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Early life predictors of adolescent suicidality

by

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Abstract

Background

Suicidal thoughts affect 12% of Canadian adolescents. Previous research has linked many factors to suicidality but has not considered how these factors may act together or their effect on non-mental health outcomes.

Methods

I used the National Longitudinal Survey of Children and Youth to construct predictive models for suicidal thinking. Recursive partitioning models were constructed and the sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) for suicidal thoughts and secondary outcomes was calculated. I tested the models in the Avon Longitudinal Survey of Parents and Children.

Results

Predictive model sensitivity was 24.2%, specificity was 89.8%, PPV was 24.7%, and NPV was 89.5% and had similar accuracy in the second dataset. The models were better at predicting other adverse outcomes compared to suicidal ideas.

Conclusion

Exposure to multiple risk factors is predictive of several poor outcomes in adolescence including suicidal thoughts.

[Words: 144]

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List of abbreviations

ALSPAC	Avon Longitudinal Study of Parents and Children
CART	Classification and Regression Trees
CES-D	National Institute of Mental Health's Centre for Epidemiological Studies Depression scale (CES-D).
CHID	Chi-squared Interaction Detection
CHAID	Chi-squared Automatic Interaction Detection
DSM-III/IV	Diagnostic and Statistical Manual of Mental Disorders, Third/Forth Edition
NLSCY	National Longitudinal Study of Children and Youth
NPV	Negative predictive value
PMK	Person most knowledgeable
PPV	Positive predictive value

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Chapter 1: Introduction and literature review

1.1 Epidemiology of suicide

Each year, over 800,000 people die by suicide worldwide (1–3). It is an important public health issue both internationally and in Canada (4). Suicide is a major cause of preventable death in Canada with an annual rate of 11.5 deaths per 100,000 people and 100,000 years of potential life lost (5). In addition to the mortality associated with suicide, each suicide has psychological, social, and financial impacts on family, peers, and community (4,6–9).

The impact of suicide is particularly pronounced among adolescents and young adults aged 15-34 where suicide is a leading cause of death, second only to unintentional injury (10). In fact, as medical and technological advances have led to significant reductions in unintentional injury and other causes of death, suicide accounts for an increasing proportion of deaths among youth aged 15-19. Today suicide accounts for 23% of all deaths in this age group, up from 9% in 1974 (5). Further, for each youth who dies by suicide, there are up to 400 documented and undocumented suicide attempts and thousands more engaging in serious thoughts about suicide (11,12). A systematic review of literature on adolescent suicidality showed that 9.7% (95% CI, 8.5-10.9) of adolescents had attempted suicide at some point in their lives, 29.9% (95% CI, 26.1-33.8) had thought about suicide at some point, and 19.3% (95% CI, 11.7-27.0) have had such thoughts in the previous year (13). Further, the scope of the problem may be underestimated as suicidal thoughts and attempts may not be reported due to stigma, even on anonymous surveys (14).

It is important to understand adolescent suicidality, as research has shown that it is not merely a transitory state, but an indicator of longer-term vulnerability, including increased risk of subsequent non-fatal and fatal suicidal behaviours (15–19). Research suggests that suicidal adolescents are more likely to experience suicidal behaviours and die by suicide as adults (14,20–22), however, other research by Moran et al. (2012) showed that self-harming behaviours spontaneously resolved in most adolescents as they aged into young adulthood, with the exception of those with mental illness (23). In addition to an elevated risk of subsequent suicide, individuals who have engaged in suicidal behaviour are at an increased risk of premature death from other causes (16,24,25). Goldman-Mellor et al. (2014) showed that young people (24 years or younger) who attempt suicide were two times more likely to experience persistent mental health problems (including depression, substance dependence, and suicide attempts), three times more likely to report additional suicide attempts, and were more likely to have physical health problems, including a two-fold increase in metabolic syndrome, and a four-year increase on the Framingham cardiovascular disease risk score than non-attempters as they aged (22). Youth and young adults who attempt suicide were also more likely to engage in violence, to require long-term welfare or unemployment, and to be less satisfied with their lives as they approach midlife, even after accounting for social class and youth psychiatric diagnosis (22). Given the severity and impact of suicide, many organizations have identified suicidal behaviour as a priority and have indicated that urgent action is needed (7,26). Where much of the research on suicide prediction have focused on factors present near the time of suicidal thoughts and behaviours, the research described in this thesis aims to understand the distal factors that contribute to elevated risk. By gaining a better understanding of the early life factors that increase risk of

suicidality, prevention strategies that support health from early childhood through adolescence can reduce morbidity and mortality, and build the foundation for adult health and productivity (27,28).

Considering the scope and impact of suicidal thoughts and behaviours, understanding the factors that contribute to later suicide risk may provide information to guide the development of suicide prevention interventions targeting high-risk groups. The focus on understanding distal predictors detectable prior to the onset of suicidality creates the opportunity for the implementation of early intervention programs. Further, understanding potential markers of suicidal thoughts may also contribute to greater insight into other important health and social outcomes in adolescence. Many risk factors for suicide may be markers of early-childhood difficulty, and thus the predictors that accurately identify higher suicidality may also be able to predict other adverse outcomes in adolescence including antisocial behaviour, substance misuse, poor physical health, poor mental health, risky health behaviours, and poor academic performance. Literature shows that there is a close inter-relationship between psychological, emotional, and behavioural problems, which tend to co-occur and, to a large extent, tend to stem from the same conditions (29–31). It is plausible that the absence of a nurturing childhood environment or the presence of multiple risk factors may be predictive of multiple measures of adversity in later life. In this way, understanding how combinations of distal risk and protective factors increase or decrease suicidality across the suicidal continuum has the potential to improve population health by highlighting developmental pathways to suicidality (4). Additionally, these early life predictors may not be specific to the suicide context and may, in fact, also be indicators of a difficult early life. Thus, they may also shed light on the development of other important adolescent outcomes.

1.2 Suicide continuum

Historically, the relationship between suicidal thoughts, behaviours, and death has been theoretically conceptualized using a suicide continuum, first proposed by Beskow (1979), where suicidal thoughts precede suicidal behaviour, including fatal suicidal acts (32) (see Appendix 1 for definitions). Suicidal thoughts may transition into suicidal behaviour, including acts of self-harm for some individuals and, for a proportion of these individuals, acts of self-harm may escalate to death by suicide (32–36). Research supporting the continuum model has showed that suicidal thoughts are an important precursor to both suicide attempts and suicide; most people who have attempted or died by suicide have engaged in suicidal thoughts prior to their acts (33,36–47). However, the use of the suicide continuum has been controversial. Despite research supporting it, some researchers maintain that not all suicidal individuals proceed through the discrete steps outlined in the suicide continuum, which is connected to the broader debate about the relationship of thoughts to behaviour.¹ Despite these questions, the determination of suicidality in the studies included in this research were based on a suicide continuum approach, where only participants who

¹ While supported by a large body of evidence, not all individuals appear to proceed through the discrete steps outlined in the suicide continuum, as there is evidence that many suicide attempts in adolescence are unplanned (283). There is a level of impulsivity associated with suicidal behaviors. Simon et al (2001) showed that 24% of youth who had made suicide attempts of life-threatening severity carried out the attempt within five minutes of having made the decision to do so.

It is important to note that the stages along the suicide continuum are not mutually exclusive, and further, not all suicidal individuals advance sequentially through these stages across the continuum (12,265). However, this was the theoretical underpinning of the questionnaire used in the National Longitudinal Survey of Children and Youth (NLSCY), where unless an individual endorsed the item on suicidal thoughts, that individual would not be asked about behaviours or attempts.

indicated they had suicidal thoughts were asked about behaviours, plans, and attempts (this is further discussed in the limitations section).

Suicidal thoughts have thus been of interest to many suicide researchers as most people who die by suicide have previously thought about the act (12). Although there is evidence to show that those who die by suicide have some different characteristics than those who think about suicide, ideation-focused research is able to provide valuable insight on the suicidal process (35). However, the information gathered from those with suicidal thoughts may not be broadly generalizable to all those with suicidality, as there are important differences according to age and gender between those who have suicidal thoughts and those who die by suicide. Notably, there is wide agreement that females are more likely to report suicidal thoughts, while males are more likely to die by suicide (48–50). Further, there are important age-related trends, which indicate that the characteristics of individuals with suicidal thoughts may not be completely applicable to the population of those who die by suicide. Suicidal ideation has been shown to affect many youth, however prevalence estimates of past year ideation vary dramatically from 4.7% to 19.3%, due in part to different age cut-offs and the use of different criteria to assess suicidal ideation between studies (37,51–55).

Practically, the study of those with suicidal thoughts can provide rich data, as the subjects are still alive to provide information. From a statistical standpoint, since suicidal thoughts are more prevalent than death by suicide, the study of suicidal thoughts allows researchers to identify important socio-demographic variables that may not be possible to do for suicide deaths, due to the low base rate in the adolescent population (35). Statistically, the higher prevalence of suicidal thoughts compared to deaths allows for accurate identification

of demographic and personal characteristics. This is particularly true of longitudinal research where the number of participants who die by suicide is likely to be too low to detect any meaningful predictors. Other methods of studying those who die by suicide, particularly the use of psychological autopsies, are plagued by biases and limitations that diminish the usefulness of the information (56,57). In addition, suicide those with suicidal thoughts are able to report on internal thoughts and feelings that would not be available to friends or family members of those who die by suicide. One of the limitations to much suicidology is that the internal thoughts or feelings prior to the suicide death are not available to researchers following a suicide, which has led many researchers to study those who have suicidal thoughts or behaviours. While a strength of longitudinal research is that the thoughts and feelings prior to a suicide would have been recorded, the low base rate in a population sample make it difficult to accurately study those who die by suicide even in large samples.

Onset of suicidal thoughts and subsequent progression along the continuum of suicidality may be rapid, particularly in the presence of acute triggers. This highlights the importance of upstream prevention approaches which reduce the number of youth who enter the suicidal continuum (32,33,58,59). In addition to being a useful marker of later suicidal behaviours and deaths by suicide, suicidal thoughts themselves are an indicator of significant distress. Suicidal thoughts have been associated with a range of psychological difficulties and negative health states including: poor psychosocial functioning; risky sexual behaviour; aggressive behaviour; substance use disorders; and depressive disorders (34,36,60,61). Thus, interventions that prevent suicidal thoughts may also decrease associated health risks. While there is evidence that those with suicidal thoughts, those who attempt suicide, and those who die from suicide may have different characteristics, children and adolescents who “only”

engage in suicidal thoughts are exhibiting serious and significant distress that requires urgent attention (12).

1.3 Risk factors for suicidality

The robust risk factor literature on suicide has clearly established the existence of numerous risk factors for suicide; however, these have often been investigated individually. Research that considers multiple risk factors is necessary in order to detect important combinations that dramatically increase the risk of suicidality. This study aims to assess the contribution of the interactions between biological, psychosocial, social, and environmental factors that increase in risk of suicidal thoughts. In order to account for the multiple spheres of influence that have been linked to suicidality, this research was grounded in a theoretical approach.

1.3.1 Conceptual model

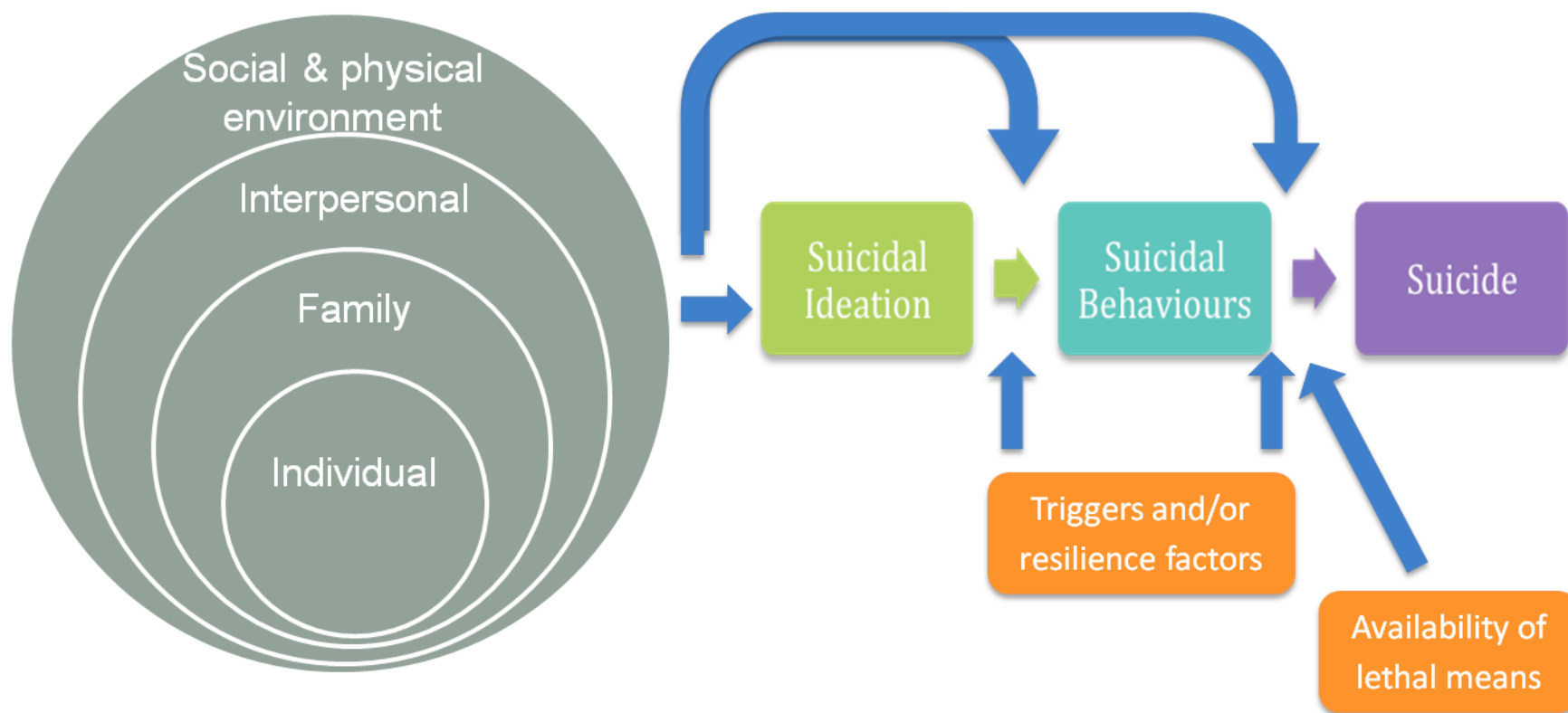
This research is guided by a conceptual model (see Figure 1.1), which has been informed by the main themes emerging in the suicide literature. The *life course perspective* provides the theoretical underpinning for this model, positing that an individual accumulates exposures across the life course that affects disease risk. Thus, biological, behavioural, and psychosocial exposures in gestation, childhood, adolescence, and adulthood have the potential to increase or decrease the risk of suicidality (62,63). These proximal and distal risk and protective factors may attenuate or exaggerate the risk of progressing along the *suicidal continuum*, from thoughts to behaviour, or from behaviour to death by suicide. The life course model allows for the exploration of early life exposures and developmental factors,

but also to understand potential trajectories through childhood that are influenced by intermediate factors that exaggerate or attenuate the level of suicide risk in adolescence (51,62). These *chains of risk* highlight how risk is accumulated gradually across the life course, and how experiencing certain negative exposures increase the probabilistic risk of further negative exposures. An individual who experienced poverty and social disadvantage in early life, for instance, may have access to fewer educational opportunities, which in turn leads to decreased employment opportunities, lower income, and higher rates of chronic diseases (62). This individual may have a high allostatic load, which is the price the body pays for prolonged exposure to stressful situations because of cumulative damage to the body due to the number and duration of negative exposures (62,64–66). Individuals who have been exposed to chronic stressors experience negative consequences due to over-exposure to stress hormones, which result in various negative outcomes, including earlier aging, more mental illness, increased risk of suicide, and increased odds of various morbidities (66). The differential experiences of allostatic loads and physiological stress may partly explain the gradients in health between rich and poor (66).

The left portion of the conceptual model (Figure 1.1) was drawn from the *Social ecological model*, which highlights that risk and protective factors that influence suicidal thoughts are found at various social ecological levels, ranging from the individual and family to interpersonal and environmental (29,67,68). This is taken from extensive literature showing how risk and protective factors associated with different domains, and the interactions between factors, increase or decrease suicidality in adolescence (see 1.3.2 for more on risk factors for suicide).

A strength of this approach is the ability to acknowledge *risk clustering*. This includes how certain risk factors are socially organized and how certain individuals are likely to experience a number of clustered risk factors. For example, children who live in adverse social circumstances are more likely to have low birth weight, poor nutrition in childhood, and to be exposed to negative environmental exposures like passive tobacco smoke or contaminants (62). Previous research has shown that the accumulation of risk factors may be better able to predict outcomes than a single risk factor (69). Understanding the multiple levels of risk and protective factors, and the underlying theoretical constructs are important to investigating suicidality (70–73).

Figure 1.1 Conceptual Model – Social ecological model of suicidal ideation, behaviours, and suicide



1.3.2 Risk factors and predictive factors for suicidality

“Each way to suicide is its own: intensely private, unknowable and terrible... and any attempt by the living to chart this final terrain of a life can be only a sketch, maddeningly incomplete” (74).

A large body of evidence supports the conceptual model above, which illustrates that there are numerous individual, family, interpersonal, and environmental factors that have been linked to suicidality. Broadly, risk factors can be defined as “a measurable characteristic of an individual, group, or environment that precedes and increases the probability of an outcome” (29,75). Epidemiological risk factor research has been very useful in identifying high-risk persons. This can be used to: increase awareness in high risk groups; encourage help-seeking; target preventative public health interventions; or design treatment programming to promote health and prevent adverse outcomes among high-risk groups (35).

Risk factor research has been common in the suicide literature, and suicide risk assessment has focused on either *distal risk factors* and *chronic risk factors*, which include factors that predispose an individual to suicidal risk; or *proximal risk factors*, also called ‘*triggers*’, ‘*warning signs*’ and ‘*acute risk factors*’, which are factors or conditions that indicate that a suicidal crisis may be imminent (12,35). In this research, only distal risk factors were considered in order to identify which factors may increase vulnerability to suicidal thoughts in the long term. Interestingly, despite this distinction between chronic risk factors and acute warning signs, many risk factors have not been investigated longitudinally to see which are potent years prior to the suicidality and which are most important only in the

time immediately prior to suicidal behaviours. This inquiry is therefore important in order to see if particular characteristics are of concern long before the suicidal events may occur.

