, 13.35
Peer drinking		
No peers	1	Referent
A few peers	2.03	1.28, 3.20
Most/all peers	3.77	2.18, 6.53

Table 4. Independent correlates of multiple behavioral risk factors in Canadian youth aged 10–15 years (n = 1,747), National Longitudinal Survey of Children and Youth, Cycle 4, 2000–2001[a] (Continued)

[a] Behavioral risk factor level was the dependent variable.
[b]Cumulative odds ratio from a multivariate ordinal logistic regression model with adjustment for all covariates.
[c] Confidence intervals derived from multivariate ordinal logistic regression analysis.
[d] Anxiety was assessed using a global score ranging from 0 to 14, with higher scores indicating the presence of greater anxiety.
[e] Self-esteem was assessed using a global score ranging from 0 to 16, with higher scores indicating positive self-esteem.

5.3 MANUSCRIPT III

INDIVIDUAL AND SOCIAL DETERMINANTS OF MUTLIPLE BEHAVIORAL RISK FACTORS AMONG YOUTH

Preamble

Findings of Manuscript II indicated that several individual and social characteristics were related to multiple unhealthy behaviours among youth. In particular, older youth, those with low self-esteem, those living in low SES and lone-parent families as well as those whose parents or friends smoked cigarettes were found to be at greatest risk of having multiple behavioural risk factors. However, none of the school-related variables were found to be correlated with multiple health risk behaviours. These results may have important implications for the development of tailored-specific multiple-behaviour interventions among youth. Manuscript III examines more closely the longitudinal associations of selected individual and social characteristics and the occurrence of multiple behavioural risk factors among a cohort of young Canadians.

The review of the literature of Section 2.2 indicated the absence of any longitudinal studies of multiple behavioural risk factors for chronic diseases. Previous cross-sectional studies provided only a snapshot of the potential associations between the variables under investigation and the occurrence of multiple behavioural risk factors (Table III, Chapter 2, Section 2.2.5, *p.40*). In addition, prior to Manuscript III presented herein, studies of multiple chronic disease behavioural risk factors did not use a theoretical framework applicable to multiple behaviours. Thus, Manuscript III aims to address the aforementioned gaps in the literature by examining the longitudinal influence of a set of conceptually-related individual/social distal and ultimate variables on the rate of occurrence of multiple chronic disease behavioural risk factors among Canadian youth. Results of this novel investigation would be valuable particularly because of its prospective design as well as its use of a unique theoretical framework to guide the study of potential determinants of multiple behavioural risk factors in children and adolescents. Findings of this study would help to understand the contribution of distal and ultimate variables on the rate of co-occurrence of behavioural risk factors which may be important when developing multiple-behaviour intervention strategies.

Individual and social determinants of multiple behavioral risk factors among youth

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Footnotes

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Abstract

Behavioral risk factors are known to co-occur among youth and increase risks of morbidity and mortality later in life. However, little is known about potential determinants of multiple behavioral risk factors, particularly among youth. Previous studies have been cross-sectional and carried out atheoretically. This study assessed the longitudinal influence of a set of conceptually-related individual and social variables on the rate of occurrence of multiple behavioral risk factors (including physical inactivity, sedentary behavior, tobacco smoking, alcohol drinking, and high body mass index) in a representative sample of Canadian youth aged 10-11 years at baseline. Multiple behavioral risk factors were assessed using a multiple risk factor score ranging from 0 (no risk factor) to 5 (all 5 risk factors). Prospective data from Cycle 4 (2000-2001), Cycle 5 (2002-2003) and Cycle 6 (2004-2005) of the National Longitudinal Survey of Children and Youth were used (n = 1135). Longitudinal Poisson models within a generalized estimating equations framework were constructed to assess the associations between selected covariates and the rate of occurrence of multiple behavioral risk factors. Social distal variables (social variables situated at an intermediate distance from behaviors such as parental/peer behaviours) (Log-likelihood ratio (LLR) = 187.86, degrees of freedom (DF) = 8, $p < 0.001$) and individual distal variables (individual variables situated at an intermediate distance from behaviors such as sense of self) (LLR = 76.94, DF = 4, $p < 0.001$) significantly influenced the rate of multiple risk factor score. Specifically, caregiver smoking (rate ratio (RR) = 1.11; 95% confidence interval (CI): 1.05, 1.16), reporting that most/all of one's peers drank alcohol (RR = 1.23; 95% CI: 1.14, 1.34) or smoked cigarettes (RR = 1.41; 95% CI: 1.28, 1.55) increased the likelihood of having multiple behavioral risk factors. Self-esteem (RR = 0.98; 95% CI: 0.98, 0.99) was inversely related to the rate of multiple risk factor score. These results suggest targeting individual distal and social distal factors in prevention programs of multiple health risk behaviors among youth.

Keywords: Adolescent, Child, Health behavior, Risk factors, Longitudinal studies

5.3.1 Introduction

Behavioral risk factors including tobacco smoking (Milton, Woods, Dugdill, Porcellato, & Springett, 2008), alcohol drinking (Dube, Miller, Brown, Giles, Felitti, Dong et al., 2006), physical inactivity (Kimm, Glynn, Kriska, Fitzgerald, Aaron, Similo et al., 2000), sedentary behavior (Sisson, Church, Martin, Tudor-Locke, Smith, Bouchard et al., 2009) and overweight (Herman, Craig, Gauvin, & Katzmarzyk, 2009) originate in childhood and adolescence, and cause significant negative health and social consequences throughout the life course (Kasa-Vubu, Lee, Rosenthal, Singer, & Halter, 2005; Mokdad, Marks, Stroup, & Gerberding, 2004; Must & Strauss, 1999). A growing body of evidence also suggests that behavioral risk factors co-occur among youth (Alamian & Paradis, 2009a; Driskell, Dyment, Mauriello, Castle, & Sherman, 2008; Lawlor, O'Callaghan, Mamun, Williams, Bor, & Najman, 2005; Plotnikoff, Karunamuni, Spence, Storey, Forbes, Raine et al., 2009), and that their combinations yield greater risks for chronic diseases than the sum of their individual independent effects (Breslow & Enstrom, 1980; Meng, Maskarinec, Lee, & Kolonel, 1999). Although much is known about single behavioral risk factors and their determinants, less is know about potential determinants of multiple behavioral risk factors, particularly among youth. Previous studies of multiple behavioral risk factors for chronic diseases have been cross-sectional; these studies have identified a few individual characteristics, such as being female (Plotnikoff et al., 2009; Sanchez, Norman, Sallis, Calfas, Cella, & Patrick, 2007), older age (Alamian & Paradis, 2009b; Mistry, McCarthy, Yancey, Lu, & Patel, 2009; Sanchez et al., 2007), depression (Mistry et al., 2009; Pronk, Anderson, Crain, Martinson, O'Connor, Sherwood et al., 2004), and low self-esteem (Alamian & Paradis, 2009b), as well as social characteristics, including living in a lone-parent family (Alamian & Paradis, 2009b; Mistry et al., 2009), low parental education (Alamian & Paradis, 2009b) and having parents (Alamian & Paradis, 2009b; Sanchez et al., 2007) who engage in unhealthy lifestyles as correlates of multiple behavioral risk factors among youth. While these findings are important, there is a need for prospective cohort studies to obtain more conclusive evidence.

Identifying factors that contribute to the co-occurrence of health behaviors should be based on a theory applicable to multiple behaviors (Noar, Chabot, & Zimmerman, 2008).

However, studies of multiple behavioral risk factors have not consistently used a sound theoretical framework (Pronk et al., 2004; Raitakari, Leino, Rakkonen, Porkka, Taimela, Rasanen et al., 1995; Rosal, Ockene, Ma, Hebert, Merriam, Matthews et al., 2001; Sanchez et al., 2007). In addition, several theories of health behavior, including the Health Belief Model (Becker, 1974), the Theory of Reasoned Action (Ajzen & Fishbein, 1980) and the Theory of Planned Behavior (Ajzen, 1991) are considered behavior-specific, particularly because these theories suggest that each behavior has its own set of determinants, commonly referred to as proximal factors, since they are most directly linked to a specific behavior (Flay, 2002; Petraitis, Flay, & Miller, 1995); these include attitudinal, social normative beliefs, self-efficacy and decisional/intentional factors (Noar et al., 2008).

Other prominent theories including the Social Learning Theory (Bandura, 1986), the Problem Behavior Theory (Jessor, 1991), the Bronfenbrenner's Ecological Systems Theory (Bronfenbrenner, 1977) and the Theory of Triadic Influence (Flay & Petraitis, 1994) address more distal determinants of behaviors such as self-esteem, social bonding with others as well as characteristics of the social environment. However, of all integrative theories, the Theory of Triadic Influence seems to be the most comprehensive one because not only it addresses determinants of different types, such as individual and social characteristics, but it also attempts to explain how different types of variables influence multiple behaviors (Flay & Petraitis, 1994; Petraitis et al., 1995). According to this framework, individual and social factors influence health behaviors through 3 tiers of constructs, represented by several proximal, distal and ultimate variables. Flay & Petraitis (1994) argue that contrary to proximal variables which are behavior-specific, distal and ultimate variables are likely to have more generalizable effects and thus, they are thought to be predictive of multiple behaviors (Flay, 2002). Indeed, in an empirical study of 702 American high school students, one's intentions to use drugs, a proximal determinant, was found to be a stronger predictor of substance abuse compared to prosocial coping, a distal determinant, as well as compared to depression, an ultimate determinant (Sussman, Dent, & Leu, 2001). According to the Theory of Triadic Influence, ultimate variables are the most general set of principles that transcend specific behaviors, and they comprise factors considered almost unchangeable such as inherited dispositions, or difficult to change such as personality traits and characteristics of the social environment (e.g., family

socioeconomic status) (Flay & Petraitis, 1994). Distal variables are more immediate determinants of behavior, and they comprise factors considered easier to modify, such as one's general knowledge, social relations and sense of self (Flay & Petraitis, 1994).

To our knowledge, no study has yet investigated the longitudinal relationship between a large set of distal and ultimate variables and the occurrence of multiple behavioral risk factors for chronic diseases among youth. The present study is therefore guided by the Theory of Triadic Influence and uses prospective data to examine the longitudinal influence of selected individual/social distal and ultimate variables on the rate of occurrence of multiple behavioral risk factors in a representative sample of Canadian youth.

5.3.2 Methods

Study population

The National Longitudinal Survey of Children and Youth (NLSCY) is a large representative survey of Canadian children that follows their development and well-being from birth to adulthood. The NLSCY uses a stratified, multistage probability sample design with data collection occurring at two-year intervals (Statistics Canada and Human Resources Development Canada, 2006). The present analysis was based on a weighted longitudinal sample of Canadian youth aged 10-11 years in Cycle 4 (2000-2001), 12-13 years in Cycle 5 (2002-2003) and 14-15 years in Cycle 6 (2004-2005) of the NLSCY. Of 2081 youth aged 10-11 years in Cycle 4, 1838 (88.3%) responded to Cycle 5. Of these 1838 youth, 1649 (79.2% of the original sample) responded to Cycle 6. Of these 1649 youth, analyses were based on 1135 youth (68.9%) with complete data on lifestyle variables and covariates. Table 1 presents the characteristics of youth included in the study population and of those lost to follow-up or excluded because of incomplete data. This study received approval from the Ethics Committee on Research on Human Subjects of the Faculty of Medicine of the University of Montreal.

Data collection

The person most knowledgeable (PMK) about the child, most often the mother, completed a parent questionnaire and a child questionnaire. The parent questionnaire gathered

information on family socioeconomic status and PMK adverse health behaviors, while the child questionnaire was used to obtain the child's height and weight (for children below age 12 years). Adolescents aged 12 years or more self-reported their height and weight. Information regarding youth behaviors and social relations was assessed through age-specific self-administered questionnaires for children aged 10 years or more.

Measures

Risk factors

Physical inactivity was measured in Cycles 4, 5 and 6 using 2 closed questions adapted from the World Health Organization Health Behavior in School-aged Children (HBSC) survey: 1) "During the past 12 months, how often have you played sports or done physical activities without a coach or an instructor (biking, skateboarding, etc.)?"; 2) "During the past 12 months, how often have you played sports with a coach or an instructor, other than gym class (swimming lessons, baseball, hockey, etc.)?"(Wold, Aaro, & Smith, 1993). Response choices included "never", "less than once a week", "1 to 3 times a week" and "4 or more times a week". Because the Canadian *Physical activity Guides for Children and Youth* (Public Health Agency of Canada and Canadian Society for Exercise Physiology, 2002) recommend daily participation in physical activities, we defined physical inactivity as engaging in organized/unorganized activities fewer than 4 times per week. The physical activity questions have been validated by means of the Multistage Fitness Test (Leger & Lambert, 1982), and have been shown to have acceptable validity. The intra-class correlation coefficient for the reliability of this measure was 0.74, in the targeted age groups (Booth, Okely, Chey, & Bauman, 2001).

Sedentary behavior was measured in Cycles 4, 5 and 6 using a closed question from the HBSC survey: "On average, about how many hours a day do you watch television or videos?" (Wold et al., 1993). Because the American Academy of Pediatrics guidelines recommend limiting screen viewing to 2 hours per day or less (Committee on Public Education, 2001), we defined sedentary behavior as watching television or videos for more than 2 hours per day. The sedentary behavior measure has been validated using a 7-day television viewing diary. Spearman correlation coefficients ranged from 0.36 to 0.54 (Vereecken, Todd, Roberts, Mulvihill, & Maes, 2006). Test-retest intra-class correlation

scores for the reliability of this measure ranged from 0.76 to 0.81 (Vereecken et al., 2006; Wold et al., 1993).

Ever smoking was defined as having ever tried a cigarette, even a few puffs (Health Canada, 2005), in Cycles 4, 5 and 6. Ever drinking was defined as ever having had at least 1 alcoholic drink (Pica, 2005), in Cycles 4, 5 and 6.

High body mass index (weight (kg)/height $(m)^2$) was defined as overweight or obese, in all three cycles, according to Cole et al.'s (2000) international age- and sex-specific body mass index cutoffs for children and adolescents, corresponding to body mass indices of 25 and 30, respectively, at age 18 years (Cole, Bellizzi, Flegal, & Dietz, 2000).

Independent variables

The independent variables were selected on the basis of factors previously identified as correlates of several health risk behaviors in the literature and comprised four groups of variables: individual ultimate, individual distal, social ultimate and social distal variables, as per our framework based on the Theory of Triadic Influence (Figure 1).

Individual ultimate variables referred to demographic and personality factors such as sex, age at baseline (10-11 years in Cycle 4), and anxiety. Anxiety was assessed, in Cycles 4 through 6, using 7 questions from the Ontario Child Health Study assessing degree of nervousness, anxiety and depression (Statistics Canada, 1987). Based on the responses, a global score ranging from 0 to 14 was calculated, with higher scores indicating the presence of greater anxiety. This measure has been validated through factor analyses and has been shown to have good construct validity. Its reliability was also satisfactory (Cronbach's α = 0.76) in the NLSCY (Statistics Canada and Human Resources Development Canada, 2003).

Individual distal variables referred to child's sense of self and achievement such as self-esteem and academic performance. Self-esteem was measured, in Cycles 4 through 6, using 4 items from the General Self-Scale of the Marsh Self-Description Questionnaire (Marsh & O'Neil, 1984). A global score ranging from 0 to 16 was computed, with higher scores indicating positive self-esteem. This measure has been shown to have high convergent

validity (factor intercorrelation = 0.76) (Gilman, Laughlin, & Huebner, 1999). Its reliability was also satisfactory (Cronbach's $\alpha = 0.73$) in the NLSCY (Statistics Canada and Human Resources Development Canada, 2003). Academic performance was assessed, in Cycles 4 through 6, using a closed question: "How well do you think you are doing in your school work?" (Statistics Canada and Human Resources Development Canada, 2003). Response choices included: "very well", "well", "average", "poor" and "very poor". In the analyses, the response categories "poor" and "very poor" were combined to ensure adequate cell sizes.

Social ultimate variables referred to characteristics of the child's immediate social environment such as family structure (2 parents, 1 parent); PMK education defined as low education (<12 years of schooling) and high education (12 years of schooling or more) (Johnson, Cohen, Smailes, Kasen, & Brook, 2002; Kraywinkel, Heidrich, Heuschmann, Wagner, & Berger, 2007); and total annual household income (<Can$30,000, Can$30,000-59,999, Can$60,000-89,999 or ≥Can$90,000) (Ross & Roberts, 1997), assessed in all cycles.

Social distal variables pertained to child's social relations with others as well as behaviors of influential role models. PMK smoking was defined as smoking "daily" or "occasionally", in all cycles (Statistics Canada and Human Resources Development Canada, 2003). PMK drinking was defined as consuming alcohol at least once a week or more, in all cycles (Ding, Eigenbrodt, Mosley, Hutchinson, Folsom, Harris et al., 2004; Statistics Canada and Human Resources Development Canada, 2003). The parent-child relationship was assessed, in Cycles 4 through 6, using 7 questions from the Western Australia Child Health Survey evaluating the child's perception of the parents' degree of attention, appreciation and affection (Statistics Canada and Human Resources Development Canada, 2003). A global score ranging from 0 to 28 was computed, with higher scores indicating better parent-child relationships. The reliability of this scale was excellent (Cronbach's $\alpha = 0.88$) in the NLSCY (Statistics Canada and Human Resources Development Canada, 2003). Peer smoking and peer drinking were assessed, in Cycles 4 through 6, using 2 closed questions: "How many of your close friends smoke cigarettes"? and "How many of your close friends drink alcohol?" (Statistics Canada and Human

Resources Development Canada, 2003). Response choices included "none", "a few", "most" and "all". In the analyses, response categories "most" and "all" were combined to ensure adequate cell sizes. Peer-child relationships were assessed, in Cycles 4 through 6, using 4 items from the Ontario Child Health Study evaluating how well the child feels he/she gets along with his/her peers (Statistics Canada, 1987). A global score ranging from 0 to 16 was computed, with higher scores indicating better relationships with peers. The reliability of this scale was satisfactory (Cronbach's $\alpha = 0.78$) in the NLSCY (Statistics Canada and Human Resources Development Canada, 2003).

Statistical analyses

Baseline characteristics of the study cohort were described using the chi-squared test and t-test. The prevalence and 95% confidence intervals (CIs) of single and multiple behavioral risk factors by sex were estimated using sampling and bootstrap weights (Statistics Canada and Human Resources Development Canada, 2006). Single behavioral risk factors were coded as binary variables (yes = 1, no = 0). A multiple risk factor score ranging from 0 to 5 (0 = no risk factor, 5 = all 5 risk factors) was then created by summing individual risk factor scores (Sanchez et al., 2007). Sex-specific trends in the percentage of single and multiple behavioral risk factors were examined using polynomial trend tests (Fisher & Yates, 1938). The distribution of multiple behavioral risk factors by selected categorical covariates was described by estimating the mean number of behavioral risk factors by selected covariates across time. The distribution of multiple behavioral risk factors by selected continuous covariates was described by estimating correlations between the multiple risk factor score and selected covariates across time. We used longitudinal Poisson regression, within a generalized estimating equations (GEE) framework, to assess the longitudinal associations between selected individual distal/ultimate and social distal/ultimate variables and the multiple risk factor score. GEE models account for non-independence of repeated observations and provide robust parameter and standard error estimates (Zeger & Liang, 1986). In addition, the longitudinal Poisson regression models provided direct estimates of rate ratios for the associations between selected covariates and the multiple risk factor score along the entire follow-up period (Twisk, 2006). First, a set of longitudinal Poisson models was constructed to assess the direct influence of individual ultimate and individual distal variables on the rate of multiple risk factor score, as per our

conceptual framework. We then built a second set of longitudinal Poisson models to assess the direct influence of social ultimate and social distal variables on the rate of multiple risk factor score, as per our conceptual framework. A final set of multivariate models was then constructed to assess the independent longitudinal influence of individual distal/ultimate and social distal/ultimate variables on the rate of multiple risk factor score. The log-likelihood ratio statistic was used to assess the contribution of each block of variables to the models (Twisk, 2006). Interaction terms were added to the models to test possible interactions between each covariate and sex as well as between each covariate and time. None of the interactions were found to be significant. Our final multivariate model included adjustment for all potential covariates (i.e., individual and social variables). Sampling and bootstrap weights were used in all analyses to adjust for sample selection and nonresponse (Statistics Canada and Human Resources Development Canada, 2006). All statistical analyses were performed using SAS, version 9.1 (SAS Institute Inc., Carry, North Carolina), and SUDAAN, version 9.01 (RTI International, Research Triangle Park, North Carolina).

5.3.3 Results

Descriptive findings

Analyses comparing baseline characteristics of youth in the study cohort to those of subjects lost during the follow-up or excluded because of incomplete data showed some differences between the two groups (Table 1). In particular, compared to youth in the study cohort, subjects who were lost were more often males ($p = 0.03$), had lower self-esteem ($p < 0.001$) and greater anxiety ($p = 0.02$). Subjects lost were also more likely to be from lower socioeconomic status families than youth in the study cohort. With respect to lifestyle risk factors, there were no significant differences between the two groups except for ever drinking ($p = 0.005$) and high body mass index ($p = 0.004$), which were higher among youth who were lost to follow-up or excluded from the analysis.

At baseline (2000-2001), 50% of youth in the study cohort, aged 10-11 years, were physically inactive, 42% engaged in sedentary behavior, 6% were ever smokers, 6% were ever drinkers and 23% were overweight or obese (Table 2). For males and females,

respectively, the prevalence of physical inactivity increased by 18% ($p < 0.001$) and 15% ($p = 0.002$), the prevalence of ever smoking increased by 25% ($p < 0.001$) and 23% ($p < 0.001$) and the prevalence of ever drinking increased by 41% ($p < 0.001$) and 43% ($p < 0.001$) over time. Overall, females were more physically inactive than males ($p < 0.02$), while males tended to engage in more sedentary behavior than females especially at the age of 14-15 years ($p = 0.002$).

About 28% of youth at baseline aged 10-11 years had none of the five behavioral risk factors, 41% had 1 risk factor, 24% had 2 risk factors and 7% had 3 or more risk factors (Table 2). By the age of 14-15 years, only 8% of these youth had no risk factor, 29% had 1 risk factor, 32% had 2 risk factors and 31% had 3 risk factors or more. There were no significant differences between males and females in the percentage of multiple behavioral risk factors at baseline or across the follow-up period.

For the entire sample, the mean number of behavioral risk factors increased by 82%, from 1.1 (95% confidence interval (CI): 1.1, 1.2) in 2000-2001 to 2.0 (95% CI: 1.9, 2.1) in 2004-2005 (Table 3). Youth with poor/very poor academic performance as well as youth from families with a low annual household income were more likely to have higher risk factor scores, especially when they were aged 14-15 years. Across the entire follow-up period, the mean number of risk factors was higher among youth whose caregiver was a smoker and youth who reported having peers who smoked cigarettes or peers who drank alcohol. Lower self-esteem and poorer parent-child relationships were found to be correlated with higher risk factor scores across time (Table 4). In contrast, youth having better relationships with their peers tended to have lower risk factor scores.

Longitudinal Poisson regression models

In the regression analyses, individual and social variables were grouped into 4 blocks of conceptually-related variables to determine their influence on the rate of multiple risk factor score. Longitudinal Poisson models assessing the direct influence of individual distal and individual ultimate variables on the rate of multiple risk factor score showed that both individual distal and individual ultimate variables contributed to the model (Table 5). However, individual distal variables (Table 5, Model 2, Log-likelihood ratio (LLR) =

76.94; degrees of freedom (DF) = 4; $p < 0.001$) contributed more to the model than individual ultimate variables (Table 5, Model 1, LLR = 35.9; DF = 3; $p < 0.001$). Analyses assessing the direct influence of social distal and social ultimate variables on the rate of multiple risk factor score also showed that both social distal and social ultimate variables contributed to the model (Table 6). However, social distal variables (Table 6, Model 2; LLR = 254.07; DF = 8; $p < 0.001$) contributed much more to the model than social ultimate variables (Table 6, Model 1; LLR = 22.03; DF = 5; $p < 0.001$).

Adjusted longitudinal Poisson models (i.e., including both individual and social variables) led to similar results as in the models investigating the direct influence of individual distal/ ultimate and social distal/ultimate variables (i.e., Table 5 and Table 6). In particular, social distal variables (Table 7, Model 3, LLR = 187.86; DF = 8; $p < 0.001$), individual distal variables (Table 7, Model 1, LLR = 76.94; DF = 4; $p < 0.001$) and individual ultimate variables (Table 7, Model 2, LLR = 9.34; DF = 3; $p < 0.05$) significantly contributed to the rate of multiple risk factor score. Social ultimate variables (Table 7, Model 4, LLR = 10.93; DF = 5; $p = 0.05$) contributed minimally to the overall rate of occurrence of multiple behavioural risk factors. Among the variables under investigation, PMK smoking (rate ratio (RR) = 1.11; 95% CI: 1.05, 1.16), having reported that a few or most/all of one's peers drank alcohol (a few–RR = 1.12; 95% CI: 1.04, 1.19; most/all–RR = 1.23; 95% CI: 1.14, 1.34) or smoked cigarettes (a few–RR = 1.14; 95% CI: 1.07, 1.22; most/all–RR = 1.41; 95% CI: 1.28, 1.55) were associated with an increased rate of multiple risk factor score (Table 7, Model 4). Higher self-esteem (RR = 0.98; 95% CI: 0.98-0.99) was related to a decline in the rate of multiple risk factor score (Table 7, Model 4).