Understanding and predicting suicidal thoughts, behaviours, and deaths has proven challenging given the complex aetiology and the interacting biological, psychological, social, and environmental correlates, as well as the interconnected risk and protective factors. Emile Durkheim, one of the first academics to investigate suicide and associated social patterns, identified associations between rates of suicide and levels of social disintegration in certain populations (4,76,77).² Research also supports the life course model, which posits that suicidal ideation and behaviour is a long-term outcome that is influenced by accumulated experiences, beginning in the prenatal stage through childhood, adolescence, and adulthood (4,60). Despite the limitations of existing research, there is emerging consensus that suicidal thoughts and behaviour are linked to risk factors present throughout the life course (60,78). Thus, understanding individual, family, interpersonal, and neighbourhood risk factors that predict suicidal thoughts may lead to the early identification of children who are at highest risk of later suicidality. Further, using a developmental perspective is appropriate for the investigation of suicidal outcomes, as the accumulation of negative or positive exposures throughout childhood and adolescence may act to increase risk or to buffer against harm (61).

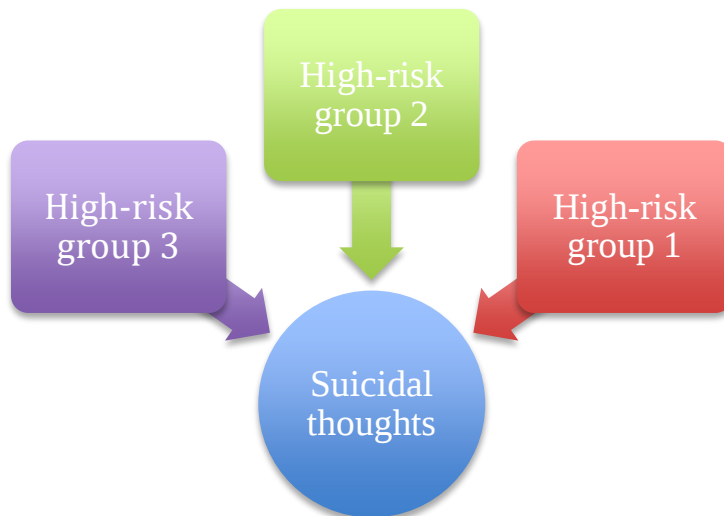
² Emile Durkheim (1951) identified four types of suicide – egotistic, altruistic, anomic, and fatalistic suicides (77). Egotistic suicide is where the individual is socially isolated and lacks community, family, or friends. Altruistic suicide is where an individual's identity is subordinate to the group, as in Kamikaze pilots or suicide bombers. Anomic suicide occurs in response to a crisis with which the person is unable to cope and for which the individual views suicide as the solution. Finally, fatalistic suicide occurs when people believe that their lives are limited by a larger societal situation to such a degree that there is no point to living.

Decades of risk factor research on suicidality have made it clear that there is not one universal set of risk factors or pathway for every suicidal person, but rather have pointed towards the equifinality of suicidal behaviour. In the words of Bertini (2009):

The investigation into the suicidal mind is not a simple one. The path to completed suicide is complex and generally has multiple causes, which culminate in one final act. Each individual who completes suicide has his own unique trajectory which leads him down this path to self-inflicted death.

In this context, equifinality, or the idea that the same result can come from different events, posits that suicidal outcomes may be a common end point that can be predicted by a number of potential developmental pathways (61,79,80).

Figure 1.2 Equifinality of suicidal thoughts



Risk factor research in suicide is not new, so there is a large body of research linking multiple factors to increased odds of suicidal thoughts, behaviour, and/or death by suicide. However, an interesting challenge reflected in previous risk factor research on suicide is that a majority of individuals who die by suicide would be classified as low-risk. This reflects the classical epidemiological and prevention problem with focusing solely on high-risk groups. As demonstrated by Rose (1981) in cardiovascular disease research, low-risk groups produce

up to 90% of cases, as there is a most of the population is classified as low-risk and therefore account for more cases in absolute numbers, while only a small proportion of cases are generated in the high-risk group, as few individuals would be classified as high-risk (81).

In order to assess which factors should be considered for inclusion in the predictive models, a literature review was conducted (see Appendix 2 for more details). There are several factors that have been strongly linked to suicide prediction, which are not relevant to the research question, as they do not occur in the early childhood period. These include diagnosed *mental illness* (60,63,82–93), history of *suicidal ideation and suicidal behaviour* (63,84,94) (95), *education level* (60,83,94,96–98), *age* (63,83,87,99), and *sexual orientation* (12,35,86,94,96,100–105). These factors have all been strongly associated with suicidality partially due to temporal proximity to suicidal events; however, because the focus of this investigation is on factors that are detectable before the age of 5, they are not discussed more thoroughly in this review.

Genetic, prenatal, and postnatal risk factors

Investigation into the pre-and-post-natal periods has revealed that the “seeds” of suicidal vulnerability may be planted very early in development. Increased understanding of early-life development has also uncovered several factors in infancy that have been linked to later suicidality (106). Research has linked neurobiological, genetic, and epigenetic factors to increased odds of suicide, including genetic influences governing serotonin levels and possible epigenetic mechanisms including DNA methylation and histone modifications (12,61,72,106–109).

Low birth weight and prematurity have both been linked to suicidal outcomes (109–111). Research by Blasco-Fontecilla et al (2013) showed that prematurity both increases the

risk of violent suicide attempts with an odds ratio (OR) of 2.38 (95% CI, 1.12-5.08), and additionally, appears to be the first step in a cascade of stressors that increase risk. Maternal substance use during pregnancy, including tobacco and alcohol, have been linked to increased risk of suicidality for the offspring, as has the experience of post-partum depression (112).

Individual-level risk factors

At the individual level, diverse factors have been linked to suicidal outcomes, ranging from demographic factors, behavioural characteristics, and life experiences. At a demographic level, a strong but paradoxical gender effect persists in most studies, which show that females are more likely to report suicidal thoughts but less likely to die by suicide than their male counterparts (17,50,51,54,60,63,87,90,93,99,113–120). There has been much investigation on this interesting relationship, highlighting the effects of gender norms, differential influences of risk and protective factors between girls and boys (both prevalence and strength of risk factors), patterns of help-seeking behaviours, and choice of method for suicidal acts (12,119).

Research has shown that rates of suicidal thoughts and behaviours differ between racial, cultural, or ethnic backgrounds (12,35,54,61,63,101,121–123). Various studies have shown that that ethnic minority groups in North America, including Asians, Blacks, and Hispanics have higher rates of suicidal ideations compared to whites, however other studies have not found race alone to be a significant predictor of suicidal outcomes (13,61). These differences might be explained by different cultural orientations towards suicidal behaviours, and further, might be affected by a variety of risk factors such as racial discrimination, or internalized feelings of social rejection and prejudice (61,106,124). Also, the experience of

being part of a racial/ethnic minority may be related to discrimination or prejudice, which may lead to feelings of social rejection that can be internalized and can create significant issues (12,106,123). In the Canadian context, research suggests that Aboriginal people face higher suicide risk due in part to the colonial legacy and continuing influence of social determinants of health (125).

A number of other factors, including immigration, religious beliefs and practices, and rural or urban residence, have been linked to suicidal outcomes as well. The experience of immigration may also be linked to suicidal outcomes due to acculturative stress, going through a significant change, and experiencing psychological distress associated with the immigration process (123). Religious beliefs and practices have been linked to suicidal outcomes (84,94,126–128). There is some evidence to suggest that suicidal thoughts, behaviours, and deaths might vary by rural or urban area of residence (129). Wagner (2009), for example, showed that the states with low population density had higher suicide rates. The difference in rates of suicidality between rural or urban centres might be linked to social isolation, poverty levels, or provision of mental health services.

Consistently, the strongest predictor of suicidal thoughts and behaviours is the presence of psychopathology, including the diagnosis of a mental illness like depression, anxiety, schizophrenia, psychosis, conduct disorders, and addiction/substance dependence. While these disorders are typically not diagnosed in young children, symptoms of internalizing or externalizing difficulties in early childhood may lead to difficulties in later life, including depression, anxiety, risk-taking behaviours, aggression, and violence (130). Externalizing and internalizing problems have been used to estimate the prevalence of psychiatric difficulties in childhood. Egger & Angold (2006) estimated that 19.5% of preschool children experience mental health problems (131). Behavioural difficulties in early

childhood including aggression/externalizing behaviours (36,63,70,88,94,121,132–136), internalizing behaviours and emotional problems (137,138), and hyperactivity/ inattention (137), have been linked to the later development of psychopathology (more details included in Appendix 2). Additionally, it has been suggested that IQ in childhood is inversely associated with suicidal thoughts and attempts (139).

The experience of chronic illness, pain, or activity limitation during childhood may have an impact on suicidal outcomes (45,60,63,84,94,140). Bertini (2009) suggests that the relationship between childhood chronic conditions and activity limitations to suicidality might be due in part to the influence of familial and parental relationships and the provision of care. In addition to the difficulty the child experienced related to a chronic illness, the child may feel like a burden to the family and thus may have experienced heightened distress, particularly in the absence of a compassionate, supportive, and understanding parental relationship.

A large body of evidence has shown that exposure to stressful life experiences and adverse childhood experiences have been strongly linked to suicidal thought (14,54,60,63,64,84,93,122,141–149). Individual studies have shown the effect of abuse, parental separation or divorce, illness, or death within the family on the development of suicidal ideation and behaviours (see Appendix 2). Additionally, research suggests that exposure to certain stressful experiences, like maltreatment, may be particularly potent in the early life period (from 0-5 years) (149). The importance of stressful life experiences, for all females and for some males, is not surprising, considering the extensive literature on adverse childhood experiences on physical and mental health (150). Afifi et al (2008) showed that having experienced an adverse childhood event accounted for a substantial proportion of suicidal ideation and attempts among both women and men (143). The possible mechanism

underlying this strong association is potentially that the stressful experience affects the development of coping strategies and increases an individual's desire to escape emotional pain (143). Despite the strength of this association, there appear to be several important factors including gender, depression, hopelessness, autonomy, and competence, that moderate the relationship between stressful life events and suicidality (151–153).

Family-level risk factors

The family environment has an important role on the development of a child and also impacts vulnerability to suicidality later in life. A range of parental and familial factors have been linked to suicidal outcomes, including socio-demographic factors, parental age, parental mental and physical health, family composition, parenting style, and family functioning. Measures of the family socioeconomic status, including parental education, employment and income have all been linked to suicidal ideation. Low socioeconomic status, including the experience of poverty or financial adversity, unemployment, and low education levels, have been shown to be a risk factor for mental health concerns, including suicidality (31,50,60,78,82,84,85,87,90,102,115,154–156).

Both young and old maternal age have been weakly linked to suicidal outcomes. Some research has found that having a young mother has potentially negative impacts on her offspring, increasing the risk of suicidal outcomes (109,112). Research by Niederkrotenthaler et al. (2012) found that having a teenage mother significantly increased odds for suicide attempt (OR: 1.66 (95% CI, 1.53-1.80)) (109). Conversely, other research has linked advanced maternal age has also been linked to many negative health outcomes including mental health problems and suicidality (157). These differences might occur because younger mothers and older mothers differ on many characteristics, including access to social and economic resources, stress levels, parenting style and more.

Having a parent with a mental illness or history of suicidality has been shown to be an important predictor of the development of suicidality in children (12,28,60,63,82,90,112,158). The presence of psychopathology in the family might influence the development of suicidality both through genetic and environmental pathways. Research has shown that many mental health problems have a genetic link, which partly explains the link between parental mental illness and subsequent child suicidality. This may be partly due to the heritable link for mental disorders, where genetics and neurobiology confer personality traits which are the foundation upon which the individual develops (72,106). In addition to the role of genetics, the early childhood environment may be operative, and environmental processes may affect early childhood development (158). There is a plausible gene-environment interaction; however, this has not been closely examined in the suicide context. Similarly, research has shown a strong link between a family history of suicide and the development of suicidality. This link may have both an environmental and genetic component partially due to the strong correlation between mental illness and suicidal behaviours (63,82,84,90,94,122). Family concordance for suicidal behaviours is consistent with both genetic and environmental models of suicidality. Indeed, the genetic predisposition to mental illness may increase the odds of suicidal behaviour, as may the modeling of self-destructive or suicidal behaviour (61). Further, parental alcohol or drug use problems have also been linked to increased suicidal ideation and attempts in offspring (60,99,159).

Both family composition and relationships, including family functioning and parenting style, have been linked to suicidal outcomes (34,36,51,60,76,82,86,94,96,97,160–162). Suicidal thoughts and attempts occur at higher rates among those who are living without either biological parent, with only one biological parent, and also among those who experience family disruption due to separation, divorce, incarceration, or death of a parent

(61). Parental divorce during childhood has also been found to increase the odds of suicidal thoughts among certain populations (52,163,164). Additionally, odds of suicidal behaviour were elevated among individuals who have been adopted, compared to those who were not adopted (165).

Family relationships and parenting style, including the presence of family dysfunction, have also been linked to suicidal outcomes. Much of the critical social development of children during early life occurs at the home, thus a large body of research has focused on the influence of the family on the development of suicidal thoughts or behaviours (61). The first five years are a crucial period of brain development and growth, including the development of emotion and behaviour regulation (166,167). Difficulties with social-emotional regulation in early life can persist into adolescence and adulthood, creating ongoing difficulties with mental health (167–169). Parenting style can have a lasting impact on the socio-emotional development of a child. Positive parenting has been associated with positive social-emotional regulation (170) whereas poor attachment relationships in infancy and early childhood have been associated with increased stress reactivity (169,171,172). Positive parenting in early life may provide a child with a foundation for self-worth, where he learns that he is worthy of love; enhancing his resilience when facing challenges (106). Even for those who have experienced sexual abuse, supportive parenting has been shown to be protective for suicidal thoughts, particularly among boys (163). On the other hand, neglectful, aversive, or unavailable parenting styles have been linked to increased suicidality (173,174). Research by Richards (1999) found that more than half of patients who attempted suicide or died by suicide had experienced rejection or abandonment in their early years (175). Many suicidal patients reported feeling disconnected from their parents, which contributed to suicidal thoughts and actions (106). Low maternal responsiveness, including

low availability and low acceptance, as early as age three has been shown to be predictive of suicide attempts in adolescence (176). Further, negative parent-child relationships with low levels of warmth and high levels of criticism have been found more frequently in families of suicidal youths than in control groups (61). Bertini (2009) suggested a plausible mechanism whereby the child craves love and support from his/her caregiver, but it is unattainable, so the child may begin to form negative self-esteem and believe that he/she is not deserving of love and affection. These repeated cycles of seeking love and feeling rejected in the early life period may cement a negative sense of self from early childhood, which carries into adulthood and may lead to low self-worth, depression, or anxiety (106). Additionally, parental inconsistency, hostility, or ineffectiveness can have negative implications for the child (106,173).

Negative family relationships, poor communication, and conflict have all been linked to suicidality. Suicidal adolescents are more likely than their peers to report poor family relationships, higher family dysfunction, and more interpersonal conflict with their parents (12,35). Poor family communication, particularly avoidant or hostile communication, has been linked to suicidality (61). Families that are poor communicators, that are ineffective at problem solving, or that have difficulties dealing with everyday problems and challenges have been linked to increased suicidality (61,177). A lack of family cohesiveness, supportiveness, and flexibility in the face of change have all been shown to predict future suicide attempts (177,178). However, some research shows that family-wide characteristics, like family cohesion or family disorganization, are not as impactful as communication problems or conflict in the parent-teen dyad (61,179). Parent-child conflict and parent-child communication difficulties correspond to increased odds of suicidal thoughts (179,180), and further, good parent-child communication mediates the odds of suicidality among those

exposed to multiple risk factors (179). Levels of parental monitoring have also been linked to a wide range of health and social outcomes (181). High exposure to violent TV as a child may be a marker of low levels of parental monitoring, which may be linked to negative outcomes in adolescence.

Interpersonal and environmental

Beyond the family environment, there is a growing body of evidence around the importance of the social and neighbourhood environment on the socio-emotional development and health of children (182). High social capital, strong social relationships, high feelings of belonging and inclusion, and safe, trustworthy neighborhoods have been linked to a range of positive health and social outcomes (183–185). Social inclusion and participation, including participation in voluntary organizations, has also been linked to reduced suicide risk (156). Research has found that neighbourhood deprivation and low levels of social cohesion was associated with poor mental health, even after adjusting for individual risk factors, possibly due in part to limited access to resources, social norms, or perceptions of danger (182,184). Geographic clustering of suicidal phenomena suggest that there may be contextual influences of the neighbourhood environment, including levels of social cohesion, inclusion, or characteristics of the neighbourhood environment, like lack of resources, high levels of disruption, or low levels of perceived safety (98). Relatedly, suicide tends to cluster in disadvantaged neighbourhoods, and neighbourhood poverty has been found to be significantly associated with both suicidal thoughts and attempts (186).

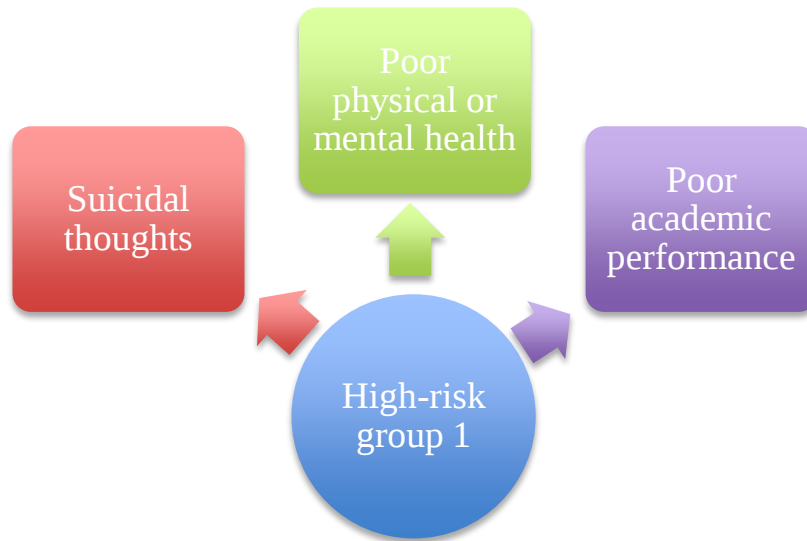
1.4 Predicting other outcomes in adolescence

These risk factors may shed light on suicidal thoughts, but they may also be shared with other mental, emotional, and behavioural difficulties during adolescence. Just as it is

important to consider multiple risk factors in order to better understand and predict suicidality, the field of prevention science shows that the same risk factors affect multiple outcomes (69). Investigating the universality of risk factors to multiple negative outcomes in adolescence provides a more fulsome understanding of the developmental process (69). Similar risk factors, including stressful life events, socio-economic disadvantage, and family or community dysfunction, have been linked to multiple psychopathological conditions, including mental illnesses, antisocial problems, low academic achievement, and substance misuse (29,187). For example, experiencing childhood trauma, including witnessing violence, experiencing abuse, or living with mentally ill family members has been linked to a range of negative outcomes later in life, including substance misuse, mental illness, and suicide attempts (29,188).