5.3.4 Discussion

This study assessed the potential longitudinal influence of selected conceptually-related variables on the rate of occurrence of multiple behavioral risk factors in a representative cohort of Canadian youth aged 10-11 years at baseline. Our results first indicate a 23% increase in the percentage of youth with 3 or more risk factors and a 20% decline in the percentage of youth with 0 risk factors across the follow-up period. These age-related trends in the prevalence of multiple behavioral risk factors have been also observed in a

small number of recent cross-sectional studies conducted among children and adolescents (Alamian & Paradis, 2009a; Driskell et al., 2008; Plotnikoff et al., 2009). However, this study is the first to report longitudinal trends in the percentage of multiple behavioral risk factors for chronic diseases among youth.

To our knowledge, this is the first prospective cohort study to identify potential factors contributing to the occurrence of multiple unhealthy behaviors for chronic diseases in a representative sample of youth. Our multivariate analyses showed that individual distal, social distal and individual ultimate variables significantly influenced the rate of multiple risk factor score among youth. However, overall, the log-likelihood ratio statistic indicated that distal variables, particularly social distal factors, contributed more to the longitudinal Poisson model. This finding is important because distal variables tend to be easier to modify through effective interventions compared to ultimate variables (Flay & Petraitis, 1994). We are aware of no other study assessing the influence of blocks of distal or ultimate variables on the rate of occurrence of multiple behavioral risk factors in either youth or adults. Hence, it is difficult to compare results of this study with other relevant reports. Nevertheless, our results corroborate findings of a recent cross-sectional study, also based on the Theory of Triadic Influence, where friends' substance use, a social distal variable, was found to be significantly correlated with both alcohol use and cigarette smoking in two convenience samples of Russian and American high school students in grade 10. In contrast, depression, an individual ultimate variable, was not correlated with either behaviors in the same study (Gunning, Sussman, Rohrbach, Kniazev, & Masagutov, 2009).

Of the social distal variables considered in our study, caregiver smoking was linked to an 11% increase in the rate of multiple risk factor score among youth. Adverse parental health behaviors have been associated with unhealthy behaviors of their children in only two cross-sectional studies of multiple behavioral risk factors for chronic diseases (Alamian & Paradis, 2009b; Sanchez et al., 2007), and several longitudinal studies of single risk factors including cigarette smoking (Brook, Pahl, & Ning, 2006) and obesity (Burke, Beilin, & Dunbar, 2001; Valerio, D'Amico, Adinolfi, Munciguerra, D'Amico, & Franzese, 2006). Two other social distal variables including having peers who smoked cigarettes and having

peers who drank alcohol increased the likelihood of having multiple risk factors by up to 41% and 23%, respectively. These findings are consistent with results of other longitudinal studies where having friends who consumed alcohol (Van Der Vorst, Vermulst, Meeus, Dekovic, & Engels, 2009) or peers who smoked cigarettes (Ali & Dwyer, 2009) were associated with the occurrence of single behavioral risk factors among adolescents. However, we are aware of no other longitudinal study investigating the potential association between peer unhealthy lifestyles and the rate of occurrence of multiple behavioral risk factors for chronic diseases among youth. As suggested by several social bonding theories, parents and peers are perceived as role models, and are thought to affect youth health behaviors by shaping perceived social norms to adopt or maintain health behaviors (Flay & Petraitis, 1994). Hence, these findings suggest the importance of interventions in the child's immediate social environment to support multiple-behavior change.

Among the individual distal variables studied, higher self-esteem was associated with a decline in the rate of multiple risk factor score among youth. This finding is concordant with results of a longitudinal study where lower self-esteem was linked to single health-compromising behaviors including cigarette smoking, alcohol use and problem behavior among adolescents aged 15 years (McGee & Williams, 2000). It has been suggested that individuals with stronger self-esteem tend to place greater value on self-determination and possess a strong will to modify, regulate or restrain their health behaviors (Flay & Petraitis, 1994).

The social ultimate variables considered in this study contributed minimally to the overall rate of multiple risk factor score. The evidence from the literature regarding the association of socioeconomic status and multiple behavioral risk factors has been mixed. For example, in a recent cross-sectional study, family structure and parental education, but not household income, were correlated with multiple chronic disease behavioral risk factors among Canadian youth aged 10-15 years (Alamian & Paradis, 2009b). An Australian study found a cross-sectional association between family income and the co-occurrence of behavioral risk factors among adolescents aged 14 years (Lawlor et al., 2005), while two American cross-sectional studies did not find an association between parental level of education and the

presence of multiple behavioral risk factors in children and adolescents aged 11 to 15 years (Mistry et al., 2009; Sanchez et al., 2007). These divergent findings may be partly attributed to the use of different definitions for parental education and household income across these studies. For example, Lawlor et al. (2005) defined family/household income as a dichotomous variable using a threshold of ≤$25,999 *versus* ≥$25,999; Alamian et al. (2009b) defined household income using the same categories as in this study while parental education was defined as having a high school degree or less, some postsecondary education or a postsecondary degree; Sanchez et al. (2007) defined the highest household education as less than high school through associate degree, bachelor's degree, and graduate or professional degree; and Mistry et al. (2009) defined parental education as less than high school, high school, or more than high school. Apart from these differences, it is important to note that previous studies were all cross-sectional and thus the observed associations between socioeconomic indicators and multiple behavioural risk factors were only seen among "static" populations. Hence, there is a need for additional research on the association of socioeconomic status and the occurrence of multiple behavioural risk factors among youth using prospective longitudinal designs.

This study comprised some limitations. First, some selection bias may have occurred due to loss to follow-up or the exclusion of subjects because of incomplete data. In particular, children included in the study population were more likely to be from higher income, higher educational level, and two-parent families compared to children lost to follow-up or excluded because of missing data. Also, children who were excluded from the analysis were more likely to be ever drinkers and overweight/obese, compared to children included in the study. Thus, the sample may have been selected towards youth from more affluent and healthy families. Since single and multiple behavioural risk factors tend to be more prevalent among youth of low socioeconomic status (Alamian & Paradis, 2009a), the observed associations may be even stronger in reality because of the limited inclusion of youth from less affluent families. Also, although our final multivariate models adjusted for all covariates, it remains possible that additional unaccounted factors explain our findings. Health behaviors were self-reported in the NLSCY and thus subject to recall and social desirability biases. Moreover, the measure of body mass index was based on parent-reported height and weight for children aged 10-11 years, and self-reported height and

weight for adolescents aged 12 years or over in the NLSCY. It has been suggested that when parents report their children's height and weight, overweight and obesity may be overestimated, mainly because parents tend to underestimate their children's height (Shields, 2006). In contrast, self-reported height and weight tend to yield slightly lower estimates of body mass index compared to objective measures (Shields, 2006).

Despite these limitations, this study had several important strengths including its use of a nationally representative sample of children, the use of an integrative theoretical framework to guide the study of determinants of multiple behavioral risk factors and its longitudinal design. This study also contributed new knowledge about determinants of multiple behavioral risk factors. In particular, this longitudinal investigation showed that individual distal and social distal variables exerted a stronger influence on the rate of co-occurrence of behavioral risk factors among youth, compared to ultimate variables. Specifically, parental and peer unhealthy lifestyles were associated with an elevated rate of multiple risk factor score. Youth with stronger sense of self over time were less likely to have multiple behavioral risk factors. These results support the use of distal variables as potential targets in public health interventions aiming to curb the increased rate of occurrence of multiple behavioral risk factors among youth. Further research is needed to evaluate the influence of ultimate variables, often considered the root causes of behaviors and hard to modify (Flay & Petraitis, 1994), on multiple behavioral risk factors among children and adolescents.

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Conflict of interest statement

The authors declare that there are no conflicts of interest.

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Table 1 Comparison of baseline characteristics of youth in the study cohort and of subjects lost to follow-up or excluded because of incomplete data, National Longitudinal Survey of Children and Youth, 2000-2005

	Study cohort, %[a] (n = 1135)	Subjects lost, %[a] (n = 946)	*p* value[b]
Individual characteristics			
Ultimate			
Sex			0.03
Female	51	46	
Age, years			0.26
10	50	53	
11	50	47	
Anxiety, mean (SE)[c]	3.4 (0.1)	3.7 (0.1)	0.02
Distal			
Self-esteem, mean (SE)[d]	13.7 (0.1)	13.3 (0.1)	<0.001
Academic performance			0.56
Poor/very poor	2	1	
Average	18	19	
Well	46	46	
Very well	34	34	
Social characteristics			
Ultimate			
Family structure			0.005
2 parents	84	79	
1 parent	16	21	
PMK Education			<0.001
Low (<12 years of school)	19	28	
High (≥12 years of school)	81	73	

Table 1 Comparison of baseline characteristics of youth in the study cohort and of subjects lost to follow-up or excluded because of incomplete data, National Longitudinal Survey of Children and Youth, 2000-2005 (continued)

	Study cohort, %[a] (n = 1135)	Subjects lost, %[a] (n = 946)	*p* value[b]
Annual household income, CAN $			<0.001
<30,000	15	21	
30,000-59,999	31	40	
60,000-89,999	31	23	
≥90,000	23	16	
Distal			
PMK smoking status			0.03
Tobacco smoker	26	30	
PMK drinking status			0.61
Alcohol drinker	28	27	
Parent-child relationship, mean (SE)[e]	22.9 (0.2)	22.3 (0.2)	0.005
Peer smoking			0.94
No peers	95	96	
A few peers	4	3	
Most/all peers	1	1	
Peer drinking			0.05
No peers	97	95	
A few peers	2	4	
Most/all peers	1	1	
Peer-child relationship, mean (SE)[f]	12.8 (0.1)	12.8 (0.1)	0.86
Lifestyle risk factors			
Physical inactivity[g]	50	55	0.09
Sedentary behaviour[h]	42	46	0.11
Ever smoking[i]	6	7	0.60
Ever drinking[j]	6	10	0.005
High body mass index[k]	23	30	0.004

Table 1 Comparison of baseline characteristics of youth in the study cohort and of subjects lost to follow-up or excluded because of incomplete data, National Longitudinal Survey of Children and Youth, 2000-2005 (continued)

Note. CAN = Canadian; PMK = person most knowledgeable; SE = standard error.
[a] Weighted percentage expressed in terms of the proportion of Canadian youth aged 10-11 years in Cycle 4 and followed biannually until Cycle 6 of the National Longitudinal Survey of Children and Youth.
[b] *p*-value from a chi-squared test or *t* test.
[c] Anxiety was assessed using a global score ranging from 0 to 14, with higher scores indicating the presence of greater anxiety.
[d] Self-esteem was assessed using a global score ranging from 0 to 16, with higher scores indicating positive self-esteem.
[e] The parent-child relationship was assessed using a global score ranging from 0 to 28, with higher scores indicating a better relationship between parents and child.
[f] Peer-child relationships were assessed using a global score ranging from 0 to 16, with higher scores indicating a better relationship between the child and his/her peers.
[g] Engaging in organized/unorganized physical activities fewer than 4 times per week.
[h] Watching television or videos for more than 2 hours per day.
[i] Ever smoking a cigarette, even a few puffs.
[j] Ever having a standard drink of alcohol.
[k] Being overweight/obese, as defined by cutoff points of Cole et al. (2000)

Table 2
Prevalence of single and multiple behavioral risk factors, by sex, at each time point, National Longitudinal Survey of Children and Youth, 2000-2005

		Time 1[a] (n = 1135)		Time 2[a] (n = 1135)		Time 3[a] (n = 1135)		*p*
		%[b]	95% CI[c]	%[b]	95% CI[c]	%[b]	95% CI[c]	for trend[d]
Risk factors								
Physical inactivity[e]	Male	43	36, 49	44	37, 50	61	55, 67	<0.001
	Female	57	50, 64	59	52, 65	72	65, 78	0.002
Sedentary behavior[f]	Male	49	42, 55	43	37, 50	50	44, 56	0.78
	Female	36	30, 42	36	30, 43	36	29, 42	0.99
Ever smoking[g]	Male	6	3, 11	12	9, 17	31	26, 38	<0.001
	Female	6	3, 10	15	11, 20	29	24, 36	<0.001
Ever drinking[h]	Male	7	4, 11	16	12, 22	48	41, 54	<0.001
	Female	5	3, 9	14	10, 18	48	41, 55	<0.001
High body mass index[i]	Male	24	19, 30	23	17, 30	18	13, 23	0.07
	Female	22	17, 29	15	11, 19	14	10, 18	0.05
No. of Risk factors								
0	Male	31	25, 37	21	17, 26	6	4, 11	<0.001
	Female	26	21, 32	22	17, 28	10	6, 16	<0.001
1	Male	38	32, 44	40	34, 47	27	22, 32	0.003
	Female	44	37, 50	39	33, 47	31	24, 38	0.01
2	Male	24	19, 30	27	22, 33	37	31, 43	0.002
	Female	24	19, 29	25	18, 32	27	21, 34	0.42
3-5	Male	7	5, 11	12	8, 16	30	25, 36	<0.001
	Female	6	4, 11	14	10, 19	32	27, 38	<0.001

Table 2
Prevalence of single and multiple behavioral risk factors, by sex, at each time point, National Longitudinal Survey of Children and Youth, 2000-2005 (continued)

Note. CI = confidence interval.
[a] Time 1 refers to Cycle 4 (2000-2001), Time 2 refers to Cycle 5 (2002-2003) and Time 3 refers to Cycle 6 (2004-2005) of the National Longitudinal Survey of Children and Youth.
[b] Weighted percentage expressed in terms of the proportion of Canadian youth aged 10-11 years in Cycle 4 and followed biannually until Cycle 6 of the National Longitudinal Survey of Children and Youth.
[c] CIs were computed using bootstrap weights to account for the complex sampling design of the National Longitudinal Survey of Children and Youth.
[d] *p*-value for linear trend in the percentages of single and multiple behavioral risk factors over time obtained from the polynomial trend test.
[e] Engaging in organized/unorganized physical activities fewer than 4 times per week.
[f] Watching television or videos for more than 2 hours per day.
[g] Ever smoking a cigarette, even a few puffs.
[h] Ever having a standard drink of alcohol.
[i] Being overweight/obese, as defined by cutoff points of Cole et al. (2000).

Table 3
Mean number of behavioral risk factors by selected categorical study covariates at each time point, National Longitudinal Survey of Children and Youth, 2000-2005

	Time 1[a] (n = 1135)			Time 2[a] (n = 1135)			Time 3[a] (n = 1135)		
	%[b]	Mean[c]	95% CI[d]	%[b]	Mean[c]	95% CI[d]	%[b]	Mean[c]	95% CI[d]
Total	100	1.1	1.0, 1.2	100	1.3	1.2, 1.4	100	2.0	1.9, 2.1
Individual characteristics									
Sex									
Female	51	1.1	1.0, 1.2	51	1.4	1.2, 1.5	51	2.0	1.8, 2.2
Male	49	1.1	1.0, 1.2	49	1.3	1.2, 1.4	49	2.0	1.9, 2.2
p-value[e]		0.69			0.64			0.62	
Age, years									
10	50	1.1	1.0, 1.2	50	1.2	1.1, 1.3	50	1.8	1.7, 1.9
11	50	1.1	1.0, 1.2	50	1.5	1.3, 1.6	50	2.2	2.0, 2.4
p-value[e]		0.90			0.008			0.002	
Academic Performance									
Poor/very poor	2	1.3	0.8, 1.8	4	1.8	1.3, 2.2	8	2.7	2.5, 3.0
Average	18	1.2	1.0, 1.4	24	1.5	1.4, 1.7	31	2.2	2.0, 2.4
Well	46	1.0	0.9, 1.2	42	1.3	1.1, 1.4	38	1.9	1.7, 2.1
Very well	34	1.2	1.0, 1.3	30	1.2	1.1, 1.4	23	1.7	1.5, 1.8
p-value[e]		0.42			0.006			0.001	

Table 3
Mean number of behavioral risk factors by selected categorical study covariates at each time point, National Longitudinal Survey of Children and Youth, 2000-2005 (continued)

	Time 1[a] (n = 1135)			Time 2[a] (n = 1135)			Time 3[a] (n = 1135)		
	%[b]	Mean[c]	95% CI[d]	%[b]	Mean[c]	95% CI[d]	%[b]	Mean[c]	95% CI[d]
Social characteristics									
Family structure									
2 parents	84	1.1	1.0, 1.2	83	1.3	1.2, 1.4	80	1.9	1.8, 2.1
1 parent	16	1.1	0.8, 1.3	17	1.5	1.3, 1.7	20	2.3	1.9, 2.6
p-value[e]		0.59			0.17			0.08	
PMK Education									
Low (<12 years of school)	19	1.2	1.0, 1.5	14	1.5	1.2, 1.8	15	2.2	1.9, 2.5
High (≥l2 years of school)	81	1.1	1.0, 1.2	86	1.3	1.2, 1.4	85	2.0	1.8, 2.1
p-value[e]		0.32			0.36			0.11	
Annual household income									
<CAN$30,000	15	1.0	0.8, 1.2	12	1.3	1.0, 1.6	11	2.4	2.1, 2.8
CAN$30,000-59,999	31	1.1	0.9, 1.3	28	1.4	1.2, 1.5	24	1.9	1.6, 2.1
CAN$60,000-89,999	31	1.2	1.1, 1.4	30	1.4	1.3, 1.6	33	2.0	1.8, 2.3
>CAN$90,000	23	1.0	0.8, 1.2	30	1.3	1.1, 1.4	32	1.9	1.7, 2.1
p-value[e]		0.13			0.63			0.05	
PMK smoking status									
Nonsmoker	74	1.0	0.9, 1.1	79	1.3	1.2, 1.4	79	1.9	1.8, 2.0
Smoker	26	1.4	1.2, 1.6	21	1.6	1.4, 1.8	21	2.4	2.2, 2.6
p-value[e]		0.001			0.003			0.001	

Table 3
Mean number of behavioral risk factors by selected categorical study covariates at each time point, National Longitudinal Survey of Children and Youth, 2000-2005 (continued)

	Time 1[a] (n = 1135)			Time 2[a] (n = 1135)			Time 3[a] (n = 1135)		
	%[b]	Mean[c]	95% CI[d]	%[b]	Mean[c]	95% CI[d]	%[b]	Mean[c]	95% CI[d]
PMK drinking status									
Nondrinker	72	1.1	1.0, 1.2	70	1.3	1.2, 1.4	66	2.0	1.8, 2.1
Drinker	28	1.1	1.0, 1.3	30	1.4	1.2, 1.6	34	2.1	1.9, 2.3
p-value[e]		0.88			0.37			0.33	
Peer smoking									
No peers	95	1.1	0.9, 1.1	84	1.2	1.1, 1.3	59	1.6	1.5, 1.7
A few peers	4	1.8	1.4, 2.2	13	2.0	1.8, 2.2	31	2.3	2.0, 2.5
Most/all peers	1	3.9	1.0, 4.4	3	2.6	1.8, 3.3	10	3.5	3.2, 3.7
p-value[e]		0.001			0.001			0.001	
Peer drinking									
No peers	97	1.1	1.0, 1.1	81	1.2	1.1, 1.3	31	1.4	1.3, 1.6
A few peers	2	1.7	1.2, 2.1	15	1.9	1.7, 2.2	38	1.9	1.7, 2.1
Most/all peers	1	3.8	0.4, 4.2	4	2.3	1.7, 2.8	31	2.7	2.5, 2.9
p-value[e]		0.02			0.001			0.001	

Note. CAN = Canadian; CI = confidence interval; PMK = person most knowledgeable.
[a] Time 1 refers to Cycle 4 (2000-2001), Time 2 refers to Cycle 5 (2002-2003) and Time 3 refers to Cycle 6 (2004-2005) of the National Longitudinal Survey of Children and Youth.
[b] Weighted percentage (distribution) of selected categorical study covariates.
[c] Weighted mean number of behavioral risk factors by selected categorical study covariates.
[d] CIs were computed using bootstrap weights to account for the complex sampling design of the National Longitudinal Survey of Children and Youth.
[e] *p*-value for differences in the mean number of behavioral risk factors by selected categorical study covariates obtained from *t* test or analyses of variance.

Table 4
Correlations between the multiple behavioral risk factor score and selected continuous study covariates at each time point, National Longitudinal Survey of Children and Youth, 2000-2005

	Time 1[a] (n = 1135)			Time 2[a] (n = 1135)			Time 3[a] (n = 1135)		
	Mean (SE)[b]	Corr.[c]	*p*-value[d]	Mean (SE)[b]	Corr.[c]	*p*-value[d]	Mean (SE)[b]	Corr.[c]	*p*-value[d]
Individual characteristics									
Anxiety[e]	3.4 (0.1)	0.14	0.001	3.2 (0.1)	0.16	0.001	3.4 (0.1)	0.09	0.002
Self-esteem[f]	13.7 (0.1)	-0.08	0.007	13.1 (0.1)	-0.26	0.001	12.7 (0.1)	-0.25	0.001
Social characteristics									
Parent-child relationship[g]	22.9 (0.2)	-0.08	0.01	22.4 (0.2)	-0.22	0.001	21.0 (0.2)	-0.22	0.001
Peer-child relationship[h]	12.8 (0.1)	-0.03	0.39	13.2 (0.1)	-0.10	0.001	13.3 (0.1)	-0.12	0.001

Note. Corr. = correlation; SE = standard error.
[a] Time 1 refers to Cycle 4 (2000-2001), Time 2 refers to Cycle 5 (2002-2003) and Time 3 refers to Cycle 6 (2004-2005) of the National Longitudinal Survey of Children and Youth.
[b] Weighted means and their standard errors for selected continuous study covariates.
[c] Weighted correlations between the multiple behavioral risk factor score and selected continuous study covariates.
[d] *p*-value for correlations between the multiple behavioral risk factor score and selected continuous study covariates.
[e] Anxiety was assessed using a global score ranging from 0 to 14, with higher scores indicating the presence of greater anxiety.
[f] Self-esteem was assessed using a global score ranging from 0 to 16, with higher scores indicating positive self-esteem.
[g] The parent-child relationship was assessed using a global score ranging from 0 to 28, with higher scores indicating a better relationship between parents and child.
[h] Peer-child relationships were assessed using a global score ranging from 0 to 16, with higher scores indicating a better relationship between the child and his/her peers.

Table 5
Rate ratios (95% CIs) for the longitudinal associations between selected individual distal and individual ultimate variables and multiple behavioral risk factors (n = 1135), National Longitudinal Survey of Children and Youth, 2000-2005[a]

	Rate ratio[b]	95% CI[c]		Rate ratio[b]	95% CI[c]		Rate ratio[b]	95% CI[c]
	Model 1			**Model 2**			**Model 3**	
	Individual characteristics			**Individual characteristics**			**Individual characteristics**	
	Ultimate			**Distal**			**Ultimate**	
	Sex			Self-esteem[f]	0.97	0.97, 0.98	Sex	
	Female	1	Referent	Academic performance			Female	1	Referent
	Male	1.01	0.96, 1.06	Poor/very poor	1	Referent	Male	1.00	0.95, 1.05
	Age, years[d]			Average	0.93	0.85, 1.01	Age, years[d]		
	10	1	Referent	Well	0.88	0.80, 0.96	10	1	Referent
	11	1.08	1.02, 1.15	Very well	0.88	0.79, 0.97	11	1.07	1.01, 1.13
	Anxiety[e]	1.02	1.01, 1.03	Time			Anxiety[e]	1.01	1.00, 1.02
	Time			1 (Cycle 4)	1	Referent	**Distal**		
	1 (Cycle 4)	1	Referent	2 (Cycle 5)	1.08	1.03, 1.14	Self-esteem[f]	0.98	0.97, 0.98
	2 (Cycle 5)	1.11	1.06, 1.17	3 (Cycle 6)	1.37	1.30, 1.44	Academic performance		
	3 (Cycle 6)	1.43	1.35, 1.50	Intercept	3.38	3.00, 3.81	Poor/very poor	1	Referent
	Intercept	1.89	1.78, 2.01				Average	0.93	0.85, 1.01
							Well	0.88	0.80, 0.97
							Very well	0.88	0.79, 0.98
							Time		
							1 (Cycle 4)	1	Referent
							2 (Cycle 5)	1.09	1.03, 1.14
							3 (Cycle 6)	1.37	1.30, 1.44
							Intercept	3.09	2.66, 3.60
-2 Log L[g]	1335.42			1294.37			1285.03		
Log L ratio[h]	**35.90**[*]			**76.94**[*]			**86.28**[*]		
DF	3			4			7		

Table 5
Rate ratios (95% CIs) for the longitudinal associations between selected individual distal and individual ultimate variables and multiple behavioral risk factors (n = 1135), National Longitudinal Survey of Children and Youth, 2000-2005[a] (continued)

Note. CI=confidence interval; DF = degrees of freedom.
[a] Multiple behavioral risk factor score was the dependent variable.
[b] Rate ratios from the multivariate longitudinal Poisson regression model with adjustment for all covariates in the corresponding model and time (cycles).
[c] CIs were computed using bootstrap weights to account for the complex sampling design of the National Longitudinal Survey of Children and Youth.
[d] Age at baseline (Cycle 4).
[e] Anxiety was assessed using a global score ranging from 0 to 14, with higher scores indicating the presence of greater anxiety.
[f] Self-esteem was assessed using a global score ranging from 0 to 16, with higher scores indicating positive self-esteem.
[g] -2 (log-likelihood) for the model containing each specific block of distal and ultimate variables. The -2 (log-likelihood) of the initial (intercept-only + time) model was 1371.31.
[h] Log-likelihood ratio or change in -2 (log-likelihood) compared to the initial (intercept-only + time) model.
[*] $p < 0.001$.