The biopsychosocial processes that lead to these disorders are not fully understood. However, considerable research has shown that the healthy development of mental, emotional, or behavioural processes is dependent on complex interactions that play out at every socio-ecological level to alter developmental trajectories and increase or decrease the risk of developing difficulties in adolescence or adulthood (29). In other words, “many of the family risk factors for suicidal behaviours are not unique to families of suicidal youth but instead are shared by families of youths with other disorders” (61). This idea is consistent with the idea of multifinality, which holds that given risk conditions can lead to several different outcomes due to interconnected developmental processes (61,80). Multifinality shows that a number of negative characteristics of the individual, family, school, or neighbourhood can lead to a number of negative outcomes, including suicidal behaviour, poor mental or physical health, poor academic performance, and others (80).

Figure 1.3 Multifinality with of high-risk subgroups



Thus, variables that predict suicidal outcomes may be understood as markers of a difficult early life and therefore may also predict other negative adolescent outcomes. If this research finds that there are common risk factors between suicidal thoughts and other adverse outcomes in adolescence, there may be an opportunity to investigate how high-risk subgroups can be targeted with interventions and support which may prevent multiple adverse outcomes and enhance overall health and social outcomes in adolescence.

1.5 Importance of the early life period for development of suicidality

The early life period is important developmentally, as it lays the foundation for health and well-being throughout the life course (189,190). Early childhood experiences play an important role in brain development and growth, and research has shown that patterns of neural connectivity are developed in this period, which create patterns for health and learning throughout childhood, adolescence, and adulthood (191,192). Research has also shown that difficulties in early childhood may become entrenched, manifesting as mental difficulties later in life (193,194). Early signs of difficulties are apparent at a very early age: parents

often report concerns before age 5 (29). Further, according to Durkheim, the social factors that influence individuals to suicide “only gradually penetrates them,” accumulating across the life course, meaning that early life conditions have long-term implications (156,195).

From a practical standpoint, most children enter school at 4-5 years of age, which represents an opportunity for identification of high-risk subgroups as well as possible intervention points for those who are at increased risk. The use of the school setting for universal screening programs has become increasingly common. This research provides evidence on the accuracy of screening for adolescent difficulties based on early-life factors, but there are many additional considerations to investigate before recommending universal screening programs at school entry.

1.6 Tree-based modeling for predicting suicidal thoughts

Previous investigation into risk factors for suicidality have shown that there is not one uniform set of risk factors applicable to all cases of suicidal thoughts or behaviours. There may be unique groups of risk factors or interactions between variables that better illustrate the predictors of suicidal thoughts. In order to simultaneously consider the influence and interaction of numerous variables, non-traditional modeling approaches were used. Decision tree approaches have the capacity to model non-parametric, high-order interactions through recursively partitioning the sample in order to identify the profiles of adolescent sub-groups that differ in terms of risk of suicidal thoughts. Decision trees are powerful tools that have many benefits over traditional logistic or linear regression models for the development of prediction rules, although they do have some limitations.

Tree-based approaches have been successfully used for many applications and are preferred to other statistical methods like linear or logistic regression analysis because they

have no distributional assumptions, they are able to detect high-level interactions, they are robust to outliers, and the results are presented in an intuitive and interpretable format. The decision tree method, including Chi-square interaction detection (CHID) trees and Classification and Regression Trees (CART), does not require distributional assumptions, including the normal distribution of variables (196–200). Thus, the flexibility and non-parametric nature of tree models makes them attractive tools for building models with high face validity that could be easily applied in clinical settings or to describe real-world situations (197). In addition to not requiring strong distributional assumptions, tree models are well-suited for exploratory research with non-linear data, as the models are able to identify the most significant variables and eliminate those that are not significant (14,200). Another major strength of tree models is that they are able to discover and describe complex interactions between independent variables (197,198,201,202). Due to this sensitivity to higher order interactions, tree models are appropriate for this research, as the objective is to detect interactions between independent variables in order to discuss the many different combinations of variables that can determine subgroups that have high, medium, or low risk of suicide thoughts (201). A further advantage of tree models over traditional regression analysis is the robustness to outliers and the ability to handle noisy data. Outliers can be split into a separate node, which then do not decrease the accuracy of the overall model (200). Finally, tree models are preferred to other multilevel modeling due to the graphic, intuitive, and easily interpretable presentation of results. Even complicated tree models are presented in a way that facilitates the interpretability and comprehension of the results (14,196,201,203). The contingent nature of tree models follows the same logic as clinical assessment tools, where the sequence of questions depend on the answers to the prior questions (201,204,205). The success of decision trees in clinical medical practice, like the

Ottawa Ankle Rules, suggest that classification trees may be feasible screening tools, particularly when assisted by computerized technology (206–208). This makes tree models easy to interpret in practice, particularly when compared to other forms of multivariate analysis (199).

Previous research has shown that decision tree models, including Iterative Classification Trees (ICT) or CART are flexible and powerful modeling tools that have allowed investigation of complex relationships, development of predictive models, and creation of clinical screening tools (209,210). Researchers have used ICTs to assess violence risk in order to develop a nuanced and interactive understanding of the causal processes of violence, ultimately leading to the development of clinically useful tools for use in violence risk assessment (201,205,211). CART models have also been used to show the complex interplay of factors associated with cancer reduction, since CART is able to identify interactions between ecological factors in order to identify priority subgroups (212). Schennach (2012) used CART model techniques to show the predictor of better treatment trajectories which allowed the researchers to analyze a variety of socio-demographic and clinical variables in order to predict treatment trajectories (213). Eaton et al (2013) used a similar methodology to understand comorbid mental and behavioural disorders (202). Computerized ICT methods have also been implemented by the Correctional Service of Canada to detect the mental health needs of offenders, detecting fewer false positives and a comparable number of false negatives as standard binary screening (204). Recursive partitioning methods were used in the development of the Ottawa Ankle Rules, which have been successfully integrated into clinical practice to predict fractures in patients with ankle injuries (206–208).

Despite these advantages to tree-based approaches and a history going back over 30 years, decision tree methodology had not gained wide-spread popularity in the epidemiological literature until recently. Given the complex relationships between the numerous factors associated with risk of suicidal thoughts, decision tree models may be useful in identifying groups at high risk of suicidal thoughts.

1.7 Aim and objectives

This research investigated the early life predictors of adolescent suicidality. Building from risk factor literature, this research used modeling techniques to investigate the association between factors present at elementary school entry and suicidal thoughts in adolescence. Additionally, this research applied the risk classification from the models to see if the models built to predict suicidal thoughts may also be able to predict other adverse outcomes in adolescence. This research also compared two approaches to building tree models and regression-based model building to compare the strengths of each approach. Predictive models were built using Canadian longitudinal data and validated in a British longitudinal cohort.

Objective 1:

Research question: Are there identifiable groups of individuals that are at increased risk for adolescent suicidal thoughts based on groups of factors identifiable in early childhood?

Hypothesis: Factors present at school entry predict later suicidal thoughts, particularly among those with multiple signs of adversity. While much suicide prediction research has focused on proximal risk factors, developmental theories of disease and illness suggest that the precursors of psychiatric distress and suicidal ideation may be present in early life.

Objective 2:

Research question: Are these measures of a difficult early life also predictors of other negative health and social outcomes in adolescence?

Hypothesis: The factors that predict adolescent suicidality may also predict other negative outcomes during adolescence, including antisocial behaviours and problematic alcohol or substance use.

Objective 3:

Research question: Do tree models have an advantage over logistic regression in predicting suicidal thoughts and further, is there a preferred methodological approach to building tree models in this context?

Hypothesis: Assuming that there are several different “ways” by which an individual may experience increased risk, theoretically the methods that can account for multiple interactions will likely prove to be better at predicting suicidal outcomes. Further, while there is some debate about the most appropriate methodological approach to building predictive trees, they have underlying theoretical similarities and thus may not prove to provide dramatically different results.

Objective 4:

Research Question: Are the predictive models valid in a second cohort and able to accurately predict suicidal thoughts in adolescence?

Hypothesis: While prediction rules frequently do not perform as well in a different cohort than the one from which they were originally defined, high-risk groups will still be identifiable in a second cohort based on predictive models derived from the first cohort.

What gap is this filling:

Past research has shown that suicidal thoughts, behaviours, and deaths are complex phenomena, resulting from multiple factors. Even in light of a rich body of risk factor

research on suicidality, to date, few studies have considered the risk factors simultaneously in order to detect high-risk groups. While research has linked a multitude of factors to suicidality, a limitation of much of the risk factor research is that there is a tendency to consider a small number of covariates. This approach does not adequately account for the dose-response relationship between the number of adversities experienced and the probability of adolescent suicidality or the interplay between risk and protective factors (94,142). Analysis must be able to account for this complexity in order to estimate the predictive probability of adolescent suicidality.

This approach allowed for the consideration of both individual and environmental factors that are associated with the development of suicidal thoughts, and it has shed light on the organization and interaction of these factors in order to detect increased risk for suicidality (214). Decision tree analysis was used to identify the profiles of groups of adolescents based on their risk of suicidal ideation.

A further limitation of some of the association studies based on cross-sectional data is that it is difficult to disentangle the relationship between risk factors and suicidal outcomes when studied at a single point in time, as the temporal sequencing of these factors is not clear (36). Taking a longitudinal approach to the study of suicidal ideation is important to understand its predictive factors. This research used longitudinal data, which fills a gap identified by Waldrop (2007): “future studies should utilize longitudinal designs to identify more carefully subgroups of adolescents who are at risk for future suicide attempts” (99).

While the predictive value of early life factors may be lower than factors more proximally associated with suicidal ideation, investigating early life predictors created an opportunity for upstream interventions to be developed that target individuals or groups most at risk of later suicidal thoughts. Information about individual, family, or environmental risk

factors for suicide and other negative health outcomes may provide useful information in the development of prevention strategies for children identified as high risk (99). This has particular potential if the research is able to support the multifinality hypothesis, which may provide a rationale to expand from a narrow focus on suicide prevention and instead focus on assisting children and youth at increased risk in order to enhance multiple health outcomes, potentially providing support for comprehensive intervention programs.

From a methodological perspective, this research compared the use of tree models (both Chi-square Interaction Detection and Classification and Regression Trees) and logistic regression in order to discuss the differences between these approaches and the appropriateness of these statistical methods for investigating this research question.

Chapter 2: Methods – NLSCY analysis

2.1 Study design

The *National Longitudinal Survey of Children and Youth* (NLSCY) was used for the first three objectives in this research project. The NLSCY, conducted by Statistics Canada and Human Resources and Skills Development Canada, was a long-term study of Canadian children which followed their development from childhood (between 0 and 11 years of age) to early adulthood (215). It started in 1994/1995 (Cycle 1) and collected information biennially on health, physical development, social environment, and general well-being until 2008/2009 (Cycle 8) (215). The survey includes children from Canada's ten provinces, excluding children living on reserves or crown lands, residents of institutions, full-time members of the Canadian Armed Forces, and residents of some remote regions and representative of Canadian children and youth at the initiation of the study.

The NLSCY uses a complex survey design, based on the Labour Force Survey's sampling frame. For the first collection, 25,000 children between 0-11 were selected from the 10 provinces, plus 2,300 from the territories (216). In the study design, each province constituted an independent sample, and the sample was allocated to ensure there was sufficient numbers in each province to provide reliable provincial estimates for all children. The multi-stage cluster design meant the data were clustered in a hierarchal way, where each province was broken down into two parts – large cities and rural or small urban areas. Within these strata, clusters of dwellings were identified (including city blocks) and households were selected from these clusters (219). In order to maintain an emphasis on young children, this sample was divided into 7 age groups (0-11 months, 1 year, 2-3 years, 4-5 years, 6-7 years, 8-9 years, and 10-11 years) to ensure that nationally representative estimates could be

derived in each age group for characteristics that had a minimum prevalence of 4% (217,218).

The study was conducted in eight cycles and consists of a number of components. These include a *child component* for 0-11 year olds, where the respondent is the person most knowledgeable (PMK) about the child, which was usually the mother (in cycle 1, 91.3% of the PMK was the mother); an *adult/general component* completed by the PMK or the spouse of the PMK for children; a *self-completed questionnaire* for 10-17 year olds; a series of *cognitive tests* testing learning and development at various ages; and finally a *youth component* completed by youth ages 16 and above (215,217,220–225). For more details about the NLSCY, see Appendix 3.

2.2 Study population

For this study, participants aged 0-5 years in cycle 1 were included and followed through the remaining cycles until age 14-19.

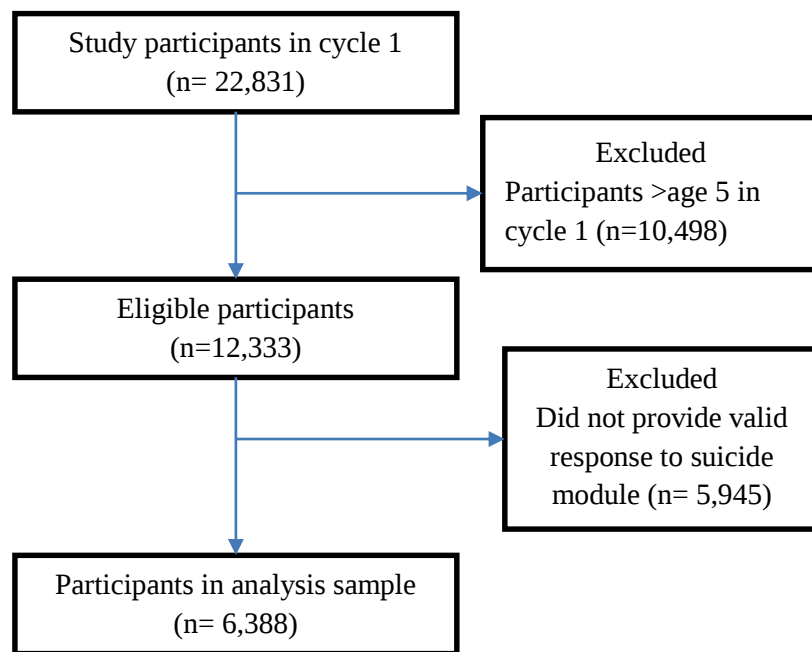
Table 2.1 NLSCY cycles, years, participant ages, and measures

Cycle	Year	Participant ages	What is measured
Cycle 1	1994	0-5	Predictors for participants aged 0-5
Cycle 2	1996	2-7	Predictors for participants 2-5 years
Cycle 3	1998	4-9	Predictors for participants aged 4-5 years.
Cycle 4	2000	6-11	N/A
Cycle 5	2002	8-13	Outcomes for participants aged 12-13
Cycle 6	2004	10-15	Outcomes for participants aged 12-15
Cycle 7	2006	12-17	Outcomes for participants aged 12-17
Cycle 8	2008	14-19	Outcomes for participants aged 14-19

In order to answer the study objective, this cohort was chosen based on the availability of predictive factors in early life and participation in the later self-completed surveys for youth. This cohort was selected because they were asked questions about both early life

characteristics and conditions, and adolescent outcomes, including at least one response to the suicide questionnaire, which is asked of participants starting at age 12. The unweighted sample size for this study was 6,388.

Figure 2.1 Study population and analysis cohort, NLSCY CONSORT flow diagram



In total, 15,579 households were selected to participate in the NLSCY. Out of these selected households a response was obtained for 13,439 which results in an overall response rate of 86.3% (221). Participants over the age of 5 in cycle 1 were excluded, as were those who did not have at least one valid response to the suicidal ideation question during cycles 5, 6, 7, or 8.

2.3 Materials

2.3.1 Predictors

Predictor Variables: This research considered 75 possible risk and protective factors in the pre- and post-natal, individual, familiar, interpersonal, and environmental domains for inclusion in the predictive model. Predictive factors included information collected from the

mother and direct measures, focusing on information collected at ages 4 and 5 as well as important information from early life that could be recalled in a screening situation.

For some measures, any experience with the factor during the predictor cycles 1-3 was considered to be exposure (for example, any reporting of low income during the first 5 years of life was coded as experiencing poverty). For other measures that were asked during multiple cycles, only the response solicited when the child was 4-5 years old was included in the model (for example, child's general health was measured in multiple cycles, but for the purpose of this model, only the measure taken at 4-5 years was considered).

All predictors were dichotomized (yes/no) with an additional category for missing data. For several of the predictors with a small number of missing values (<4%), instead of coding a missing category, missing values were combined with the "no" category. For example, those who reported being an immigrant were coded as 1, and those who did not report immigrant status (either said 'no' or did not provide a response) were not considered to be an immigrant. The following are the variables for which "missing" values were combined with those who responded "no": race=white (n=170, 2.7%), race=aboriginal (n=170, 2.7%), immigration (n=5, 0%), child general health (n=193, 3.0%), physical activity (n=200, 3.1%), chronic conditions (n=60, 0.9%), pain and discomfort (n=203, 3.2%), activity limitation (n=203, 3.2%), injuries (n=197, 3.1%), teenage status of parents at birth (n=127, 2.0%), PMK immigrant status (n=24, 0.4%), college/university graduate (n=1, 0.0%), single parent status (n=237, 3.7%), intact family (n=110, 1.7%). This decision to group 'no' and 'missing' did not change the most predictive variable splits. See Appendix 4 for details about predictor variables and how they were dichotomized.

Pre- and post-natal predictors

Due to the link between pre- and post-natal factors and suicidal outcomes in later life, 11 predictors measuring aspects of the pre- and post-natal period were included in the predictive models, including prenatal medical problems, prenatal substance use (smoking cigarettes, drinking alcohol, prescription drug use, over-the-counter (OTC) drug use), low birth weight, prematurity, infant special medical care after birth, maternal hospitalization after birth, post-partum depression, and breastfeeding.

Individual predictors

A large body of research discusses the numerous individual factors that have been linked to later suicidal ideation and behaviours. These include socio-demographic factors, including gender, racial/ethnic background, immigrant status, and rural/urban residence. While considering racial background, including Aboriginal status, is important to note that the sampling frame of the NLSCY excluded Aboriginal peoples living on reserve. As such, this variable provides an incomplete picture of Canadian Aboriginal people and may not fully represent the differential risks of suicidality faced by Aboriginal peoples.