Table 6
Rate ratios (95% CIs) for the longitudinal associations between selected social distal and social ultimate variables and multiple behavioral risk factors (n = 1135), National Longitudinal Survey of Children and Youth, 2000-2005[a]

	Rate ratio[b]	95% CI[c]		Rate ratio[b]	95% CI[c]		Rate ratio[b]	95% CI[c]
Model 1			**Model 2**			**Model 3**		
Social characteristics			**Social characteristics**			**Social characteristics**		
Ultimate			**Distal**			**Ultimate**		
Family structure			PMK smoking status			Family structure		
2 parents	1	Referent	Nonsmoker	1	Referent	2 parents	1	Referent
1 parent	1.07	0.98, 1.17	Smoker	1.10	1.05, 1.15	1 parent	1.05	0.97, 1.12
PMK Education			PMK drinking status			PMK Education		
Low (<12 years of school)	1	Referent	Nondrinker	1	Referent	Low (<12 years of school)	1	Referent
High (≥l2 years of school)	0.94	0.88, 1.01	Drinker	1.01	0.97, 1.06	High (≥l2 years of school)	0.98	0.92, 1.04
Annual household income			Parent-child relationship[d]	0.99	0.99, 1.00	Annual household income		
<CAN$30,000	1	Referent	Peer smoking			<CAN$30,000	1	Referent
CAN$30,000-59,999	1.01	0.94, 1.09	No peers	1	Referent	CAN$30,000-59,999	1.01	0.94, 1.08
CAN$60,000-89,999	1.07	0.98, 1.16	A few peers	1.14	1.06, 1.22	CAN$60,000-89,999	1.09	1.00, 1.17
≥CAN$90,000	1.03	0.93, 1.13	Most/All peers	1.41	1.27, 1.56	≥CAN$90,000	1.04	0.96, 1.14
Time			Peer drinking			**Distal**		
1 (Cycle 4)	1	Referent	No peers	1	Referent	PMK smoking status		
2 (Cycle 5)	1.10	1.05, 1.16	A few peers	1.13	1.06, 1.21	Nonsmoker	1	Referent
3 (Cycle 6)	1.41	1.34, 1.49	Most/All peers	1.26	1.17, 1.37	Smoker	1.10	1.05, 1.15
Intercept	2.10	1.94, 2.29	Peer-child relationship[e]	0.99	0.98, 1.00	PMK drinking status		
			Time			Nondrinker	1	Referent
			1 (Cycle 4)	1	Referent	Drinker	1.01	0.97, 1.05
			2 (Cycle 5)	1.06	1.01, 1.11	Parent-child relationship[d]	0.99	0.99, 1.00
			3 (Cycle 6)	1.16	1.09, 1.24			

Table 6
Rate ratios (95% CIs) for the longitudinal associations between selected social distal and social ultimate variables and multiple behavioral risk factors (n = 1135), National Longitudinal Survey of Children and Youth, 2000-2005[a] (continued)

			Rate ratio[b]	95% CI[c]		Rate ratio[b]	95% CI[c]
	Model 1	**Model 2**			**Model 3**		
		Intercept	2.75	2.45, 3.08	Peer smoking		
					No peers	1	Referent
					A few peers	1.14	1.06, 1.22
					Most/All peers	1.41	1.27, 1.57
					Peer drinking		
					No peers	1	Referent
					A few peers	1.13	1.06, 1.21
					Most/All peers	1.26	1.17, 1.36
					Peer-child relationship[e]	0.99	0.98, 1.00
					Time		
					1 (Cycle 4)	1	Referent
					2 (Cycle 5)	1.05	1.00, 1.11
					3 (Cycle 6)	1.15	1.08, 1.23
					Intercept	2.71	2.39, 3.07
-2 Log L[f]	1349.28	1117.23			1107.07		
Log L ratio[g]	**22.03***	**254.07***			**264.24***		
DF	5	8			13		

Note. CAN=Canadian; CI=confidence interval; DF=degrees of freedom; PMK=person most knowledgeable.
[a] Multiple behavioral risk factor score was the dependent variable.
[b] Adjusted rate ratios from the multivariate longitudinal Poisson regression model with adjustment for all covariates in the corresponding model and time (cycles).
[c] CIs were computed using bootstrap weights to account for the complex sampling design of the National Longitudinal Survey of Children and Youth.
[d] The parent-child relationship was assessed using a global score ranging from 0 to 28, with higher scores indicating a better relationship between parents and child.
[e] Peer-child relationships were assessed using a global score ranging from 0 to 16, with higher scores indicating a better relationship between the child and his/her peers.
[f] -2 (log-likelihood) for the model containing each specific block of distal and ultimate variables. The -2 (log-likelihood) of the initial (intercept-only + time) model was 1371.31.
[g] Log-likelihood ratio or change in -2 (log-likelihood) compared to the initial (intercept-only + time) model.
* $p < 0.001$.

Table 7
Adjusted rate ratios (95% CIs) for the longitudinal associations between selected individual/social distal and ultimate variables and multiple behavioral risk factors (n = 1135), National Longitudinal Survey of Children and Youth, 2000-2005[a]

	Rate ratio[b]	95% CI[c]		Rate ratio[b]	95% CI[c]		Rate ratio[b]	95% CI[c]		Rate ratio[b]	95% CI[c]
Model 1			**Model 2**			**Model 3**			**Model 4**		
Individual characteristics			**Individual characteristics**			**Individual characteristics**			**Individual characteristics**		
Distal			**Distal**			**Distal**			**Distal**		
Self-esteem[d]	0.97	0.97, 0.98	Self-esteem[d]	0.98	0.97, 0.98	Self-esteem[d]	0.98	0.98, 0.99	Self-esteem[d]	0.98	0.98, 0.99
Academic performance			Academic performance			Academic performance			Academic performance		
Poor/very poor	1	Referent	Poor/very poor	1	Referent	Poor/very poor	1	Referent	Poor/very poor	1	Referent
Average	0.93	0.85, 1.01	Average	0.93	0.85, 1.01	Average	0.98	0.88, 1.09	Average	0.98	0.88, 1.09
Well	0.88	0.80, 0.96	Well	0.88	0.80, 0.97	Well	0.94	0.84, 1.05	Well	0.94	0.84, 1.04
Very well	0.88	0.79, 0.97	Very well	0.88	0.79, 0.98	Very well	0.96	0.86, 1.08	Very well	0.96	0.85, 1.08
Time			**Ultimate**			**Ultimate**			**Ultimate**		
1 (Cycle 4)	1	Referent	Sex			Sex			Sex		
2 (Cycle 5)	1.08	1.03, 1.14	Female	1	Referent	Female	1	Referent	Female	1	Referent
3 (Cycle 6)	1.37	1.30, 1.44	Male	1.00	0.95, 1.05	Male	1.01	0.97, 1.05	Male	1.01	0.97, 1.05
Intercept	3.38	3.00, 3.81	Age, years[e]			Age, years[e]			Age, years[e]		
			10	1	Referent	10	1	Referent	10	1	Referent
			11	1.07	1.01, 1.13	11	1.01	0.96, 1.06	11	1.01	0.96, 1.06
			Anxiety[f]	1.01	1.00, 1.02	Anxiety[f]	1.00	0.99, 1.01	Anxiety[f]	1.01	1.00, 1.01
			Time			**Social characteristics**			**Social characteristics**		
			1 (Cycle 4)	1	Referent	**Distal**			**Distal**		
			2 (Cycle 5)	1.09	1.03, 1.14	PMK smoking status			PMK smoking status		
			3 (Cycle 6)	1.37	1.30, 1.44	Nonsmoker	1	Referent	Nonsmoker	1	Referent
			Intercept	3.09	2.66, 3.60	Smoker	1.10	1.05, 1.16	Smoker	1.11	1.05, 1.16
						PMK drinking status			PMK drinking status		
						Nondrinker	1	Referent	Nondrinker	1	Referent
						Drinker	1.01	0.97, 1.06	Drinker	1.01	0.97, 1.05
						Parent-child relationship[g]	1.00	0.99, 1.00	Parent-child relationship[g]	1.00	0.99, 1.00

Table 7
Adjusted rate ratios (95% CIs) for the longitudinal associations between selected individual/social distal and ultimate variables and multiple behavioral risk factors (n = 1135), National Longitudinal Survey of Children and Youth, 2000-2005[a] (continued)

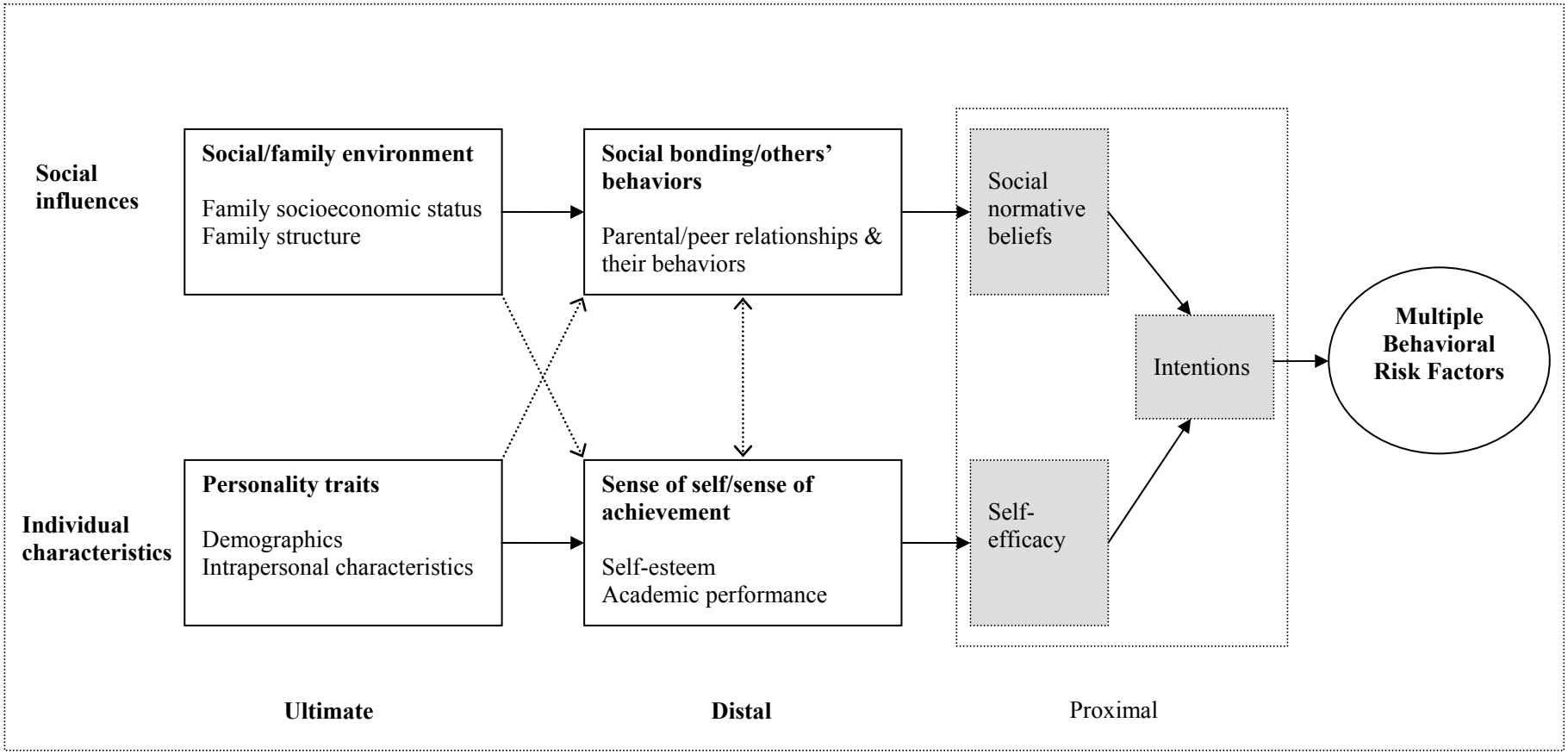
			Rate ratio[b]	95% CI[c]		Rate ratio[b]	95% CI[c]
Model 1	**Model 2**	**Model 3**			**Model 4**		
		Peer smoking			Peer smoking		
		No peers	1	Referent	No peers	1	Referent
		A few peers	1.13	1.06, 1.21	A few peers	1.14	1.07, 1.22
		Most/All peers	1.40	1.27, 1.54	Most/All peers	1.41	1.28, 1.55
		Peer drinking			Peer drinking		
		No peers	1	Referent	No peers	1	Referent
		A few peers	1.12	1.05, 1.20	A few peers	1.12	1.04, 1.19
		Most/All peers	1.24	1.15, 1.35	Most/All peers	1.23	1.14, 1.34
		Peer-child relationship[h]	1.00	0.99, 1.00	Peer-child relationship[h]	0.99	0.99, 1.00
		Time			**Social characteristics**		
		1 (Cycle 4)	1	Referent	**Ultimate**		
		2 (Cycle 5)	1.05	0.99, 1.10	Family structure		
		3 (Cycle 6)	1.15	1.08, 1.23	2 parents	1	Referent
		Intercept	3.04	2.60, 3.35	1 parent	1.04	0.97, 1.12
					PMK Education		
					Low (<12 years of school)	1	Referent
					High (≥l2 years of school)	0.99	0.94, 1.05
					Annual household income		
					<CAN$30,000	1	Referent
					CAN$30,000-59,999	1.00	0.94. 1.08
					CAN$60,000-89,999	1.09	1.00, 1.17
					≥CAN$90,000	1.04	0.96, 1.12

Table 7
Adjusted rate ratios (95% CIs) for the longitudinal associations between selected individual/social distal and ultimate variables and multiple behavioral risk factors (n = 1135), National Longitudinal Survey of Children and Youth, 2000-2005[a] (continued)

					Rate ratio[b]	95% CI[c]
	Model 1	**Model 2**	**Model 3**	**Model 4**		
				Time		
				1 (Cycle 4)	1	Referent
				2 (Cycle 5)	1.04	0.99, 1.10
				3 (Cycle 6)	1.15	1.08, 1.22
				Intercept	2.95	2.49, 3.50
-2 Log L[i]	1294.37	1285.03	1097.17	1086.24		
Log L ratio[j]	**76.94*****	**9.34****	**187.86*****	**10.93***		
DF	4	3	8	5		

Note. CAN=Canadian; CI=confidence interval; DF=degrees of freedom; PMK=person most knowledgeable.
[a] Multiple behavioral risk factor score was the dependent variable.
[b] Adjusted rate ratios from the multivariate longitudinal Poisson regression model with adjustment for all covariates in the corresponding model and time (cycles).
[c] CIs were computed using bootstrap weights to account for the complex sampling design of the National Longitudinal Survey of Children and Youth.
[d] Self-esteem was assessed using a global score ranging from 0 to 16, with higher scores indicating positive self-esteem.
[e] Age at baseline (Cycle 4).
[f] Anxiety was assessed using a global score ranging from 0 to 14, with higher scores indicating the presence of greater anxiety.
[g] The parent-child relationship was assessed using a global score ranging from 0 to 28, with higher scores indicating a better relationship between parents and child.
[h] Peer-child relationships were assessed using a global score ranging from 0 to 16, with higher scores indicating a better relationship between the child and his/her peers.
[i] -2 (log-likelihood) for the model containing each specific block of distal and ultimate variables. The -2 (log-likelihood) of the initial (intercept-only + time) model was 1371.31.
[j] Log-likelihood ratio or change in -2 (log-likelihood) is presented for each block of distal and ultimate variables entered in the multivariate model. At each step, the log-likelihood of the bigger model was compared to the log-likelihood of the previous smaller model.
$^{*}p = 0.05$; $^{**}p < 0.05$; $^{***}p < 0.001$.

Figure 1. Conceptual framework of the influence of ultimate and distal variables on multiple behavioral risk factors (Adapted from the Theory of Triadic Influence (Flay & Petraitis, 1994)).



Note: Proximal variables are only presented in this framework to suggest a pathway through which individual/social distal and ultimate variables might influence multiple behavioral risk factors.

DISCUSSION AND CONCLUSION

CHAPTER 6: DISCUSSION AND CONCLUSION

The research addressed important gaps identified in the literature including limited data on the prevalence of multiple chronic disease behavioural risk factors (i.e., physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking and overweight/obesity) among youth, the absence of any data on clustering of these risk factors for Canadian youth, the scarce evidence on their determinants as well as the absence of longitudinal studies and of research using a theoretical framework to study these risk factors. The thesis objectives were formulated based a novel conceptual model, the Theory of Triadic Influence (318), which, although developed as a heuristic tool, provided a comprehensive framework for the study of the potential influence of a large number of individual, social and school characteristics on multiple chronic disease behavioural risk factors among youth. This chapter first discusses the main findings of the three analyses of this thesis in relation to the thesis hypotheses and the conceptual framework. We then present an overview of the limitations and strengths of the research. Finally, the implications of the results for public health practice, public health policy, health care professionals, school programs and future research are discussed.

6.1 Main Findings

The **first analysis** indicated that, during the 2000-2001 period, nearly two-thirds of Canadian youth aged 10-17 years had at least two or more behavioural risk factors (i.e., physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking and high BMI), including 37% with three or more behavioural risk factors. This finding confirms our first hypothesis that chronic disease behavioural risk factors co-occur frequently in Canadian children and adolescents. While a limited number of studies have previously reported the prevalence of multiple chronic disease behavioural risk factors among youth (Table I, Chapter 2, Section 2.2.3, *p.27*), our study is the first to determine both the sex- and the age-specific prevalence of multiple behavioural risk factors in a representative sample of children and adolescents. We found that the prevalence of having three or more behavioural risk factors increased with age while the prevalence of having zero or one risk factor declined with age in both males and females. Our study is also the first Canadian report of the distribution of multiple behavioural risk factors according to selected socioeconomic characteristics of youth. In particular, we found that youth with four or five

behavioural risk factors were more often from families with low household income and low educational level. The observed high prevalence of multiple behavioural risk factors among Canadian youth is of concern because behavioural risk factors tend to track from childhood to adulthood (17, 24), and individuals with two or more behavioural risk factors are at greater risk of developing chronic diseases and having shorter life expectancy than those with zero or one risk factor (60, 244). Thus, these results suggest the importance of early interventions, most notably in older adolescents and youth from low SES families. Research has shown that low SES populations tend to have limited access to resources that facilitate the adoption of healthy behaviours (such as access to fitness facilities, proximity to parks, walking and bicycle trails and access to quality foods) (290, 351). Hence, programs and policies that help to create supportive social and physical environments for youth from less affluent families may be needed. Possible strategies for intervention include creating walking and biking clubs, involving community policing to help make the streets and parks safer, working with low SES families to create community gardens that encourage physical activity and good nutrition, and increasing funding for parks and recreation facilities in low SES neighbourhoods (352, 353).

All five behavioural risk factors considered in this thesis clustered in multiple combinations, as per our first hypothesis. However, patterns of clustering were generally similar in males and females. Moreover, the observed prevalence of multiple behavioural risk factors did not differ by sex among Canadian youth. These results support the use of public health interventions aimed at a range of behavioural risk factors rather than focused on single behavioural risk factors. Though interventions need not be sex-specific, they should at minimum address health risk behaviours that show strong clustering, such as cigarette smoking and alcohol drinking. Indeed, almost all three- and four-behaviour patterns that showed clustering in our study comprised cigarette smoking and alcohol drinking; these two health risk behaviours also formed the strongest pairwise cluster (Table 6, Chapter 5, Manuscript I, *p.124*).

Among the pairwise combinations, physical inactivity also clustered with sedentary behaviour, particularly in females. We also found a significant pairwise association between sedentary behaviour and high BMI among females. In turn, physical inactivity,

sedentary behaviour and high BMI showed clustering in males and also tended to cluster in females. These findings emphasize the interrelationship of physical inactivity, sedentary behaviour and overweight/obesity among youth. They also suggest that youth obesity prevention programs might benefit by focusing efforts on increasing youth physical activity levels and limiting their time spent on screen-based media use. Indeed, several recent youth obesity prevention programs that focused on physical activity and dietary change have achieved little to no significant changes in youth BMI (354). Therefore, reducing the time youth spend in front of a screen (to watch TV and videos for example) along with efforts to promote physical activity and dietary changes might help attain more favourable weight outcomes.

The **second analysis** aimed to identify factors associated with multiple health risk behaviours to inform the development of prevention strategies. It explored the potential relations between a large number of individual, social and school characteristics and multiple chronic disease behavioural risk factors among youth. The small number of previous studies had primarily focused on a few individual or social characteristics with no known study investigating the potential relation of school characteristics and multiple behavioural risk factors among youth (Table III, Chapter 2, Section 2.2.5, *p.40*). As per our second hypothesis, we found several independent individual and social correlates of multiple behavioural risk factors in Canadian children and adolescents, including older age (i.e., 14-15 years), low self-esteem, living in a lone-parent family, low parental education, as well as having a parent or peers who smoked cigarettes and peers who drank alcohol. These findings first highlight the importance of early chronic disease prevention efforts (e.g., promotion of physical activity, low screen-based media use, non-smoking, non-drinking and healthy weight), particularly in adolescents aged 14-15 years. The results also suggest developing preventive strategies to increase youth overall self-esteem which may increase the child's self-determination (or will) to restrain from engaging in health-compromising behaviours (318, 355). A possible approach to boost youth self-esteem is to increase the child's experience/perception of social support (e.g., approval support of their parents and peers) which is known to be a strong predictor of self-esteem (356). For example, for children and adolescents who experience lack of support from their parents, family interventions focusing on improving the interpersonal relationship between the

youth and parents may be an option. For youth who experience lack of support from their peers, improving skills in domains that are valued by peers (such as sport competence and interpersonal qualities) may be helpful (356). Hence, interventions which develop physical activity skills (such as school-based physical activity programs) could enhance youth overall self-esteem (357).

The findings of this analysis also support the development of policies and programs to promote higher education for parents. Some researchers have found that less educated parents as well single-parents are less involved in their child's school work (358, 359). In turn, parental involvement in children's education has been shown to influence youth academic performance through such mechanisms as modeling, reinforcement and direct instruction (360). Since children who perform well at school are often less likely to engage in adverse health behaviours (142, 168, 202), programs that create opportunities for parents to earn higher educational degrees (e.g., through local community schools or adult learning centres) might indirectly influence the (un)healthy choices that their children could make. Finally, results of this analysis support increased efforts to promote non-smoking (or tobacco cessation) for parents and peers, as well as developing strategies to limit alcohol drinking for peers. Possible approaches for prevention include increasing cigarette and alcohol excise taxes, increasing restrictions on smoking and drinking in public places and worksites, and limiting access and availability of tobacco and alcohol products to children and adolescents (361, 362).

Since children and adolescents spend most of their time at school and many youth actually develop several adverse health behaviours (including cigarette smoking, alcohol drinking and physical inactivity) in that context (175, 293), we also expected to find a few school-related correlates. However, none were found in our study. It is possible that other school characteristics not assessed in the NLSCY, such as school health promotion and health education policies and programs influence the likelihood of having multiple health risk behaviours. While no other study has explored school-related correlates of multiple chronic disease behavioural risk factors, the presence of school policies and programs specifically designed to address single health risk behaviours has been found to be associated with lower rates of cigarette smoking (75), alcohol drinking (363), and physical inactivity among

school children (113). Thus, future studies may need to investigate the potential influence of school health policies and programs, as well as possible influences from other types of environments or contexts such as youth sociocultural communities and neighbourhoods.

The **third analysis** was based on the conceptual framework of this thesis, which hypothesized that the three different types of determinants under investigation (i.e., individual social and school characteristics) influence multiple behavioural risk factors through two tiers of construct represented by several distal and ultimate variables. Ultimate variables represent factors that are beyond the easy control of the child including individual factors (such as sex, age and emotional distress), social factors (such as family SES and family structure), and school/institutional factors (such as school type). Thus, ultimate variables are considered furthest from behaviour(s), in terms of distance, and believed to be not specific to a single behaviour. As a result, our theoretical framework assumed that ultimate variables would strongly influence multiple health risk behaviours because they represent the most general set of determinants that transcend specific behaviours. Distal variables were also hypothesized to influence multiple health risk behaviours, but to a lesser degree compared to ultimate variables, since they are closer to behaviours (i.e., they were assumed to exert less generalized effects across behaviours). Distal variables referred to individual factors such as sense of self and sense of achievement, social factors such as social relations with others and behaviours of role models, and school-related factors such as collective commitment to success and knowledge/comprehension of school rules. Since selected school variables were not associated with multiple behavioural risk factors in the second analysis, the third analysis focused on individual and social determinants of multiple unhealthy behaviours among youth. In particular, the third analysis assessed the longitudinal influence of selected conceptually-related individual/social distal and ultimate variables on the rate of occurrence of multiple behavioural risk factors in a cohort of Canadian children.

As expected, both distal and ultimate variables contributed to the likelihood of the occurrence of multiple behavioural risk factors during follow-up. However, contrary to our expectation, individual distal (i.e., sense of self and sense of achievement) and social distal variables (i.e., parental and peer behaviours and social relations) exerted a stronger

influence on the rate of co-occurrence of behavioural risk factors than individual ultimate (i.e., sex, age at baseline and anxiety) or social ultimate variables (i.e., family structure, parental education and household income). These results suggest that variables situated at an intermediate distance from behaviours (i.e., distal determinants), such as the child's self-esteem and parents/guardians/peer lifestyle habits, tend to be more often linked to or shared by several behaviours (of the child) than variables situated at an utmost distance from behaviours (i.e. ultimate determinants), such as child's inherited traits and family SES. Thus for example, peer drinking (a distal determinant) seems to be more often associated with physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking and high BMI than low household income (an ultimate determinant).