The presence of psychopathology has been shown to a strong predictor of suicidal ideation; however considering the appearance of these disorders later in childhood, adolescence, or adulthood, the individual's experience of a mental illness will not be included as a predictor in the model. Instead, symptoms of internalizing and externalizing difficulties were included, as they may be precursors to later difficulties. Mothers were asked to report on the child's behaviour at age 4-5, as measured by behaviour scales that estimate internalizing problems/hyperactivity, conduct problems/externalizing behaviour, indirect aggression, anxiety/emotional disorders, and prosocial behaviours. More details about the behaviour scale are in Appendix 4. Other measures of health status were also included,

including child's general health, physical inactivity, presence of chronic conditions, report of pain and discomfort, injuries, and presence of activity limitation at age 4-5. To get a measure of participation in activities outside the home, mothers were asked a series of questions about their child's participation in various activities, including early childhood activities, sports (with or without a coach), gymnastics, dance, arts, drama, music, guides, scouts and/or other clubs. Also, to get a measure of school readiness, cognitive function, and developmental delay, 4-5 year old children completed the age-standardized Peabody Picture Vocabulary Test – Revised (PPVT-R).

Stressful life experiences were also measured throughout early childhood. At each measurement occasion, mothers were asked to report if their child had experienced any events that caused stress or worry. Those who reported a stressful event were further asked to indicate the cause of the stressful event experienced, including death of a parent, death of a family member, divorce or separation, move, hospital stay, other separation from parents, injury or illness of the child, injury or illness of family member, abuse or fear of abuse, change in household members, alcoholism, mental health problem in the family, and/or conflict between parents. Participants were classified as 'yes' to any of these stressful life events reported and 'no' to ones the mothers did not report. Mothers were also asked to report on the child's exposure to adults hitting/fighting, or if the child was exposed to violence on TV.

Family predictors

Family composition, relationships, and parenting have also been the focus of much suicide research and there are a number of factors that have been linked to increased rates of suicidal ideation, behaviours, and deaths. Demographic characteristics of the parents were measured throughout early childhood (0 – 5 years), including age of biological parents at

birth, the age group of the mother, socioeconomic status (as measured by the ratio of the household income to the low-income cut-off), education level, employment status, housing tenure (rented vs. owned), immigrant status of the mother, and religious affiliation and participation in religious activities. Family structure was also measured using two variables: single parent status and intact vs. blended family status.

Parental health was also considered as a predictor for the model, including parental general health, presence of chronic conditions, activity limitation for the mother and her spouse/partner, and parental smoking and binge drinking. Maternal depression was also measured using the reduced version of Radloff's National Institute of Mental Health's Centre for Epidemiological Studies Depression scale (CES-D).

Parenting style was also assessed using parenting scales, which have several sub-scales. Parenting style was characterized by level of positive interactions between parent and child, level of inconsistency in parenting, use of a hostile/ineffective parenting style, or use of a punitive/aversive parenting style. A global assessment of family functioning was also included to measure level of dysfunction.

Interpersonal predictors

Several measures of interpersonal relationships were included as potential predictors, as there is a large body of evidence linking social relationships and social skills to suicidal outcomes. Predictors included perceived social support as reported by mother or the spouse/partner, changes in childcare arrangements, parental participation in volunteer activities, and a measure of the child's social skills, as reported by their teacher.

Environmental predictors

Two measures of neighborhood environment were included as possible predictors in the models, including a measure of neighbourhood cohesion and a measure of neighbourhood safety.

2.3.2 Primary outcome – suicidal ideation

Suicidal ideation: Beginning at age 12, study participants were asked “In the past 12 months, did you *seriously* consider attempting suicide [emphasis in the original]?” (yes = 1, no = 0). This question was part of a series of questions about suicide and was adapted from the British Columbia Adolescent Health Survey (223).

2.3.3 Secondary outcomes – negative health and social outcomes

The predictive factors for suicidal thoughts might be markers of a difficult life for children, and might be able to predict other negative health and social outcomes in adolescence. Thus, secondary outcomes were considered, estimating other adverse outcomes in adolescence, including antisocial behaviour, substance misuse, poor physical health, poor mental health, risky health behaviours, and poor academic performance. These were also asked in the self-complete questionnaire by the youth, and are defined below. Additional details on the questions and coding are included in Appendix 5.

Antisocial behaviour: Antisocial, risky, or illegal behaviours were assessed using the ‘Risky Behaviours’ questionnaire included on the NLSCY. Participants were asked how frequently in the past 12 months they ‘were questioned by the police’, ‘ran away from home’, ‘stayed out all night without permission’, and ‘intentionally damaged or destroyed anything that didn’t belong to you’. For these four items, 1= ‘3 or 4 times’ or ‘5 times or more’ and 2= ‘never’ or ‘once or twice’. Participants were also asked if they ‘fought with

someone to the point where they needed to care for their injuries’, ‘carried a weapon for the purpose of defending yourself or used it in a fight’, ‘sold any drugs’, ‘attempted to touch anyone in a sexual way while knowing they would probably object to this’, and ‘were part of a gang that broke the law’. For these items, any report (‘once or twice’, ‘3 or 4 times’, ‘5 times or more’) was coded as 1 and ‘never’ as 2.

Substance misuse: Participants were asked a series of questions about substance use. Participants were considered to have substance misuse if they endorsed use of the following substances at the following frequencies: cigarettes (daily or weekly use), alcohol (daily or weekly use), marijuana (once or twice a month or more frequently), hallucinogens (ever used), glue (ever used), prescription medications to get high (ever used), or other drugs such as ecstasy, crack, cocaine, heroin, and speed (ever used). Any participant reporting use of at least one of the above substances were coded as 1 while those who did not report substance misuse were coded as 2.

Poor physical health: Participants were asked to report on their general health as well as the frequency of common physical health complaints, including headache, stomachache, and backache. Those who reported their general health to be “fair” or “poor” were considered to have poor health (coded as 1), as were anyone who reported headaches and/or stomachaches and/or backaches “most days.”

Poor mental health: Participants were asked a series of questions on symptoms of depression and anxiety, and derived depression and anxiety scores were generated. Participants scoring above the thresholds for either disorder, meaning 9-36 on the depression scale, or 8-16 on the anxiety and emotional disorders scale, indicates that the participant has symptoms consistent with a clinical diagnosis of depression or anxiety from the DSM-IV

(226). Those with depression, anxiety, or both were coded as 1, while those who had scores below the cut-off for both disorders were coded as 2.

Risky health behaviours: Several items were used to categorize participants as participating in risky health behaviours, including ‘operated a motor vehicle after drinking or doing drugs’ (‘3 or 4 times’ or ‘5 times or more’), ‘being a passenger in a vehicle after the driver drank or used drugs’ (‘3 or 4 times’, ‘5 times or more’), ‘use a seat belt when riding in a car’ (‘seldom/never’, ‘no seatbelt where I sit’), ‘have sexual intercourse without protection’ (“yes” – asked of 16-19 year olds), or ‘use a condom during sexual intercourse last time’ (“no” – asked of 14-15 year olds).

Poor academic outcomes: Participants were classified as having poor academic outcomes if they felt they were doing ‘poorly’ in their school work or if they reported any of the following items at the listed frequencies: ‘skipped a day of school without permission’ (‘3 or 4 times’, ‘5 times or more’), ‘been suspended from school’ (‘once or twice’, ‘3 or 4 times’, ‘5 times or more’), ‘dropped out of school’ (‘yes’).

2.4 Statistical analysis

Recursively-partitioned tree-based models were built in order to find the best combination of predictor variables that predict suicidal ideation in adolescence. First, a Chi-Square Interaction Detection (CHID) tree was built and second, a Classification and Regression Trees (CART) model was built. A logistic regression model, using stepwise selection was also built to compare tree-based methods to more traditional statistical modeling.

Decision trees models are composed of a root (or “parent”) node that includes the entire sample of participants, which is split into two child nodes based on the predictor (the

independent variable) that best explains variance in the dependent variable and is able to divide the population into a group with or without suicidal ideation. These child nodes, in turn, become parent nodes and the recursive binary segmentation is continued in each of the branches, continuing to divide each parent node into two (or more) child nodes until a stopping rule has been met or until there is no further gain in predictive efficiency/ability. One of the most common stopping rules in the literature is to set the minimum number of participants in each node to avoid over-fitting the model. Conventionally, the minimum node sides ($n_{\min}$) is often set to 5, however, there are many examples where the minimum number of participants is increased in order to increase the accuracy of the model (14). The final node is called the “terminal node” and it represents the overall profile of a unique subgroup of individuals. From a statistical perspective, decision trees represent multiple interactions between independent variables, where as you move further from the root node, the higher the order of interaction (198). Thus, the decision tree approach allows you to consider the interactions between multiple independent variables in order to explain the variance in the dependent variable. However, the main disadvantage of tree-based approaches is that they tend to over-fit models to the data and they may create unstable trees, meaning minor modifications to the sample might lead to dramatic changes in the decision tree (200).

Two approaches to building decision trees are Chi-square interaction detection (CHID) and Classification and Regression Trees (CART). While the underlying basic format of the trees is the same (as described above), the statistic used to determine splits varies between these two approaches. In CHID, each parent node is split based on the variable with the largest Chi-square value in order to divide the parent node into two groups that differ with respect to the dependent variable, with splitting rules about the required significance level and minimum node sizes to determine when to split and when to stop. This approach

has been used to create manual trees (204) and it has been incorporated in some statistical packages to be automatically generated, including SPSS's Chi-square automatic interaction detection (CHIAD) analysis tool (201). In contrast, CART models are built using an impurity statistic (usually the Gini impurity statistic) in order to determine which variable would minimize the node impurity or heterogeneity in the child nodes (203). The Gini statistic aims to maximize the homogeneity in the child nodes and chooses the variable that is able to decrease heterogeneity the most. This approach closely aligns with the methodology initially proposed by Brieman et al (1974) in the seminal work on decision tree modeling. CART modeling is done through automatic software packages, including R and SPSS. CART models are also able to include continuous variables, and the most predictive cut-off points to be identified using receiver operator characteristic curves that balance sensitivity and specificity groups (227). Additionally, CHID and CART differ in the treatment of missing data. CART software keeps missing data with the majority, while manual CHID has the advantage of keeping missing data separate as an informative category in the model. This is useful as the missing category for some variables may have unique characteristics that are interesting to investigate and meaningful in real-world settings. While these approaches are similar and may result in similar models, some have argued that the use of the Gini statistic is more replicable and more non-parametric than the use of the Chi-square statistic for determining splits, because Chi-square interaction detection trees are not distribution-free as CART models. Thus some have argued that CART models provide an improvement to Chi-square interaction detection approaches (228). Further, the automatic CART models have additional features including the use of surrogate splits and automated pruning features, which may increase the replicability of the results. It has been suggested that Chi-squared approaches are more useful for describing relationships whereas CART approaches are better

suited to creating predictive models; however, theoretically, the increase in homogeneity measured by the Gini should be basically proportional to the Chi-square statistic of independence, making this distinction between “prediction” and “explanation” somewhat superficial. In this research, both CHID and CART were used and the models were compared. The true predictive value of these approaches were assessed using independent data from the data used to build the models, to uncover any relative advantage of one approach over the other (200). They will also be compared to traditional stepwise regression in order to see if in the prediction of suicidal thoughts using non-parametric approaches had an advantage over traditional regression models.

2.4.1 Chi-square interaction detection in SAS

For this analysis, classification trees were built using Chi-square values to determine the significant predictors for the model splits. The following splitting and stopping rules were established to guide model building:

- To avoid over-fitting the model, the smallest allowable child node ($n_{\min}$) was set at 64 individuals, representing approximately 1% of the overall sample (200,204).
- The minimum size of a parent node to permit further splitting was set at 128 individuals or $2 \times n_{\min}$.

These rules are more conservative than much of the literature, where the minimum child node size has been set at 5-10 participants (14). These minimum node sizes also follow the disclosure guidelines for NLSCY data, which require minimum group sizes for estimates to be of acceptable quality for release (221).

All of the potential predictors were entered into the model and Chi-square tests were run for each of the possible predictors. The predictor with the largest Chi-square value (and

p-value <0.05) was selected to split the first parent node into two child nodes. If the largest predictor created an inadmissible split (by creating a child node with fewer than 64 individuals), the next largest predictor was selected. This process was continued until no additional segmentation was possible, arriving at terminal nodes.

The maximal model was built, splitting all parent nodes until no further splits were possible. In the maximal tree, terminal nodes were assessed as ‘high’, ‘moderate’, or ‘low’ risk of suicidal thoughts. As there is no agreed rating system for establishing the severity of suicide risk and suicide ideation, nodes with greater than twice the base prevalence rate of suicidal ideation were designated as ‘high risk.’ Similarly, nodes with less than half (50%) the base rate of suicidal ideation were deemed ‘low risk’, and finally, any nodes with prevalence of suicidal ideation between these two cut-offs were said to have ‘moderate’ or average risk of suicidal ideation (35). This use of two cut offs was described by Monahan et al (2000) and was also used by Afonso et al (2012) to stratify patients into high, moderate, and low risk groups (197,201).

Branches of the tree were pruned from the maximal model based on predictive efficiency and clinical significance so that if the subsequent splits did not change the designation of the nodes between these three levels, the tree was pruned back to the parent node after which no further differentiation in level of risk occurred in the child nodes. For example, if the parent node was designated as “low risk” and all the splits following that node continued to differentiate the child nodes all at “low risk” as well, the tree was pruned to the parent node. This use of manual splitting was described by Afonso et al (2012) (197). For this analysis, SAS version 9.3 was used (229).

2.4.2 Classification and regression trees in R

In order to compare the different approaches to tree-building, Classification and Regression Tree (CART) models were built using the RPART program in R. This process aimed to maximize the homogeneity of the child nodes and used the Gini coefficient to measure the impurity of parent nodes. The Gini measures the distribution of the dependent variable class within each node. With maximal impurity, the node is completely mixed, and includes individuals with and without the outcome, while a completely pure node only has individuals with one class (230). The goal of splitting is to divide the sample into pure, homogeneous nodes that contain only individuals with one outcome for the dependent variable, which, in this case means moving toward nodes that only contain individuals with suicidal thoughts and other nodes that only contain individuals who do not have suicidal thoughts. The variable that was selected at each split is the one that maximizes the homogeneity of the child nodes, resulting in the largest change in the impurity level (200). The RPART program automatically considers all possible variables and selects the one that would maximize the change in impurity for each split. In order to be comparable to the CHID tree, $n_{\min}$ was set at 64 and after the maximal tree was built, manual pruning, as described above, was used to prune branches back to where they no longer differentiated between ‘high’, ‘medium’ or ‘low’ risk. This analysis was completed using R version 3.0.3, and the RPART package (231).

2.4.3 Logistic regression using stepwise model building in SAS

The 76 predictors were entered into a multiple logistic regression model to see what the best fit was and to assess the strength of prediction between using multiple logistic regression methods versus a decision tree. PROC LOGISTIC was used to create a model

using stepwise selection, modeling suicidal ideation as the outcome of interest. Stepwise regression models were created and model fit was confirmed with the Hosmer-Lemeshow goodness-of-fit test. These covariates included in the stepwise regression model were compared to those included in a backward selection model to ensure the model results were stable (results not shown). For this analysis, SAS version 9.3 was used (229).

2.5 Statistical tools, weights, outcomes, and exposures

Analysis was conducted using SAS version 9.3 (229) and R version 3.0.3 (231). As the NLSCY was a probability sample, sample weights were used to make effective use of the data and to generate valid estimates. Both CHID and CART models were conducted using longitudinal weights for the calculation of the prevalence of suicidal thoughts and the Chi-square values for the predictors. The last available longitudinal weight was used for each participant. Longitudinal weights for cycle 8 were used for all those who were included in the last cycle. For those who did not participate in cycle 8, longitudinal weights were calculated based on the last available survey point (cycle 7, cycle 6, or cycle 5). The longitudinal weighting strategy from Statistics Canada was based on a series of cascaded adjustments, where the initial weight was adjusted for non-response and post-stratification to generate the longitudinal weights (225).

Based on the final tree results, the sensitivity, specificity, positive predictive value, and negative predictive value was calculated based on high-risk vs. not high-risk, as classified by the models. Additionally, using the high-risk cut-off, calculated in the previous analysis, the sensitivity, specificity, positive predictive value and negative predictive value was calculated for the use of the models in predicting other adverse outcomes in adolescence,

including antisocial behaviour, substance misuse, poor physical health, poor mental health, risky health behaviours, and poor academic performance.

2.6 Ethics approval

Research was approved by Ottawa Health Science Network Research Ethics Board (Appendix 3).

Chapter 3: Results

3.1 NLSCY Descriptive statistics

The final sample size was 6,388 and the prevalence of reported suicidal ideation was 12.0% (weighted). Of the study sample, 49.5% were girls and 50.6% were boys. Suicidal ideation was higher among girls (15.6%) compared to boys (8.5%). The prevalence of suicidal ideation varied according to most of the predictor variables. Table 3.1 shows more detailed demographic characteristics of the study population, important risk factors, and the weighted proportion with suicidal ideation according to key factors.