We are aware of no other study assessing the potential influence of conceptually-related distal and ultimate variables on the rate of occurrence of multiple lifestyle risk factors for chronic diseases. This makes it difficult to compare results of this analysis with other relevant reports. Nevertheless, findings of this novel prospective study are encouraging and may offer clues for interventions aimed at several health risk behaviours simultaneously, especially since distal determinants tend to be easier to modify than ultimate determinants; indeed, the latter are considered often as factors that are beyond the easy control of the child (303). For example, while it is difficult for a child to change his/her personality traits and dispositions (e.g., emotional instability, external locus of control), distal determinants such as youth sense of self or academic skills may be more alterable through interventions (312). Thus, a key message of this analysis is that interventions need to be comprehensive and more often address distal determinants of multiple chronic disease behavioural risk factors among youth such as the child's sense of self as well as parents/guardians/peer unhealthy lifestyle risk factors, particularly those of cigarette smoking and alcohol drinking.

6.2 Limitations and strengths

Detailed descriptions of the limitations and strengths pertaining to the three analyses of this thesis are provided in the three manuscripts included in Chapter 5. This section provides a general overview of, first, the limitations and, second, the strengths of this research. First, other behaviours, most notably dietary habits of youth, were not assessed in the NLSCY.

Diet and nutrition along with the five behavioural risk factors considered in this thesis are identified as a set of common risk factors for several chronic diseases including diabetes, CVD and cancer (5). The inclusion of diet in this thesis could have potentially influenced the patterns and/or degree of clustering of behavioural risk factors. Nevertheless, in the absence of a measure of dietary intake, we chose to include a measure of overweight (i.e., high BMI). Although some investigators may not view BMI as a behavioural risk factor, overweight is a risk factor for several chronic diseases, and its immediate determinants include several behaviours, including imbalance between dietary energy intake and energy expenditure through physical activity. Thus, the inclusion of BMI in this thesis may have partially reflected dietary practices. In turn, the inclusion of BMI may have also reflected physical inactivity and sedentary behaviour. As a result, the degree of clustering of behavioural risk factors may have been overestimated in this study since we also included a measure of physical inactivity and a measure of sedentary behaviour. However, BMI has been successfully used in several other studies of multiple behavioural risk factors in both youth and adults where measures of physical inactivity, sedentary behaviour and/or dietary intake were also included (50, 78, 238, 246, 265). All health behaviours considered in this thesis, along with height and weight, were self-reported in the NLSCY and thus subject to social desirability bias and recall bias. With respect to self-reported height and weight, females generally underestimate their weight while males tend to overestimate their height (185). This may have led to an underestimation of BMI.

Some selection bias may have occurred in the thesis. First, similar to any nationally-based longitudinal survey, the NLSCY has suffered from total and partial nonresponse as well as operational constraints over the years, as reported in Sections 4.2 and 4.3. For example, the overall longitudinal response rates in Cycle 4, Cycle 5 and Cycle 6 of the NLSCY were respectively 67.8%, 63.1%, and 57.6%. Nonresponse can lead to biased estimates if nonrespondents have significantly different characteristics from respondents (320). To account for total nonresponse in the NLSCY, Statistics Canada employed several statistical methods including an adjustment made to the sampling weights to account for nonresponse due to attrition, and the use of a post-stratification adjustment factor to ensure consistency between the estimates produced by the NLSCY sampling weights and Statistics Canada's population estimates by age, sex and province, as reported in Section 4.2. Despite these

statistical approaches to deal with total nonresponse, nothing ensures that the NLSCY study population is a true representative sample of the Canadian children and adolescents. In particular, it is possible that subjects of lower SES (e.g., those under the poverty line) may have been underrepresented in the NLSCY due to their lower likelihood of responding to the survey or being reached - a phenomenon often attributed to the lower incidence of telephones, fixed addresses or the ability to speak English or French among this population (364). Since the exact profile and characteristics of total nonrespondents in the NLSCY were unknown, the information obtained from respondents for the purposes of this thesis may not truly reflect that of the entire Canadian children and adolescent populations, particularly those of youth from underprivileged families.

With regard to possible errors due to partial nonresponse, characteristics of participants were compared to those of nonparticipants in each of the three manuscripts. Although there were modest differences between participants and nonparticipants with respect to individual characteristics, (Table 1, Manuscript I, *p.118* and Table 1, Manuscript II, *p.149*), some differences emerged between the two groups with respect to social characteristics (Table 1, Manuscript II, *p.149* and Table 1, Manuscript III, *p.184*). In particular, youth in the study populations of Manuscript II and Manuscript III were more likely to be from higher income, higher educational level, and two-parent families compared to youth excluded because of incomplete data and/or lost to follow-up. Also, children who were lost to follow-up or excluded from the third analysis were more likely to be ever drinkers and overweight/obese, compared to children included in the study. As a result, the study populations of Manuscript II and Manuscript III may have been selected towards youth from more affluent families. However, as stated in Section 4.6, we used multiple imputation to evaluate the extent of errors due to partial nonresponse in the thesis. As indicated on page 84, parameter estimates obtained using imputed and nonimputed datasets were found to be similar for all three manuscripts, suggesting that the observed associations may not have been largely affected by bias due to partial nonresponse. Nevertheless, differences between participants and nonparticipants beyond the reported characteristics and hence the potential influence of unmeasured variables on the observed relations remains unknown. Also, although our multivariate statistical models included adjustment

for a large number of individual, social and school-related variables, residual confounding due to other potential unaccounted factors is possible.

It is also noteworthy to mention that the study population of Manuscript II included children and adolescents attending public schools only. Indeed, as reported in Section 4.3, due to operational constraints such as a heavier than anticipated workload, increased costs and the respondent burden experienced during data collection, the school component of Cycle 4 of the NLSCY included youth attending public schools only. Although beyond our control, this selection of youth in the study population, may have introduced a collider bias if students in public schools were more likely to be exposed to certain social determinants (such as peer smoking/drinking or parental smoking/drinking) and behavioural risk factors (such as smoking or drinking) than students in private schools. Hence, certain associations observed in the second manuscript may have been overestimated simply because the youth population attending public schools was studied. In contrast, the variability of school-related variables may have been reduced because youth attending private schools were not included in the study. This may explain the lack of significance of school-related characteristics in the study.

The "multiple risk factor index" (used in Manuscript II) and the variable "household income" were categorized in the thesis. Categorization (or dichotomization) of variables may lead to loss of information and reduced statistical power (365). However, in Manuscript II, the first two categories (i.e. 0 risk factors and 1 risk factor) and the two last categories (4 risk factors and 5 risk factors) of the "multiple risk factors index" were combined in order to ensure adequate cell sizes (i.e., at least 5 observations per cell) for both descriptive and multivariate analyses, as per Statistics Canada's guidelines. The variable "household income" was defined as per previous research using the NLSCY data (334). Nevertheless, the use of a categorical measure of household income may partly explain the lack of significance for the association between household income and the behavioural risk factor level in Manuscript II (Table 4, *p.158*), and for the association between household income and the rate of multiple risk factor score in Manuscript III (Table 7, *p.198*). Furthermore, residual confounding due to the use of categorical variables remains possible (365). Despite these limitations, we were able to show a univariate dose-

response relation between household income and the multiple behavioural risk factor level in Manuscript II (Table 3, *p.154*). We also conducted additional analyses classifying household income below or at/above the low income cutoffs from Statistics Canada. However, our final results remained unchanged and the newly classified household income was not significant ($p = 0.1257$) in the final multivariate model suggesting that the lack of significance for the association of household income and multiple behavioural risk factors was unlikely to be largely related to the use of our definition of household income.

Although the NLSCY covered a broad range of topics including the health and behaviours of Canadian children as well as their social environment, some measures of interest were not obtained for all age groups. For example, the measures of the quality of parent-child relationship and peer-child relationships were obtained only for youth aged 10 to 15 years. The school-related questions were also available for youth up to the age of 15 years only. These data restrictions limited our ability to include youth aged 16 and 17 years in the second and the third analyses of the thesis. In addition, children below the age of 10 were not asked about their smoking or drinking habits and hence were excluded from the analyses.

Among the strengths of this thesis is its use of diverse statistical methods to address the objectives. For example, we used an impartial analytic method to describe the clustering patterns of behavioural risk factors among youth. The O/E ratio method is a more accurate method for evaluating the degree and direction of clustering of health risk behaviours than logistic regression analysis, and discriminant analysis, as reviewed in Section 2.2.2. Also, the ordinal logistic regression analysis used to address the second objective of this thesis is a more efficient method for the analysis of ordinal outcome variables (such as the number of behavioural risk factors), compared to binary logistic regression analysis or multinomial logistic regression analysis (294). Furthermore, the longitudinal Poisson analysis used to address the third objective of this thesis allowed us to take full advantage of the longitudinal nature of the data by using all available information from subjects at the three measurement periods. Moreover, we were able to obtain accurate estimates of the variance of the estimated coefficients using the survey weights and the bootstrap technique. Other strengths of this thesis include its use of a nationally representative sample of Canadian

children and adolescents, validated questionnaires and tools and extensive quality control of data. Finally, a novel feature of this thesis can be attributed to its use of an integrative conceptual framework to study determinants of multiple chronic disease behavioural risk factors in children and adolescents. The conceptual framework of this thesis could serve as a heuristic model in future studies of determinants of multiple behavioural risk factors among youth.

6.3 Implications and future directions

Public health practice

This study found clustering of several chronic disease behavioural risk factors among many Canadian children and adolescents. This finding highlights the need to increase early chronic disease prevention efforts across multiple settings including health systems and public health departments and agencies at the local, provincial and national levels (239, 240). In particular, our results support the use of surveillance systems to monitor trends in multiple health risk behaviours (i.e., physical inactivity, sedentary behaviour, tobacco smoking, alcohol drinking and overweight/obesity) which could enable public health professionals as well as other stakeholders to track the evolution of these risk factors over time and develop appropriate interventions, and evaluate the impact of policies and programs.

Our finding that chronic disease behavioural risk factors cluster among Canadian youth suggests the importance of shifting from a single-behaviour intervention paradigm to a multiple-behaviour approach (80). In fact, apart from obesity, diabetes and CVD interventions, many health promotion interventions have largely addressed health risk behaviours as separate entities (366, 367). Yet, we showed that chronic disease behavioural risk factors co-occur more often than expected by chance among youth. When health risk behaviours cluster, one's risks for chronic diseases increase substantially with the effects likely to be multiplicative rather than additive (60, 244). Further, excess risks leads to excess health care costs (368). Hence, early interventions targeting multiple health risk behaviours may be required to curb the future increased risks of morbidity and mortality. It has been suggested that programs targeting multiple health risk behaviours could have the potential to result in more favourable benefits measured in terms of quality of life outcomes

and health care costs and utilization (80). Our results suggest that multiple-behaviour interventions should primarily target youth sense of self, parental smoking, peer smoking and peer drinking behaviours (i.e., the individual/social distal variables in our conceptual model) for the prevention of multiple behavioural risk factors. Other social distal variables including the quality of parent-child relationship and peer-child relationships may be considered as potential targets in multiple-behaviour interventions. Despite being significant only in bivariate analyses, better relationships between the parent/peers and the child tended to be associated with a decreased number of behavioural risk factors among youth. Hence, increased positive reinforcements and interactions between the child and his/her influential role models (i.e., parents and peers) may result in more favourable lifestyle practices in children and adolescents (369).

It is important to point out that although there is some evidence suggesting that multiple-behaviour interventions may have a greater impact on public health than single-behaviour interventions (80), there remains large gaps both in the delivery and in the development of effective strategies to address multiple behavioural risk factors (80, 313, 370). Specifically, more research is needed to decipher how to best intervene on multiple health risk behaviours and how to assess the long-term impact of interventions targeting multiple behaviours rather than single behaviours. One methodological challenge is whether multiple behavioural risk factors should be targeted simultaneously (i.e., concurrently) or sequentially (i.e., consecutively) (80), especially since changing more than one behaviour might pose significant intellectual and behavioural challenges and be difficult to achieve (367). Current evidence from the literature has produced mixed results with some studies, mainly conducted in adults with unhealthy behaviours or deleterious conditions (e.g., hypertension, smoking, alcohol addiction) supporting simultaneous interventions (371), while other studies reporting success in sequentially targeting multiple health risk behaviours (372, 373). Results of a recent randomized trial conducted in a convenience sample of 567 adults with no medical complaints and which attempted to increase physical activity and/or decrease fat intake indicated that sequential and simultaneous interventions might be equally effective (374). Specifically, no differences in success rates between an intervention for physical activity promotion and fat intake reduction assigned simultaneously at baseline, an intervention for physical activity at baseline and fat intake at

3 months, or an intervention for fat intake at baseline and physical activity at 3 months were found (374). Although these findings suggest that public health professionals and researchers could deliver multiple-behaviour change strategies either concurrently or consecutively, more research is needed to evaluate the efficacy and cost-effectiveness of these interventions, particularly among youth.