Table 3.1 Demographic and health characteristics of population in the NLSCY, n=6,388

		Time of data collection	N (un- weighted)	% (weighted)	% (weighted) with suicidal ideation (SI)
Gender	Girl	Study enrollment	3,190	49.5	15.6
	Boy		3,198	50.5	8.5
Prenatal problems		Cycle 1			
	Yes – at least one		741	8.0	11.9
	No problems		1,517	18.6	8.4
	Missing		4,130	73.4	12.9
Use of over-the-counter drugs during pregnancy		Cycle 1			
	Yes		676	7.6	10.8
	No		1,583	19.0	8.9
	Missing		4,129	73.4	12.9
Breastfeeding		Cycle 1, 2			
	Yes – was breastfed		1,884	22.7	8.9
	No – never breastfed		589	6.7	11.0
	Missing		3,915	70.6	13.1
Child injured		4-5 years			
	Yes		626	9.2	14.2
	No		5,762	90.8	11.8
Child has a condition that prevents/limits participation		4-5 years			
	Yes		167	3.2	20.9
	No		6,221	96.8	11.7
Child's development (PPVT score)		4-5 years			
	Delayed development		2,433	45.0	12.0
	Normal development		3,955	54.7	12.0

Stressful event (ever)		Birth-5			
	Yes	years	2,488	40.5	15.4
	No		3,900	59.5	9.7
Death in the family		Birth-5			
	Yes	years	701	11.4	16.6
	No		5,687	88.7	11.4
Mother in youngest age group at birth		Cycle 1			
	Mother <25 years at birth		1,386	17.9	14.7
	Mother ≥25 years at birth		5,002	82.1	11.4
Mother in oldest age group at birth		Cycle 1			
	Mother <40 years at birth		146	3.6	11.7
	Mother ≥40 years at birth		6,242	96.4	12.0
Single parent status		Birth-5			
	Single parent	years	1,314	22.9	16.7
	Lived with two parents		5,074	77.1	10.6
Mother's volunteer status		4-5 years			
	Does not volunteer		2,342	35.5	10.5
	Volunteers		1,929	27.4	11.9
	Missing		2,117	37.1	13.6
Participates in religious activities		4-5 years			
	No		3,873	55.9	11.0
	Yes		2,515	44.2	13.3
Family composition		4-5 years			
	Blended		1,367	24.0	15.6
	Intact		5,021	76.0	10.9
Immigrant status of mother		Birth-5			
	Mother was immigrant	years	649	18.0	9.6
	Mother not immigrant		5,739	82.0	12.5
Household income ever below the Low Income Cut-Off (LICO)		Birth-5			
	Ever below LICO	years	2,044	35.7	13.5
	Never below LICO		4,344	64.3	11.2
Mother or spouse ever unemployed		Birth-5			
	Yes	years	1,695	26.5	9.8
	No		4,127	65.2	12.5
	Missing		566	8.3	15.2
Mother has graduated high school		Birth-5			
	No	years	1,290	21.9	12.7
	Yes		5,098	78.1	11.8
Mother has graduated from university or college		Birth-5			
	No	years	3,968	63.2	12.3
	Yes		2,420	36.8	11.5
Housing tenure		Birth-5			
	Rented (ever)	years	2,198	37.8	13.8
	Always owned		4,190	62.2	10.9
Current smoking status of mother		4-5 years			
	Daily/occasional smoker		1,994	29.6	14.7
	Non-smoker		4,394	70.4	10.8

Current binge drinking status of mother	4-5 years			
Mother reported at least one binge drink occasion		1,990	27.5	14.6
Mother did not report binge drinking		4,398	72.5	11.0
Hostile or ineffective parenting	4-5 years			
Yes		739	12.8	11.9
No		4,222	64.5	12.3
Missing		1,427	22.8	11.2
Inconsistent parenting	4-5 years			
Yes		989	16.1	9.2
No/Missing		5,399	83.9	12.5
Punitive/aversive parenting	4-5 years			
Yes		1,318	20.1	13.5
No/Missing		5,070	79.9	11.6
Child sees violence on TV	4-5 years			
Often, sometimes, seldom		3,678	56.0	12.8
Never		2,710	44.0	11.0
Child changed main childcare arrangement in past 12 months	4-5 years			
Yes		1,651	22.8	12.2
No		971	15.4	12.5
Missing		3,766	61.8	11.8
Neighbourhood cohesion	Cycles 1,3			
Low		1,297	21.9	13.2
Medium/high		4,104	60.9	11.8
Missing		3,766	17.1	11.2
Neighbourhood safety	Measured once			
Low		1,299	26.0	12.1
Medium/high	between 0 – 5 years (Cycle 1)	5,089	74.0	12.0

3.2 Chi-square recursive partitioning

A Chi-square interaction detection tree model was built by starting with the full sample and splitting based on the largest Chi-square value to create two child nodes. This analysis was conducted to try to classify participants as either having suicidal ideation or not having suicidal ideation. The initial nodes showed that 12.0% of participants reported suicidal thoughts. The strongest predictor of suicidal thoughts was gender, which formed the first split in the CHID tree model, with girls having a higher rate of suicidal thoughts than

boys (15.6% and 8.5% respectively). Among girls, the most significant variable was the experience of a stressful life event, with those who had experienced a stressful life event at higher risk of suicidal ideation than those who did not. Among boys, the experience of activity limitation from a chronic condition was the first splitting variable, with those with an activity limitation at increased risk compared to those without one. Figure 3.1 shows the full CHID model. Due to the size of the tree, it has been divided across several pages.

Figure 3.1 Chi-Square Interaction Detection tree model (CHID), NLSCY, n (unweighted) and rate of suicidal ideation (weighted)

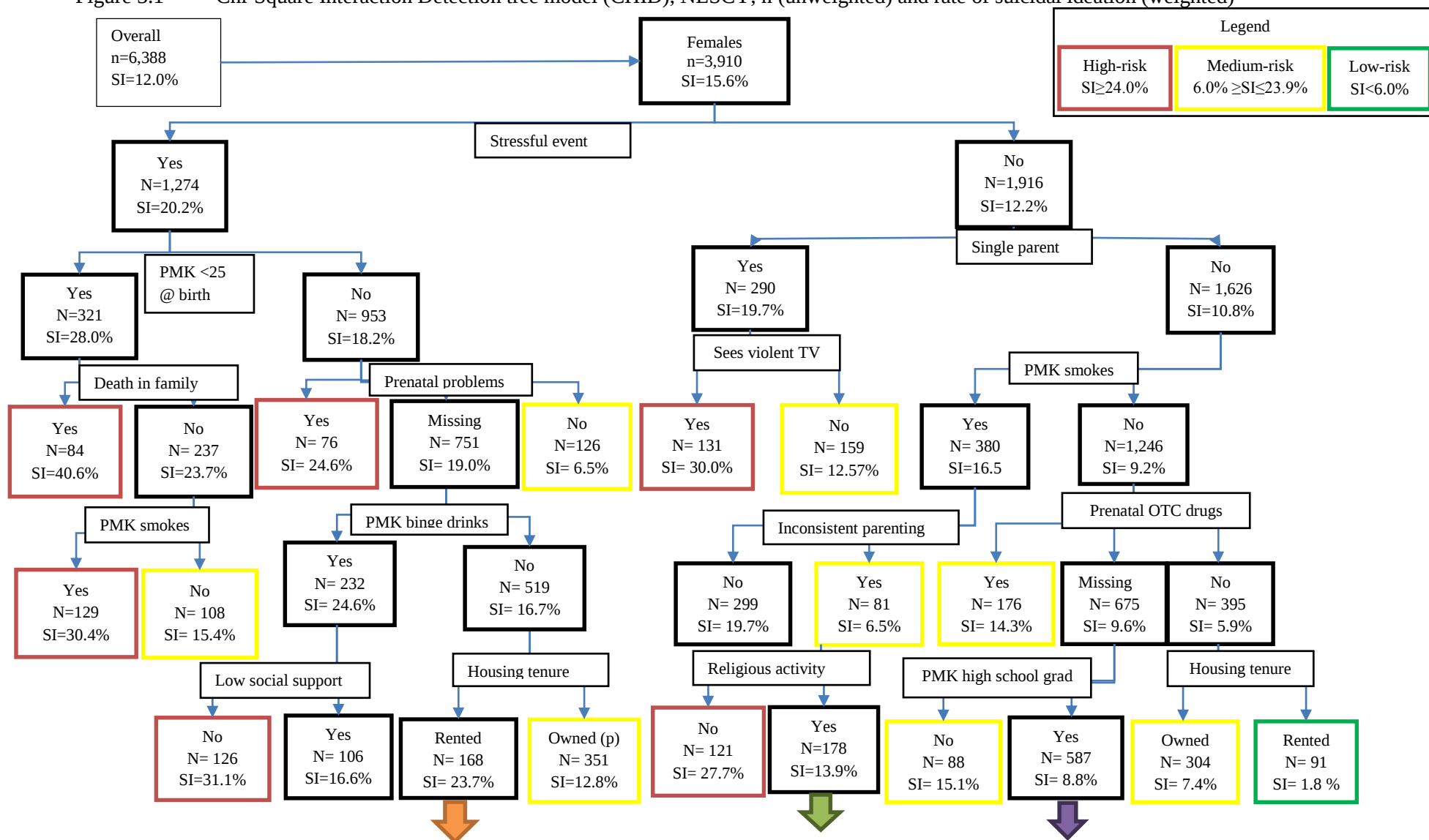


Figure 3.1 (continued) Chi-Square Interaction Detection tree model (CHID), NLSCY, n (unweighted) and rate of suicidal ideation (weighted)

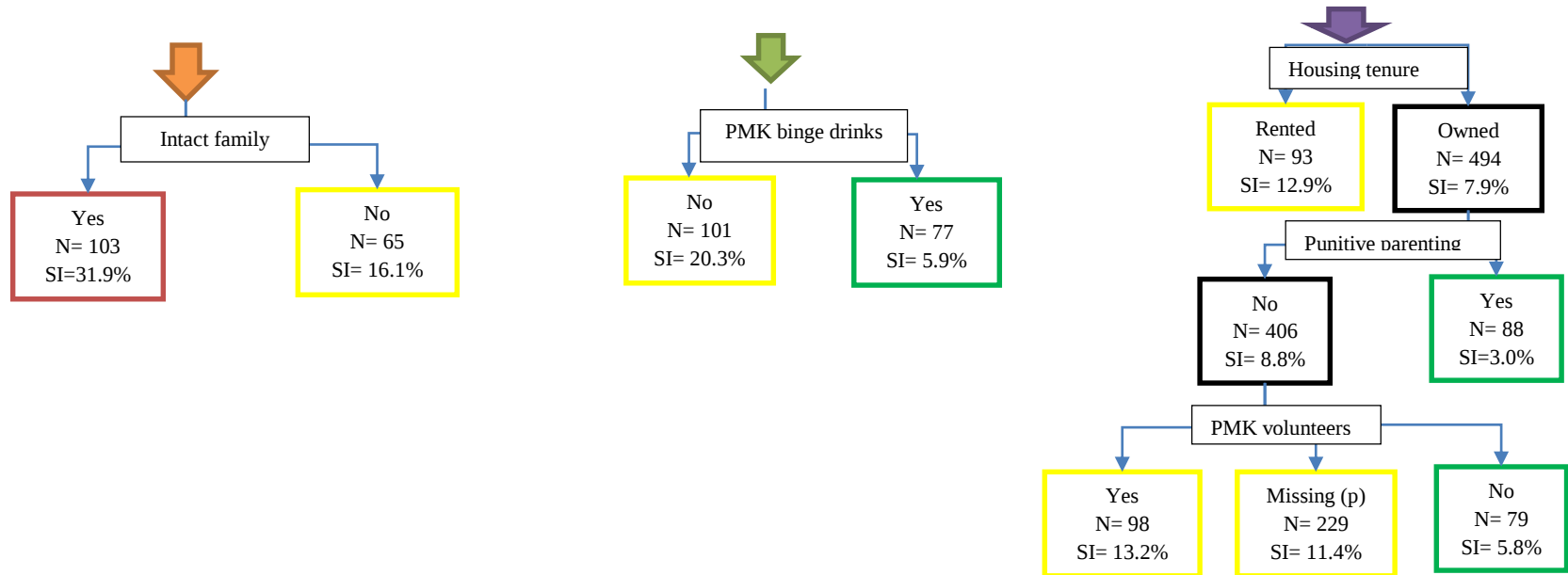


Figure 3.1 (continued) Chi-Square Interaction Detection tree model (CHID), NLSCY, n (unweighted) and rate of suicidal ideation (weighted)

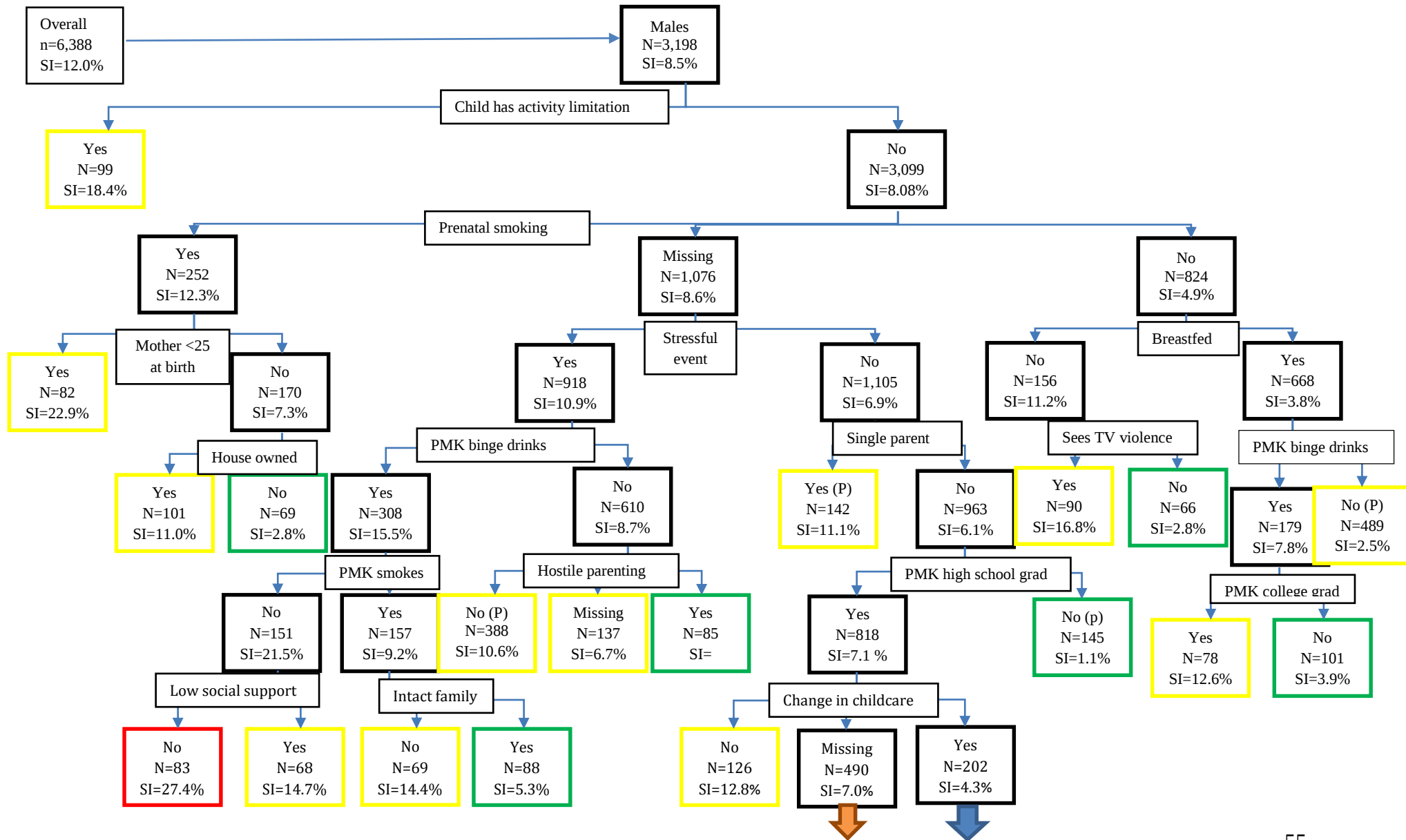
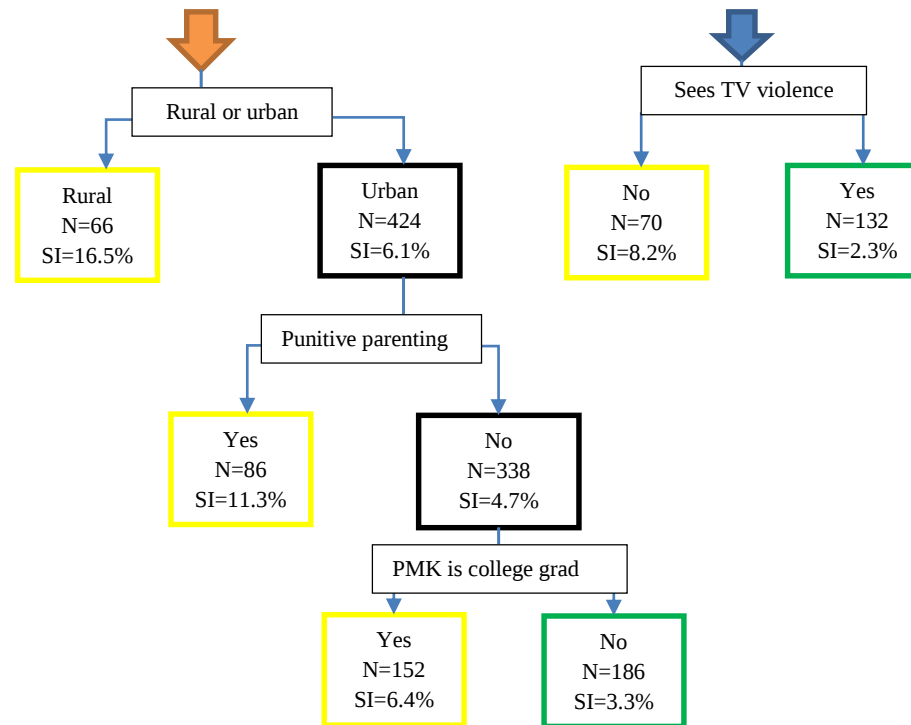


Figure 3.1 (continued) Chi-Square Interaction Detection tree model (CHID), NLSCY, n (unweighted) and rate of suicidal ideation (weighted)



The maximal model was built, splitting each node based on the variable with the highest Chi-square value that satisfied the parameters of the model (minimum node size $n=64$, $p>0.05$).

The tree was pruned to the node after which there was no further differentiation between low (0-6%), medium (6.1-23.9%), and high (24.0% or over) risk categories. After pruning, the tree identified 42 terminal nodes, which were classified into 8 high-risk, 29 medium-risk, and 12 low-risk nodes.

Below are the profiles of 8 high-risk subgroups that were identified by the model:

Table 3.3 Profiles of high-risk subgroups in Chi-square Interaction Detection tree model (CHID), NLSCY

CHID high-risk subgroup	% with suicidal ideation, n	Characteristics
CHID subgroup 1	40.6%, n=84	• Female • Stressful life experience reported (between 0 and 5 years) • Mother was under age 25 at birth (youngest age category) • Family member died (between 0 and 5 years)
CHID subgroup 2	31.9%, n=103	• Female • Stressful life experience reported (between 0 and 5 years) • Mother was 25 or older at birth • No information on prenatal problems • Mother did not report current binge drinking (at 4-5 years) • Lived in a rental dwelling (between 0 and 5 years) • Intact family (at 4-5 years)
CHID subgroup 3	31.1%, n=126	• Female • Stressful life experience reported (between 0 and 5 years) • Mother was 25 or older at birth • No information on prenatal problems (missing) • Mother reported current binge drinking (at 4-5 years) • Medium or high social support
CHID subgroup 4	30.4%, n=129	• Female • Stressful life experience reported (between 0 and 5 years) • Mother was under age 25 at birth • No family death • Mother reported current smoking (at 4-5 years)

CHID subgroup 5	30.0%, n=131	• Female • No stressful life experience reported (between 0 and 5 years) • Single parent status (between 0 and 5 years) • Exposed to violence on TV (at 4-5 years)
CHID subgroup 6	27.7%, n=121	• Female • No stressful life experience reported (between 0 and 5 years) • No single parent status (between 0 and 5 years) • Mother reported current smoking (at 4-5 years) • Consistent parenting (at 4-5 years) • Did not participate in religious activities (at age 4-5)
CHID subgroup 7	27.4%, n=83	• Male • Child did not have an activity limitations (at 4-5 years) • No information on prenatal smoking (missing) • Stressful life experience reported (between 0 and 5 years) • Mother reported current binge drinking (at 4-5 years) • Mother did not report current smoking (at 4-5 years) • Medium/high level of social support
CHID subgroup 8	24.6%, n=76	• Female • Stressful life experience reported (between 0 and 5 years) • Mother was 25 or older at birth • Prenatal problems

3.2.1 Sensitivity, specificity, positive predictive value, negative predictive value of CHID tree model for suicidal ideation, NLSCY

Sensitivity, specificity, positive predictive value, and negative predictive value were calculated based on the risk-cut offs (discussed earlier) of 24%, which is twice the base rate in the overall population, to assess the predictive ability of this model. All subgroups classified as “high risk” were combined and any medium-risk and low-risk nodes were combined for this analysis.

Table 3.4 Sensitivity, specificity, positive predictive value, negative predictive value for CHID-derived high-risk classification, NLSCY

	Proportion	95% CI
Suicidal ideation		
Sensitivity	24.2	21.2,27.2
Specificity	89.8	89.0,90.6
Positive Predictive Value	24.7	21.7,27.8
Negative Predictive Value	89.5	88.7,90.3

3.3 CART tree (in R)

The same predictive variables were entered into the RPART package in R to create a predictive tree. The full sample was included and split using the Gini statistic, measuring the level of impurity/heterogeneity within each node. The minimum node size (minbucket) was set at n=64 and results were weighted using longitudinal weights. As with the earlier analysis, we found that the strongest predictor of suicidal ideation was gender. Among females, the most predictive variable was the experience of stressful life experiences and among males the age of the person most knowledgeable was most significant. Splitting was continued to again build the maximal model that satisfied the *a priori* parameters. The tree was pruned to the node after which there was no further differentiation between low (0-6%), medium (6.1-23.9%), and high (24.0% or over) risk categories.

Figure 3.2 Classification and Regression tree model (CART), NLSCY, n (unweighted) and rate of suicidal ideation (weighted)

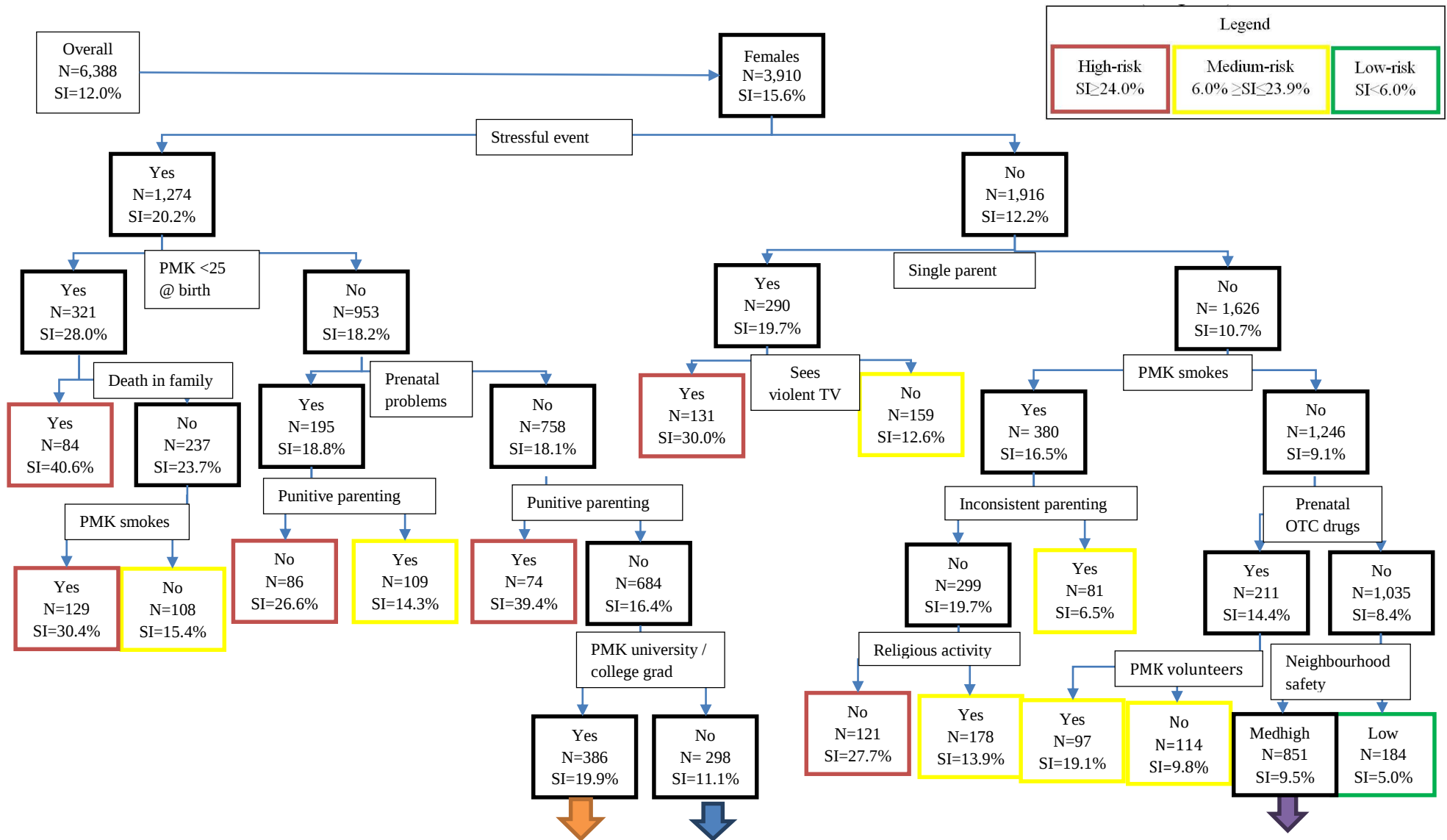


Figure 3.2 Classification and Regression tree model (CART), NLSCY, n (unweighted) and rate of suicidal ideation (weighted)

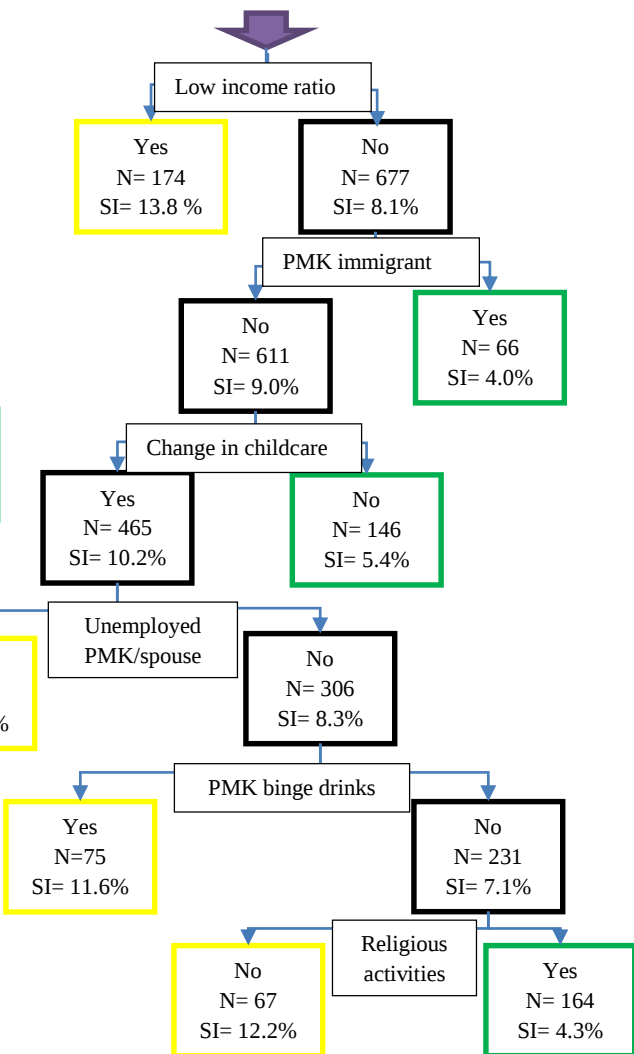
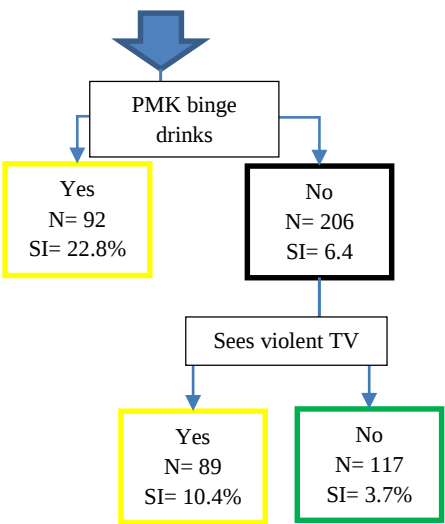
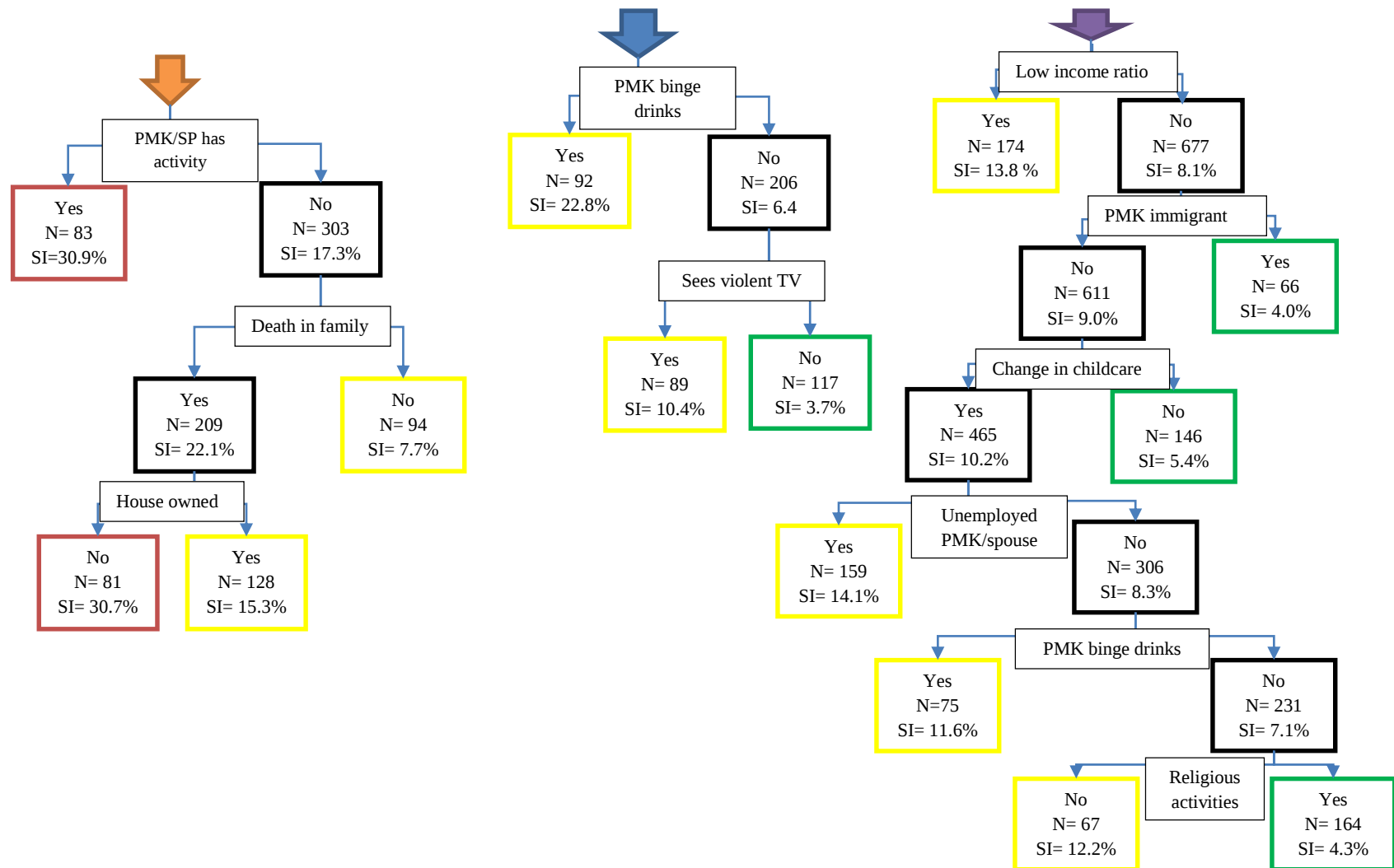


Figure 3.2 Classification and Regression tree model (CART), NLSCY, n (unweighted) and rate of suicidal ideation (weighted)

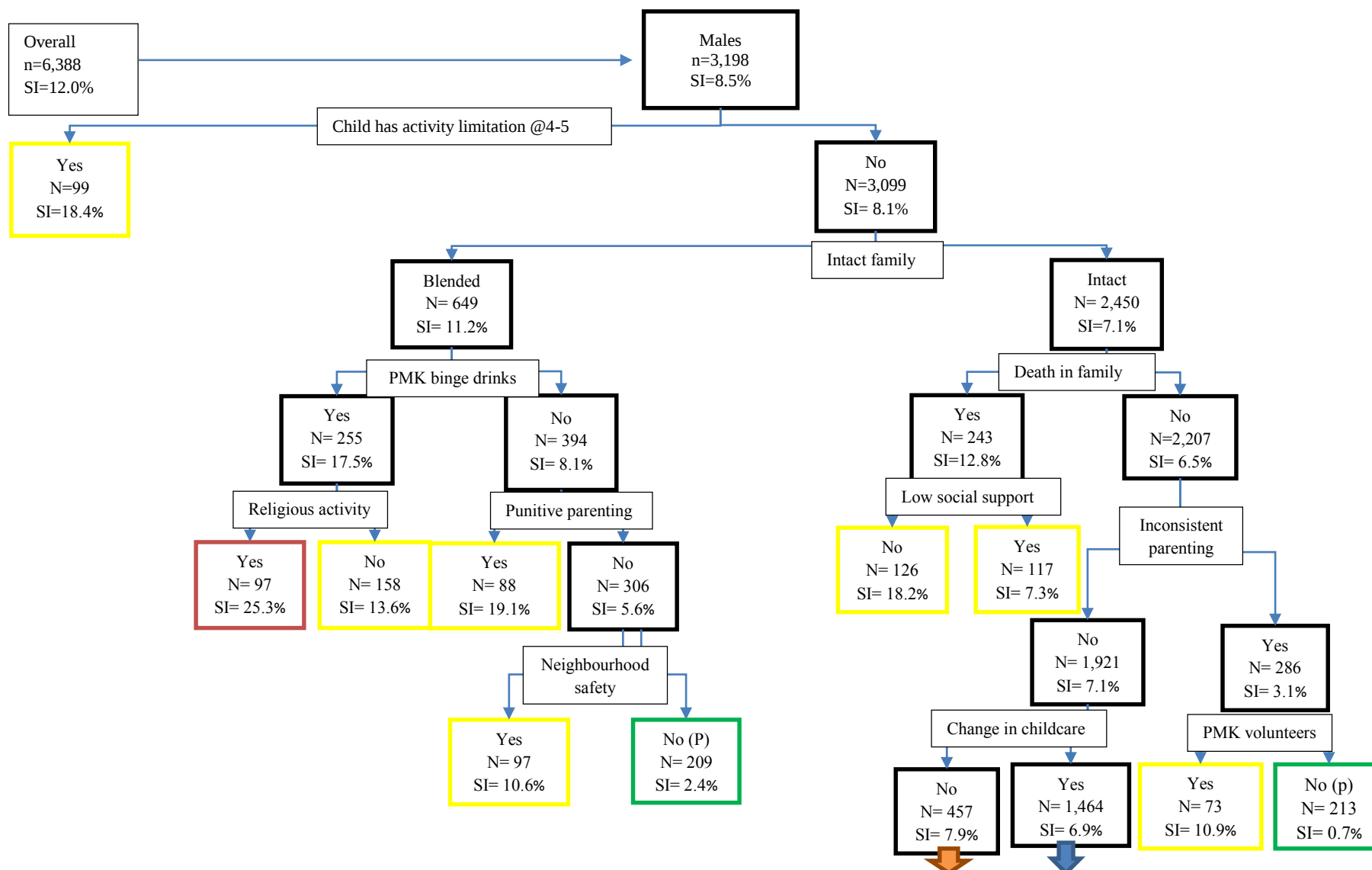
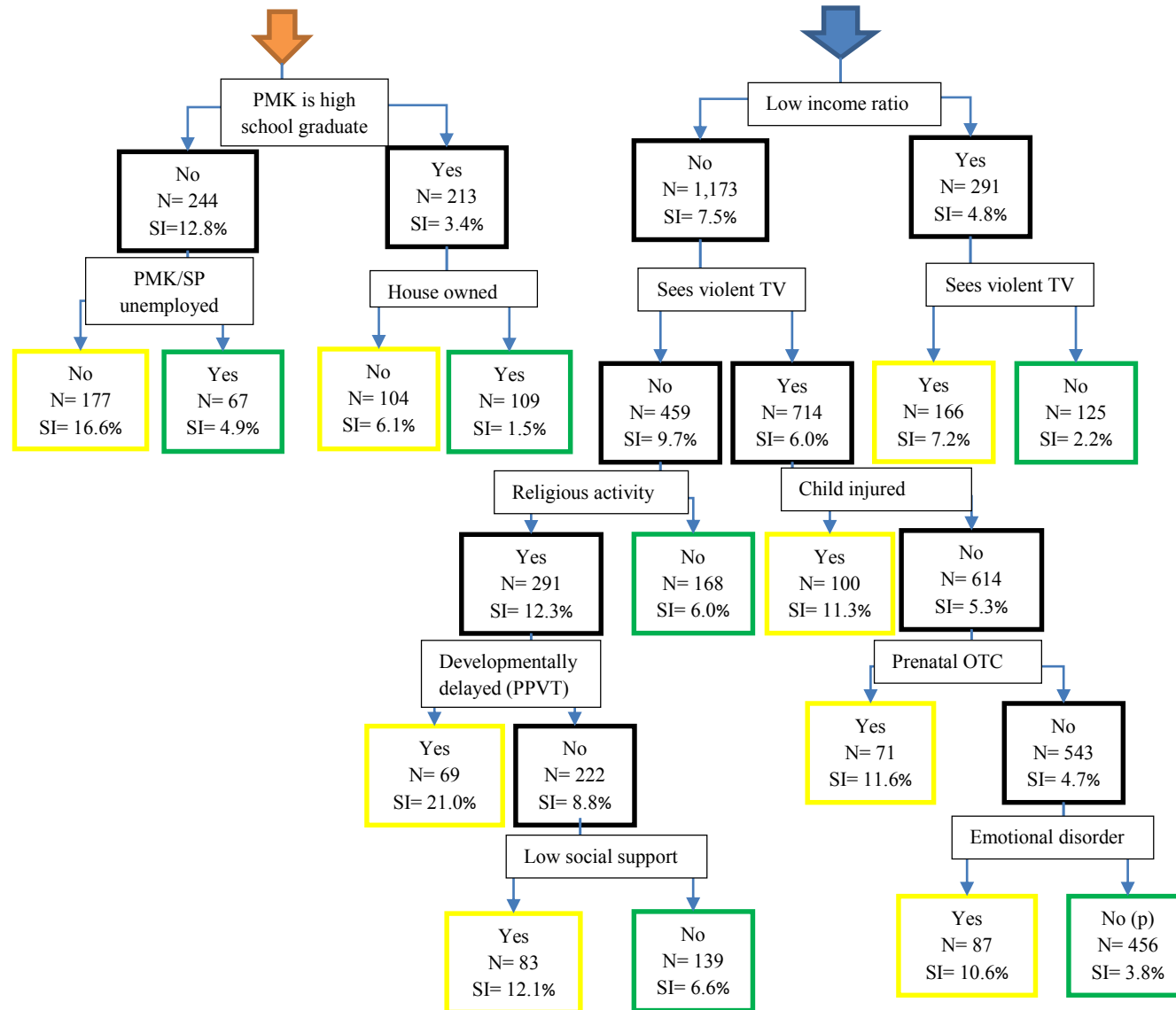