Health care professionals

Results of this thesis are relevant to physicians or other health care professionals who see children and adolescents every day in primary care clinics and hospitals. Indeed, in light of the high percentage of youth with two or more behavioural risk factors observed in this study, it would be quite a challenge for primary care physicians to provide counselling and interventions for all behaviours independently, particularly given the long list of other preventive tasks and recommendations that providers are expected to implement (366). A systematic review of interventions and strategies in primary care settings suggests that there are opportunities for clinicians to provide multiple health behaviour screening, counselling, and intervention services (366). For example, routine screening of multiple health risk behaviours can be performed using brief risk assessment surveys which may be used to generate personalized risk behaviour profiles for patients. Clinicians can also use this opportunity to provide behaviour-specific tip sheets and self-monitoring logs to their young patients (53, 375). The observed increase in the percentage of multiple behavioural risk factors with age among Canadian youth highlights the importance of early screening by clinicians. Our findings also suggest that special attention should be paid to children and adolescents who report smoking cigarettes and drinking alcohol as these two health risk behaviours might help in identifying youth with other unhealthy behaviours.

Clinicians may also provide counselling sessions through, for example, the expert-recommended "5A's" framework from the U.S. Preventive Services Task Force; this framework is used for evaluating and describing health behavioural counselling interventions in primary health care settings (366, 376). In particular, the 5A's framework entails 1) Assessing the behavioural risk factor; 2) Advising the patient/subject about personal health risks and benefits of behaviour change; 3) Agreeing on treatment goals and methods; 4) Assisting the patient by providing behavioural change techniques and medical

treatment, if appropriate; and 5) Arranging follow-up assessment and support (375, 376). The 5A's counselling is best delivered in a series of contexts including the systems that support the health care team (e.g., multidisciplinary teamwork, clinician and staff training), the health care delivery system (e.g., availability of referral sites for behavioural risk factor evaluation, family and lifestyle counselling), and community resources (e.g., community-based approaches enhancing smoking cessation and physical activity adoption) (366).

The strongest evidence for the efficacy of multiple-behaviour interventions in clinical settings comes from secondary prevention trials conducted among adult patients at high risk for or with existing CVD and diabetes (80, 366). These interventions focused mainly on changing tobacco smoking, physical activity or diet through various methods including counselling, educational/behavioural strategies and pharmacologic treatment that targeted more than one behavioural risk factor (366). There is also some evidence for the efficacy of multiple-behaviour interventions in primary care among college students (377, 378). For example, a randomized controlled trial of 218 patients (17-24 years) attending a student health service at a New Zealand university reported some success in the delivery of a web-based primary care intervention for multiple health risk behaviours. Subjects were randomly assigned to receive A) a computerized assessment, feedback and advice on their fruit and vegetable consumption, physical activity, alcohol consumption, and smoking; B) a computerized assessment only, or C) a minimal contact at baseline. Six weeks post-intervention, all subjects completed a follow-up web-based questionnaire assessing their health risk behaviours. At 6 weeks post-intervention, there was significantly higher compliance with health recommendations for fruit and vegetable consumption (33% versus 13%) and physical activity (90% versus 70%) in group A patients compared to group C patients, respectively (378). However, there were no differences in compliance for alcohol consumption between the studied groups. In addition, the effects of intervention on smoking could not be assessed due to its low prevalence in the study population. Another randomised controlled trial of 303 American college students (mean age: 19.2 years) attending a southeastern university found that subjects receiving a brief image intervention showed improvements on several behaviours (including heavy use of alcohol and marijuana, moderate exercise, driving after drinking and the amount of sleep) 3 months post-intervention, compared to subjects receiving standard care (379). The brief image

intervention consisted of a one-on-one consultation where tailored messages were used to show the effects of health promoting behaviours on positive social and self-images and the effects of risk behaviours on positive image outcomes and achievement of health promoting habits. Participants also received a one-page goal plan that asked them to select one goal for each behaviour to improve in the next week (e.g., increase physical activity, decrease alcohol/cigarette use, and increase other behaviours such as sleep). The standard care consisted of a commercial brochure that included information about the benefits of being fit (379). A recent follow-up study of the same trial found that initial 3-month outcomes were partially sustained at 12-month post-intervention. In particular, effects on alcohol and marijuana use as well as the amount of sleep were not sustained over time (380). These results suggest the need for additional research using intervention trials of larger size and longer follow-up periods among young patients.

Public health policy

The importance of modifying and preventing the occurrence of behavioural risk factors to improve the health of the public is well recognized (381). Findings of this thesis indicate that health promotion efforts and policies should employ a multifactorial, integrated approach directed at co-occurring behaviours among youth rather than trying to modify or promote a single behaviour at a time. In particular, public health policies should acknowledge the importance of the individual distal (i.e., self-esteem) and social distal (i.e., behaviours of parents and peers) determinants of multiple behavioural risk factors as integral elements of public health action. Effective policies should promote positive self-esteem among youth and create opportunities for parents and peers to adopt healthy lifestyle practices to achieve multiple-behaviour change. Policy makers should also consider the child's age when developing policies, as older adolescents, particularly those aged 14-15 years, are at higher risk of having multiple adverse health behaviours than younger adolescents.

Educating the youth and the public about the risks of multiple unhealthy behaviours for chronic diseases would also enable people to make informed choices and take effective action. Results of our first and second analyses confirm previous studies about the need to refine and tailor health education messages to children and adolescents living in low SES

families (382, 383). In particular, health messages should use a consistent style, be relatively short in length but still clearly convey the intent of the message, and be written at a reading level that is appropriate for youth of less affluent families (384). Effective health promotion strategies should be comprehensive and address the major common lifestyle risk factors for chronic diseases (including physical inactivity, sedentary behaviour, tobacco smoking, alcohol drinking, overweight/obesity and unhealthy diet) in a multisectoral perspective including the society as a whole on behalf of the children and adolescents, health education professionals and the youth themselves (385). Intersectoral initiatives should promote regular participation in physical activities, limit time spent on screen-based media, discourage cigarette and alcohol use, promote a healthy and balanced diet, and promote a healthy weight for children and adolescents.

Finally, policies aimed at creating supportive (physical and socio-political) environments may complement the policies focused on changing the individual and social determinants of health behaviours among youth (386, 387). For instance, environmental policies that create opportunities for physical activity such as access to fitness facilities, the presence of walking and bicycle trails as well as effective zoning and land use to facilitate activities in neighbourhoods may complement efforts to increase physical activity (388). Policy approaches toward tobacco and alcohol consumption such as restrictions on cigarette and alcohol advertising, prohibiting sales and access to tobacco and alcohol products to youth under the age of 18, and recommending parents and school leaders to establish a non-smoking rule at home and at school, respectively, could help reduce smoking and drinking rates among youth (361, 362). With respect to nutrition and diet, public health efforts aimed at controlling the consumption of unhealthy foods such as regulation of the production and sale of high-fat foods and increased taxation of soft drinks and energy-dense/junk foods may be helpful (389).

School programs and policies

Results of this research have important implications for schools particularly given the growing list of programs and policies that schools are expected to introduce and implement including health, ethnocultural and environmental education agendas and many others (390). In particular, our results suggest that schools have an opportunity to address, educate

and potentially intervene on several common chronic disease behavioural risk factors (including physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking and high BMI) concurrently (or consecutively) rather than addressing health risk behaviours individually. This might help to offset the potential increasing burden of an overflowing school curriculum imposed upon the teachers, principals and other school personnel.

To achieve multiple-behaviour change, school programs may need to address the (individual and social) determinants that are common to or shared by multiple behavioural risk factors including sense of self, parental smoking, peer smoking and peer drinking. Many programs addressing self-esteem are actually school-based, because they have the potential to reach a large number of children and adolescents and may be cost-effective if they become part of the regular curriculum (391). For instance, school programs can focus on developing the knowledge and skills necessary to build a positive sense of self, including modification of negative thinking, the use of more positive thinking, communication, problem solving and perception. Teachers and peers could also participate in the processes of instruction, coaching, modeling, rehearsal, feedback and praise to shape and reinforce new and improved skills relevant to the issue of self-esteem (392).

With regard to peer smoking and peer drinking, schools can develop and implement policies to ban smoking and drinking on school grounds, teach students refusal skills to discourage tobacco and alcohol use and resist peer pressure, and educate youth about the hazardous health, psychological and social effects of tobacco smoking and alcohol drinking (361, 362). These strategies, coupled with effective coping skills, can potentially be applied to a range of other risky or delinquent behaviours such as substance use, violence, aggression, stealing and unsafe sexual activity, which, although not viewed as common risk factors for chronic diseases (compared to physical inactivity, smoking, diet, drinking or overweight) (5), nevertheless pose significant adverse health and social consequences for adolescents, their family and peers, their school, and society (393).

Lastly, it should be noted, that besides targeting the school children/adolescents and their peers, school programs need to involve the parents, teachers, principals, and community leaders, and to work with them to adopt a proactive approach in discouraging youth to

engage in multiple health risk behaviours. Effective school programs also need to be developmentally appropriate, longitudinal, culturally sensitive and include ongoing monitoring and evaluation at all stages of development, implementation and institutionalization (303).

Future research

The field of multiple-behaviour research is still young. Indeed, more research is needed to develop a comprehensive theory of behaviour change that directly addresses the issue of how to intervene and change multiple health risk behaviours (80). Future studies should use a life course approach (394) for understanding the underlying mechanisms by which individual and social distal and ultimate variables influence multiple chronic disease behavioural risk factors among youth. A more complete understanding of the occurrence of multiple health risk behaviours requires consideration of individual and social factors as well as factors perhaps related to the broader economic and sociocultural contexts of children and adolescents. Future studies should be prospective in design, include children younger than the age of 10, use objective measures of health behaviours, have longer follow-up periods and include a qualitative component. In particular, qualitative data (such as information about youth beliefs, attitudes and intentions) from small group discussions can be obtained and combined with quantitative findings to provide a fuller explanation of why and how children and adolescents engage in multiple unhealthy behaviours for chronic diseases (395). Future research should also investigate determinants of specific patterns of clustering of health behaviours as this may help us understand why certain youth choose to engage in a set of health risk behaviours (such as physical inactivity, tobacco smoking and alcohol drinking) while other youth choose not engage in this set of health risk behaviours or engage in other combinations of unhealthy behaviours. There is also need for longitudinal studies to assess the future impact of the co-occurrence of behavioural risk factors among children and adolescents on adult risk profile, on future health outcomes, life-expectancy and mortality. Finally, more research is needed to evaluate and compare the efficacy of multiple-behaviour interventions in children and adolescents to that of single-behaviour interventions.

6.4 Conclusion

This thesis investigated the prevalence, clustering patterns and potential determinants of multiple chronic disease behavioural risk factors (including physical inactivity, sedentary behaviour, cigarette smoking, alcohol drinking, and overweight/obesity) in a representative sample of Canadian children and adolescents. The results showed that chronic disease behavioural risk factors are prevalent and co-occur more often than expected by chance in Canadian children and adolescents. In addition, several individual and social characteristics of youth were found to be correlated with multiple chronic disease behavioural risk factors including older age, self-esteem, living in a lone-parent family, low parental education and having a parent or peers who smoked cigarettes or peers who drank alcohol. Overall, individual/social distal determinants (i.e., variables situated at an intermediate distance from behaviours) exerted a stronger influence on the rate of occurrence of multiple behavioural risk factors compared to individual/social ultimate determinants (i.e., variables situated at an utmost distance from behaviours). Thus, public health interventions and policies should primarily target the individual/social distal determinants of multiple behavioural risk factors among youth such as sense of self, parental smoking, peer smoking and peer drinking. However, because individual distal variables (such as psychosocial characteristics) and social distal variables (such as parental and peer behaviours) might be influenced by individual ultimate variables (such as demographics) and social ultimate variables (such as parental SES), public health professionals should also develop programs and policies that improve the socioeconomic conditions of children and adolescents, particularly those of youth from less affluent families.

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APPENDICES

Appendix 1

Certificate of ethical approval

Université de Montréal

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CERTIFICAT D'APPROBATION DU COMITÉ D'ÉTHIQUE DE LA RECHERCHE DE LA FACULTÉ DE MÉDECINE (CERFM)

Le Comité d'éthique a étudié le projet intitulé :

Multiple chronic disease behavioural risk factors in Canadian children and adolescents: An investigation of individual-level and environmental-level determinants

présenté par : M. Arsham Alamian et Dr Gilles Paradis

et considère que la recherche proposée sur des humains est conforme à l'éthique.

[redacted]

Date d'étude : 15 novembre 2006

Date d'approbation : **Modifié et approuvé le 29 janvier 2007**

Numéro de référence : CERFM (06) #225

N.B. Veuillez utiliser le numéro de référence dans toute correspondance avec le Comité d'éthique relativement à ce projet.

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