Figure 3.2 Classification and Regression tree model (CART), NLSCY, n (unweighted) and rate of suicidal ideation (weighted)



After pruning, the tree identified terminal nodes, which were classified into 9 high risk, 30 medium risk, and 13 low risk nodes. Table 3.5 shows the profiles of 8 high-risk subgroups that were identified by the model:

Table 3.5 Profiles of high-risk subgroups in Classification and Regression Tree model (CART), NLSCY

CART high-risk subgroup	% with suicidal ideation, n	Characteristics
CART subgroup 1	40.6%, n=84	• Female • Stressful life experience reported (between 0 and 5 years) • Mother was under age 25 at birth (youngest age category) • Family member died between 0 and 5 years
CART subgroup 2	39.4%, n=74	• Female • Stressful life experience reported (between 0 and 5 years) • Mother was 25 or older at birth • No prenatal problems reported • Punitive/aversive parenting style (at 4-5 years)
CART subgroup 3	30.9%, n=83	• Female • Stressful life experience reported (between 0 and 5 years) • Mother was 25 or older at birth • No prenatal problems • No punitive/aversive parenting (at 4-5 years) • Mother did not have a college/university degree • Mother or spouse reported an activity limitation (between 0 and 5 years)
CART subgroup 4	30.7%, n=81	• Female • Stressful life experience reported (between 0 and 5 years) • Mother was 25 years or older at birth • No prenatal problems reported • No punitive/aversive parenting (at 4-5 years) • Mother did not have a college/university degree • Mother or spouse did not report an activity limitation (between 0 and 5 years) • No death in the family (between 0 and 5 years) • Lived in a rental dwelling (between 0 and 5 years)

CART subgroup 5	30.4%, n=129	• Female • Stressful life experience reported (between 0 and 5 years) • Mother under age 25 at birth • No family death • Mother reported current smoking (at 4-5 years)
CART subgroup 6	30.0%, n=131	• Female • No stressful life experience reported (between 0 and 5 years) • Single parent status (between 0 and 5 years) • Exposed to violent TV (at 4-5 years)
CART subgroup 7	27.7%, n=121	• Female • No stressful life experience reported (between 0 and 5 years) • No single parent status (between 0 and 5 years) • Mother reports current smoking (at 4-5 years) • Consistent parenting (at 4-5 years) • Did not participate in religious activities (at 4-5 years)
CART subgroup 8	26.6%, n=86	• Female • Stressful life experience reported (between 0 and 5 years) • Mother was 25 or older at birth • Prenatal problems • No punitive/aversive parenting (at 4-5 years)
CART subgroup 9	25.3%, n=97	• Male • Child did not have activity limitations (at age 4-5 years) • Blended family • Mother reported current binge drinking (at 4-5 years) • Participated in religious services (at 4-5 years)

3.6.2 Sensitivity, specificity, positive predictive value, and negative predictive value of CART model for suicidal ideation, NLSCY

Table 3.6 Sensitivity, specificity, positive predictive value, negative predictive value for CART model high-risk classification, NLSCY

	Proportion (%)	95% CI
Suicidal ideation		
Sensitivity	22.7	19.4,26.1
Specificity	89.2	88.4,90.0
Positive Predictive Value	17.8	15.1,20.5
Negative Predictive Value	91.8	91.1,92.6

3.4 Stepwise logistic regression

Using more traditional methods to build predictive models, the predictors were included in a logistic regression using stepwise selection to create prediction models. The final model included 14 variables listed below:

1. Gender
2. Prenatal smoking
3. Single parent status
4. Child was seriously ill between 0-5 years of age
5. Child's social skills (teacher rated)
6. Child moved between 0-5 years of age
7. Participation in religious activities
8. Conduct problems at 4-5 years of age
9. Inconsistent parenting at 4-5 of age
10. Sees violence on TV at 4-5 of age
11. Mother was a teen at birth
12. Change in household members between 0-5 years of age
13. Neighbourhood cohesion score

Table 3.7 Odds ratio estimates and 95% confidence limits for stepwise selection logistic regression, NLSCY

Effect	Point Estimate	95% Wald Confidence Limits	
Prenatal smoking (missing vs. no)	1.358	1.100	1.677
Prenatal smoking (yes vs. no)	1.691	1.249	2.289
Gender (female vs. male)	2.116	1.799	2.487
Participation in religious activities at 4-5 years (yes vs. no)	0.815	0.696	0.955
Conduct disorder at 4-5 years (yes vs. no)	1.311	1.028	1.672
Moved between 0-5 years (yes vs. no)	1.524	1.088	2.135
Was ill between 0-5 years (yes vs. no)	2.069	1.374	3.113
Change member of the household between 0-5 years (yes vs. no)	1.698	1.043	2.765
Mother or father was a teen at birth (yes vs. no)	1.553	1.045	2.306

Effect	Point Estimate	95% Wald Confidence Limits	
Ever part of a single parent family (yes vs. no)	1.320	1.093	1.595
Inconsistent parenting style (yes vs. no)	0.726	0.579	0.910
Exposed to violent TV at 4-5 years (yes vs. no)	1.204	1.025	1.414
Teacher-rated social skills at 4-5 years (missing vs. medium/high)	0.725	0.597	0.880
Teacher-rated social skills at 4-5 years (low vs. medium/high)	1.252	0.801	1.957
Neighbourhood cohesion score (missing vs. medium/high)	1.045	0.839	1.303
Neighbourhood cohesion score (low vs. medium/high)	1.269	1.049	1.535

Model fit was confirmed using the Hosmer-Lemeshow goodness-of-fit test. The test showed that this was an appropriate model fit ($p > \chi^2 = 0.8701$).

Table 3.8 Model fit statistics for stepwise selection logistic regression, NLSCY

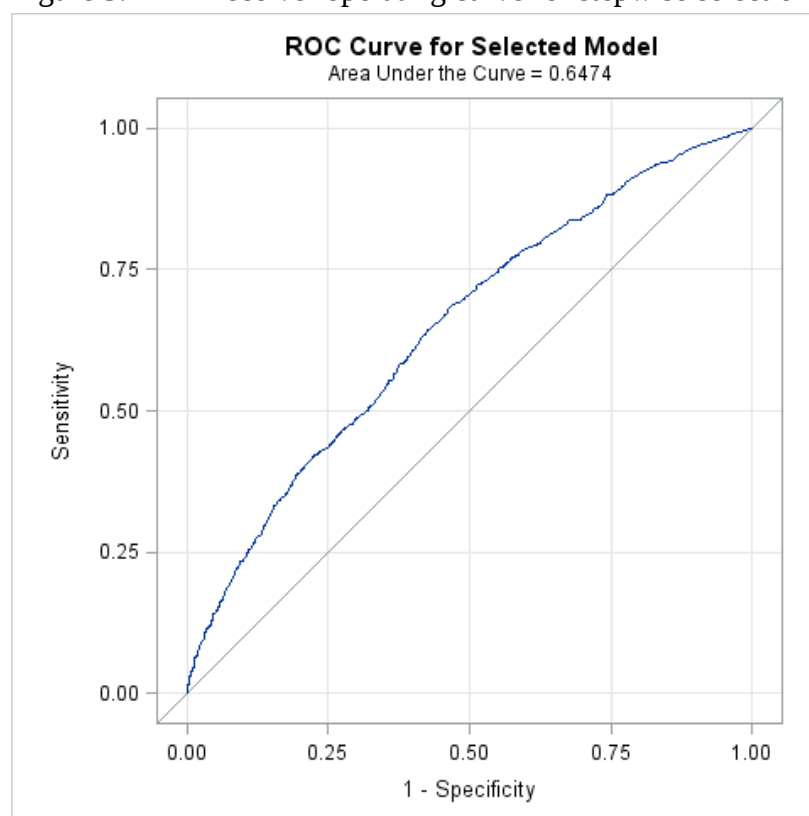
Percent concordance = 64.4%	Somers D = 0.295
Percent discordance = 34.9%	Gamma = 0.297
Percent tied = 0.7%	c = 0.647

Using the same cut-off to determine high-risk (24%) that was used in the previous two models, the sensitivity, specificity, positive predictive value, and negative predictive value was calculated for the model. See Appendix 8 for further details on the calculation of PPV and NPV. The receiver operating curve (ROC curve) was also generated for the model.

Table 3.9 Sensitivity, specificity, positive predictive value, negative predictive value for stepwise logistic regression derived high-risk classification, NLSCY

	Proportion (%)	95% confidence interval
Suicidal ideation		
Sensitivity	9.1	7.1,11.4
Specificity	96.6	96.1,97.1
Positive predictive value	26.6	21.4,32.5
Negative predictive value	88.7	87.9,89.5

Figure 3.1 Receiver operating curve for stepwise selection logistic regression, NLSCY



3.5 Results of secondary outcomes – Descriptive statistics

Prevalence estimates of adverse adolescent outcomes in the sample ranged from 11.4% (risky health behaviours) to 26.4% (substance misuse) (Table 3.10). Suicidal ideation was higher among all subgroups reporting one of the secondary adverse outcomes. For example, the prevalence of suicidal ideation was 23.8% among those reporting antisocial behaviour, while it was only 7.9% among those who did not report antisocial behaviour (Table 3.10).

Table 3.10 Weighted prevalence of primary and secondary outcomes, NLSCY, n=6,388

		% (weighted)	% (weighted) with SI
Suicidal thoughts	Yes	12.0	100
	No	88.0	0
Antisocial behaviour	Yes	25.7	23.8
	No	74.3	7.9
Substance misuse	Yes	26.4	23.1
	No	73.6	8.0
Poor physical health	Yes	15.6	27.1
	No	84.5	9.2
Poor mental health	Yes	26.6	27.7
	No	73.4	6.3
Risky health behaviours	Yes	11.4	24.7
	No	88.6	10.4
Poor academic performance	Yes	20.5	24.5
	No	79.5	8.8

3.6 Chi-square recursive partitioning model results for secondary outcomes

The CHID-derived model had identified 8 high-risk groups and 41 not-high-risk groups (29 medium-risk and 12 low-risk) for suicidal thoughts. The classification of high-risk versus not-high-risk was used to assess the model's performance in predicting other adverse outcomes in adolescence, including antisocial behaviour, substance misuse, poor physical health, poor mental health, risky health behaviours, and poor academic performance. The sensitivity, specificity, positive predictive value, and negative predictive value were calculated based on the risk classification to assess the ability of the model to predict other adverse outcomes.

3.6.1 Sensitivity, specificity, positive predictive value, and negative predictive value of secondary outcomes using CHID-derived model

Table 3.11 Sensitivity, specificity, positive predictive value, negative predictive value for secondary outcomes using CHID-derived high-risk classification, NLSCY

		Proportion	95% CI
Antisocial behaviour			
	Sensitivity	26.8	23.7,29.9
	Specificity	76.7	75.6,77.8
	Positive Predictive Value	13.7	12.0,15.5
	Negative Predictive Value	88.3	87.4,89.2
Substance misuse			
	Sensitivity	64.4	61.0,67.7
	Specificity	76.6	75.5,77.7
	Positive Predictive Value	17.4	15.6,19.3
	Negative Predictive Value	89.6	88.7,90.5
Poor physical health			
	Sensitivity	76.2	73.2,79.2
	Specificity	84.3	83.4,85.3
	Positive Predictive Value	17.4	15.1,19.6
	Negative Predictive Value	88.9	88.0,89.7
Poor mental health			
	Sensitivity	59.9	56.4,63.3
	Specificity	76.9	75.8,78.0
	Positive Predictive Value	19.4	17.5,21.3
	Negative Predictive Value	90.3	89.4,91.1
Risky health behaviours			
	Sensitivity	82.9	80.2,85.5
	Specificity	89.8	89.0,90.6
	Positive Predictive Value	18.9	16.0,21.8
	Negative Predictive Value	88.7	87.8,89.5
Poor academic performance			
	Sensitivity	73.4	79.3,76.5
	Specificity	81.9	80.9,82.9
	Positive Predictive Value	16.9	14.8,19.0
	Negative Predictive Value	89	88.1,89.8

3.7 Classification and regression model results for secondary outcomes

The CART-derived model had 9 subgroups at high-risk for suicidal thoughts and 43 that were not classified as high-risk (30 medium-risk and 13 low-risk). The classification of “high-risk” versus “not-high-risk” was used to assess the CART model’s ability to predict

the secondary adverse outcomes. The sensitivity, specificity, positive predictive value, and negative predictive value were calculated for each of the secondary outcomes based on the risk classification.

3.7.1 Sensitivity, specificity, positive predictive value, negative predictive value of secondary outcomes using CART-derived model

Table 3.12 Sensitivity, specificity, positive predictive value, negative predictive value for secondary outcomes using CART-derived high-risk classification, NLSCY

		Proportion	95% CI
Antisocial behaviour	Sensitivity	29.8	26.1,33.5
	Specificity	76.9	75.8,78.0
	Positive Predictive Value	11.7	10.1,13.3
	Negative Predictive Value	91.4	90.7,92.2
Substance misuse	Sensitivity	64.5	60.6,68.3
	Specificity	76.2	75.1,77.3
	Positive Predictive Value	13.3	11.6,15.0
	Negative Predictive Value	92	91.3,92.8
Poor physical health	Sensitivity	75.9	72.5,79.4
	Specificity	84.1	83.1,85.1
	Positive Predictive Value	13.4	11.4,15.5
	Negative Predictive Value	91.5	90.8,92.3
Poor mental health	Sensitivity	63.0	59.1,66.9
	Specificity	76.0	74.9,77.1
	Positive Predictive Value	13.7	12.0,15.4
	Negative Predictive Value	92.2	91.4,92.9
Risky health behaviours	Sensitivity	83.8	80.9,86.8
	Specificity	89.5	88.7,90.3
	Positive Predictive Value	13.6	11.1,16.2
	Negative Predictive Value	91.2	90.5,92.0
Poor academic performance	Sensitivity	69	65.3,72.7
	Specificity	82.1	81.1,82.1
	Positive Predictive Value	15.1	13.1,17.1
	Negative Predictive Value	92.1	91.3,92.8

Chapter 4: Model validation in ALSPAC

“The performance of decision trees on independent data is called the true predictive power of the tree. Therefore, the primary task is to find the optimal proportion between tree complexity and misclassification error.”
(200)

In the previous objectives, models were built using the NLSCY and participants were classified as “high risk” or “not high risk” based on the presence or absence of risk factors. In order to assess the true predictive validity of the models, an independent dataset, the Avon Longitudinal Survey of Parents and Children (ALSPAC) was used to validate the models.

4.1.1 Study design

The Avon Longitudinal Study of Parents and Children (ALSPAC) is a population-based study from England investigating the health and development of children, including how genetic and environmental factors influence their development (232).

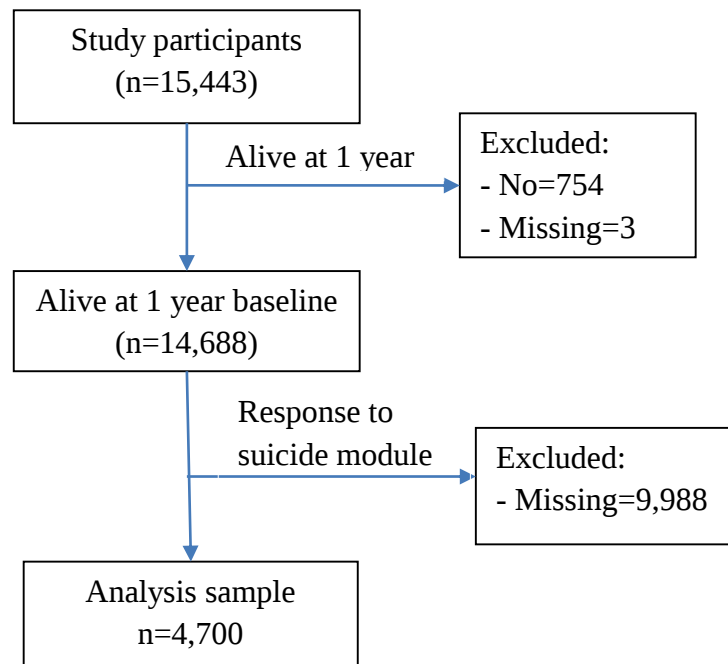
The study recruited pregnant mothers due to give birth between April 1, 1991 and December 31, 1992 living in Avon, an area in southwest England (233). The initial sample of over 14,000 pregnancies was later bolstered by additional recruitment, resulting in a final sample size of 15,458 (234). The study methodology is described in more detail at <http://www.bristol.ac.uk/alspac/researchers/resources-available/>. Studies of the representativeness of the ALSPAC cohort to the whole population of Britain show that despite small differences, the study population is broadly representative of the British population (233,235,236).

There are a number of components including: *carer questionnaires*, which were usually completed by the mother; *child-based questionnaires*, completed by the carer of the study subject or the child/young person; *partner questionnaires*, completed by the partner of

the carer about themselves; *puberty questionnaires*, completed by the main carer, then the carer and child together, and finally by the child alone; and *school questionnaires*, completed by staff at the schools attended by study participants (234). See Appendix 5 for more details.

4.1.2 Study population

Figure 4.1 Population and eligible cohort analysis, ALSPAC CONSORT flow diagram



4.2 Materials

4.2.1 Predictors

Predictor Variables:

The models derived in the previous analysis using Chi-square interaction detection (CHID) and Classification and Regression Trees (CART) identified 35 predictor variables that differentiated risk levels in the NLSCY. In order to see how well these models predict suicidal ideation in a population from which the original models were not derived, the closest comparators in ALSPAC were selected. This allowed for coding the comparable measures

that were then used to test the external validity of the model. These predictor variables were measured on mother-based surveys, child-based surveys (which the carer completed), and partner-based surveys. In order to maintain comparability, every effort was made to use measures that were measured at the point in time that was the closest to when the predictor was measured in the NLSCY. Effort was made to include all available time points between the prenatal period and age 5 for the variables that were measured across early childhood, and to include the measure of a predictor closest to age 4-5 when the predictor had been measured at the single time point in the NLSCY. Similarly, missing data was treated consistently across the two samples. For the variables where missing data was kept as a separate category in the NLSCY, a separate category was kept for ALSPAC. Finally, for variables where ‘missing’ and ‘no’ were combined to create a dichotomous variable, ‘yes, reported the factor’ or ‘no, factor was not reported or was missing’ were created. Appendix 8 contains details about the coding of all predictor variables, including the time point at which they were measured, and important differences between the ALSPAC and NLSCY measurements are noted there.

Pre- and post-natal predictors

The four pre- and post-natal predictors that emerged as significant in the NLSCY models were prenatal over-the-counter medication use, prenatal smoking, prenatal problems (including hypertension and gestational diabetes), and breastfeeding.

Individual predictors

There were eight predictors measured at the individual level that were significant in the models. They included gender, rural/urban residence, child injury, child activity limitation, developmental delay, conduct disorder, experience of a stressful life experience,

and death in the family. Rural/urban residence and child injury were not included in the analysis, as they were not measured in ALSPAC. Also, while a comparable measure of developmental delay (WASI) was administered in ALSPAC, errors were discovered by ALSPAC researchers and these data will not be released until the issues can be resolved.

Family predictors

There were 17 predictors at the family level that were important in the model, including the following socio-demographic factors: young and old maternal age at birth; parental immigrant status; basic high school education; college/university graduate education; unemployment; financial difficulties and housing tenure. Parental behaviours and practices that were significant included: participation in religious activities; parental activity limitation; current smoking; and current binge drinking. Finally, several measures of family composition and relationships were important, including: single parent status; intact vs. blended family; inconsistent parenting; hostile/ineffective parenting; and punitive/aversive parenting.

Interpersonal and environmental predictors

Predictors at the interpersonal, community, or environmental levels included: exposure to violence on TV; changes in child care arrangements; parental volunteering; social support score; neighbourhood cohesion (neighbourhood is a good place to live); and neighbourhood safety.

4.2.2 Outcome

Suicidal ideation: Study participants were asked “Have you ever thought of killing yourself, even if you would not really do it?” Those who answered “yes” were asked about the timing

of these thoughts: “If yes, when was the **last time** you felt like this?” [emphasis in the original]. Participants who indicated that the thoughts occurred in the past 12 months were deemed to have past year suicidal ideation. For the entire self-harm/suicide module, see Appendix 9.

4.3 Statistical analysis

In the previous analysis, high-risk sub-groups were specified using the NLSCY based on the presence or absence of certain risk factors. Using comparable variables available in ALSPAC, participants were classified as “high risk” or “not high risk” for both the CHID and CART models. Sensitivity, specificity, positive predictive value, and negative predictive value were calculated to see how accurately these classifications delineate high risk of suicidal ideation. These values were investigated to see if the model can accurately predict suicidal ideation in a population different from the one from which the original models were built.

4.4 Validation stage results (ALSPAC)

4.4.1 ALSPAC descriptive statistics

For the ALSPAC validation sample, the final sample size was 4,700, which included only those who had answered the suicide thoughts questions at age 16. Of this sample, 13.1% reported suicidal ideation. Of the study sample, 42.0% were girls and 58.0% were boys. Suicidal ideation was higher among girls (17.5%) compared to boys (7.2%). The prevalence of suicidal ideation varied according to most of the predictor variables. Table 4.1 shows

more detailed demographic characteristics of the study population and important risk factors and the weighted proportion with suicidal ideation according to key factors.

Table 4.1 Descriptive and health characteristics of study population, ALSPAC, n=4,700

	Time of data collection	N	%	% with SI
Gender				
Male		1,975	42.0	7.2
Female		2,725	58.0	17.5
Prenatal use of over-the-counter medications	18 weeks gestation			
Yes		1,323	30.1	14.2
No		3,074	69.9	12.5
Missing		303		
Prenatal smoking	32 weeks gestation			
Yes		523	12.2	20.3
No		3,758	87.9	12.0
Missing		419		
Prenatal hypertension and/or diabetes	12 weeks gestation			
Yes		431	10.1	17.9
No		3,855	89.9	12.6
Missing		414		
Breastfeeding	4 weeks; 6 months			
Yes		3,835	86.6	12.8
No		595	13.4	14.5
Missing		270		
Mum goes to place of worship	5 years, 1 month			
Not at all, not reported		2,601	55.3	13.7
Once/week; once/months; Once/year		2,099	44.7	12.5
Child injured in past year	3 years, 2 months			
Yes		1,572	33.5	13.2
No		3,128	66.5	13.1
Conduct disorder	3 years, 6 months			
Yes		354	8.5	17.8
No		3,808	91.5	12.5
Missing		538		

Stressful life experience	8 weeks; 2 years, 9 months;			
Yes	3,590	80.3	13.5	
No - didn't happen, yes, no effect	3 years, 11 months;	881	19.7	11.0
yes – mild effect	5 years, 1 month	229		
Missing				
Death in the family	8 weeks; 2 years, 9 months;			
Yes	1,694	38.6	11.6	
No	3 years, 11 months;	2,694	61.4	13.7
Missing	5 years, 1 month	312		
Mother <25 years	8 weeks gestation			
Yes	614	13.7	15.6	
No	3,884	86.4	12.7	
Missing	202			
Mother ≥ 40 years	8 weeks gestation			
1	66	1.5	10.6	
2	4,432	98.5	13.1	
Missing	202			
Mother/father immigrant	12 weeks gestation			*using the “parents place of residence” at birth as proxy for immigrant status
1	137	2.9	13.1	
2	4,563	97.1	13.2	
Missing				
Basic education	32 weeks gestation			
CSE or none >CSE	490	11.2	15.3	
Missing	3,893	88.8	12.7	
College degree	32 weeks gestation			
No	3,484	79.5	13.4	
Yes	899	20.5	11.8	
Missing	317			
Unemployment of mother or spouse	8 weeks			
Yes	267	6.5	15.7	
No	3,864	93.5	12.3	
Missing				
Financial difficulties	8 months			
Yes	345	12.8	17.1	
No	2,350	87.2	13.0	
Missing	2,005			
Housing tenure	8 weeks gestation			
Rented/other	647	14.8	18.1	
Owned	3,720	85.2	12.2	
Missing	333			

Mother's activity limitation	1 year, 9 months			*using "present health/fit and well" as proxy
Often unwell, never well		171	3.6	12.9
Fit and well, mostly well		4,529	96.4	13.2
Mother's current smoking status	3 years, 11 months			
Yes, currently smokes		810	17.23	16.5
No, does not report smoking		3,890	82.77	12.4
Mother's binge drinks alcohol	3 years, 11 months			
Yes		450	9.57	12.4
No		4,250	90.4	13.9
Single parent status (ever)	8 weeks gestation;			
Yes	8 months;	597	12.7	17.4
No	1 year, 9 months;	4,103	87.3	12.5
	2 years, 9 months;			
	3 years, 11 months			
Intact or blended family	3 years, 11 months			
Not-intact		607	12.9	18.0
Intact		4,093	87.1	12.4
Inconsistent parenting	3 years, 6 months			
Yes		2,821	68.0	12.8
No		1,328	32.0	13.0
Missing		551		
Hostile/ineffective parenting	3 years, 6 months			*use "winner of battle of wills" as proxy
Yes		1,236	32.7	13.8
No		2,541	67.3	12.3
Missing		923		
Punitive/aversive parenting	4 years, 9 months			
Yes		897	31.7	13.9
No		1,930	68.3	13.0
Missing		1,873		

High exposure to TV	4 years, 6 months			*90 th percentile of time spent viewing TV
Yes		415	10.3	17.6
No		3,604	89.7	12.4
Missing		681		
Changed childcare providers	4 years, 6 months			
Yes		2,368	64.9	12.6
No		1,279	35.1	13.7
Missing		1,053		
Mother's volunteer status	5 years, 1 month			
No		831	17.68	14.2
Yes		3,869	82.32	12.9
Social support	8 weeks; 8 months; 1 year, 9 months			
Low		592	12.6	19.4
High/normal		4,108	87.4	12.2
Good neighbourhood*	2 years, 9 months			*Proxy for neighbourhood cohesion
No		208	5.4	17.8
Yes		3,638	94.7	12.8
Missing		854		

Suitable proxies were not available for several variables, including child activity limitation and child developmental delay, so they were excluded from analysis.

4.4.2 Sensitivity, specificity, PPV, NPV of ALSPAC

The CHID-derived model, built from the NLSCY, had identified 8 groups at high risk for suicidal thoughts and 41 groups that were not at high risk (29 medium-risk and 12 low-risk). The classification of high-risk versus not-high-risk was used to assess the model's performance in ALSPAC, using the variables that most closely approximated the splitting variables used in the NLSCY. The sensitivity, specificity, positive predictive value, and negative predictive value were calculated based on the risk classification to assess the ability of the model to perform in an independent dataset.

Table 4.2 Sensitivity, specificity, positive predictive value, negative predictive value for CHID-derived high-risk classification, ALSPAC

	Proportion	95% confidence interval
Suicidal ideation		
Sensitivity	22.4	18.3,26.5
Specificity	87.7	86.7,88.7
Positive predictive value	14.2	11.5,17.0
Negative predictive value	92.5	91.72,93.3

Similarly, the CART model derived risk classification determined in the earlier NLSCY analysis was applied to the ALSPAC sample. The sensitivity, specificity, positive predictive value, and negative predictive value was calculated based on the 9 high risk subgroups and the 43 non-high-risk subgroups.

Table 4.3 Sensitivity, specificity, positive predictive value, negative predictive value for CART-derived high-risk classification, ALSPAC

	Proportion	95% confidence interval
Suicidal ideation		
Sensitivity	19.9	16.9,22.8
Specificity	88.0	87.0,89.0
Positive predictive value	22.5	19.2,25.8
Negative predictive value	86.3	85.2,87.3

Chapter 5: Discussion and conclusions

5.1 Principle findings of this thesis

5.1.1 Descriptive statistics

This study shows that 12% of Canadian youth answered yes to a question about seriously considering suicide, which replicates estimates reported in other studies, however is slightly lower, likely due to differences between the studies' populations and samples (see limitations for further details) (49,51). The descriptive statistics revealed that the prevalence of suicidal ideation varied between different stratified groups. Suicidal ideation was found to be higher among girls than boys (15.6% vs. 8.5%), those who experienced a stressful life event when compared to those who did not (15.4% vs. 9.7%), and among children who experienced an activity limitation at 4-5 years of age compared to those without an activity limitation (20.9% vs. 11.7%) (Table 3.1).

5.1.2 Predicting suicidal thoughts in the NLSCY using CHID and CART models

While the descriptive statistics showed differences in the prevalence of suicidal thoughts between strata, in order to move beyond investigating the relationship between single covariates and suicidal thoughts, predictive tree models were built to investigate how interactions between risk factors affected risk of suicidal thoughts. The first tree model was built using Chi-square interaction detection (CHID). The variables that determined the splits in this model were as follows: gender, stressful life experiences, childhood activity limitation, young maternal age, single parent status, prenatal exposure to smoke, death in the family, prenatal medical problems, exposure to violence on TV at age 4-5, parental smoking at age 4-5, no reported breastfeeding, parental binge drinking at age 4-5, consistent parenting style, prenatal use of over-the-counter medications, living in a rental home as opposed to

owned dwelling, parental education level, hostile parenting, non-intact family, no participation in religious activities, punitive parenting style, changes in child care arrangements, social support, rural vs. urban residence, and parental volunteer status. Based on these variables, 50 terminal nodes were found, of which 8 were classified as high risk, with at least twice the base rate of suicidal ideation compared to the overall population (see Figure 4.1).

The second model was built using Classification and Regression Trees (CART). The variables that determined the splits in the CART model were: gender, stressful life experiences, childhood activity limitation, young maternal age, single parent status, non-intact family, death in the family, prenatal medical problems, parental smoking at age 4-5, parental binge drinking at age 4-5, exposure to violence on TV at age 4-5, punitive parenting style, inconsistent parenting style, prenatal use of over-the-counter medications, no participation in religious activities, social support, parental education level, neighbourhood cohesion, parental volunteer status, changes in child care arrangements, low income ratio, parental unemployment, rental home as opposed to owned dwelling, parental activity limitation, child injury at age 4-5, and developmental delay. Based on these recursive splits, 49 terminal nodes were discovered, nine of which were classified as high risk (see Figure 4.2). The variables determining splits in both models were similar; particularly the first number of splits in the two models with minor differences emerging towards the bottom of the tree. Table 3.3 outlines the characteristics of all the high-risk subgroups for CHID and Table 3.5 shows the characteristics of CART-derived high-risk subgroups. For clarity, the CART-identified high-risk subgroups are described below, noting that there are slight differences between the CART subgroups and CHID subgroups.

Among females, the experience of a stressful life experience between 0 and 5 years of age was a common risk factor in 6 of the high-risk subgroups (CART subgroups 1,2,3,4,5,8). The subgroup with the highest prevalence of suicidal ideation (at 40.6%) was females who had experienced a stressful life event, who had a young mother at birth, and who had a family member die. CART subgroup 5 had similar characteristics to CART subgroup 1, except for the experience of familial death. Instead, this group had a mother who reported current smoking (when the child was 4-5 years old). The prevalence of suicidal thoughts in this subgroup was 30.4%.

The model only identified one high-risk subgroup of males (CART subgroup 9), which had 25.3% prevalence of suicidal thoughts. This subgroup was characterized by the report of no activity limitation at 4-5 years, the experience of a stressful life event between 0 and 5 years of age, a mother who reported binge drinking at 4-5 years, and participation in religious activities at 4-5 years.

Many of the strong predictors in the models were in line with expectations, based on the literature review; however, there were some unusual and unexpected results. Most notably, CHID subgroup 6 and CART subgroup 7 had unexpected characteristics. For example, CART subgroup 7 was characterized by the absence of several important risk factors, including not experiencing a stressful event, and not having a single parent. The only risk factors reported in this subgroup were maternal smoking at 4-5 years, and non-participation in religious activities at 4-5 years. Interestingly, the variable that was most unexpected in this, and several other subgroups, was the effect of consistent parenting. Contrary to expectations, having consistent parenting corresponded to increased risk of suicidal thoughts in this subgroup. This may be partly explained by viewing the various aspects of parenting style separately. A parent could be consistently hostile, punitive, or

neglectful, and that parent would score high for consistency, but would not have an overall positive parenting style.

Interestingly, explicit measures of socioeconomic status were only important in two of the high-risk subgroups (CART subgroups 3 and 4). For both subgroups, having a mother who did not have a college or university degree increased the risk of later suicidal thoughts. Other measures of socioeconomic status, such as being below the low-income cut-off or parental unemployment were not highly predictive in the models. While these explicit measures were not important risk factors in the high-risk subgroups, various measures of family difficulties and adversity, including stressful life events, death in the family, having a young mother, experiencing single parent status, having a blended family, living in a rental dwelling, or having a parent with an activity limitation were strongly predictive in the model. These factors are likely strongly correlated with the experience of low socioeconomic status.

There were several measures of prenatal, postnatal, and early childhood health that were prominent in the model. The most predictive factor among males (CART subgroup 9) was the presence of a childhood activity limitation at 4-5 years. The importance of this factor was theoretically consistent with the *perceived burdensomeness hypothesis*, posited by Joiner: a child who has a chronic condition that limits his ability to participate in regular activities of school or home life may grow up with a sense that he is a burden on his family, which may contribute to increased suicidality in later life (72). Further, exposure to prenatal smoking, breastfeeding, and young age of mother were important predictors in the models. Broadly, many of these factors can be described as factors associated with early-life circumstances (the presence or absence of a nurturing environment). This is consistent with the Barker's Developmental Origins of Health and Disease (DOHaD) hypothesis, which showed the enduring influence of factors present in the prenatal and early-life period on later

health and disease (237,238). This biological programming approach was supported by other researchers which showed that early-life circumstances may alter the risk of disease throughout the life course (239,240). These approaches contribute relevant information to the investigation of mental health problems, which have complex aetiology based on factors from early life interacting with effects throughout development (237).

CART subgroup 6 is characterized by two risk factors – single parent status between 0 and 5 years of age and exposure to violence television at 4-5 years. The combination of these two variables may suggest that the mechanism that increases risk in a single-parent family may be the decreased level of parental monitoring, whereby children may be exposed to violent media. This is supported by research by Dornbusch et al (1985) who suggested that the presence of an additional adult in the home decreased deviance rates (241). Additionally, Steinberg (1987) tested the “additional adult hypothesis” and showed that adolescents from single-mother homes and step-families were more susceptible to pressure from friends to engage in deviant behaviour (242). Dornbusch et al (1985) suggested three possible mechanisms to explain this relationship between single parenting and increased risk, including lack of surveillance or monitoring, lack of appropriate teaching, and lack of social support (241).

In order to assess the predictive power of the models, sensitivity, specificity, positive predictive value, and negative predictive value were calculated for both CHID and CART models (Tables 4.4 and 4.6). The two models performed similarly on all measures, with sensitivity (the ability to identify positives) at 24.2% and 22.7% respectively. These results show that the model would correctly classify just over 20% of those with suicidal thoughts as high-risk. Conversely, it means that the model is not able to predict the increased risk for 80% of those with suicidal thoughts. Despite the sensitivity being low in these models, they

are a marked improvement over traditional logistic regression modeling, where the sensitivity was 9.1%. Specificity (the power to identify negatives) was high at 89.8% for CHID and 89.2% for CART. This means that nearly 90% of those who do not experience suicidal thoughts are correctly identified as not high-risk by the models. When assessing the strength of these models against traditional screening tests, which often have sensitivities and specificities in the 70-90% range, these models have an acceptable specificity however the sensitivity is much lower (29). The lower sensitivity in these models is not unexpected, as the models are predicting outcomes that occur at least seven years later. Positive predictive value, which shows what a positive result really means, was relatively low for both models (24.7% and 17.8%), meaning for those identified as “high-risk”, only 20% would actually experience suicidal ideation and that 80% of individuals identified as “high-risk” in these predictive models would not develop suicidal thoughts. The negative predictive value, which shows what a negative result means, was high (89.5% and 91.8% respectively), meaning that 90% of those who were not labeled as high risk would not experience suicidal ideation. The high negative predictive value means that these models are quite accurate in identifying which subgroups are not at high-risk.

5.1.3 Multiple risk factors and equifinality of suicidal outcomes

In both CHID and CART, the characteristics of the high-risk subgroups show the effect of risk accumulation through exposure to multiple risk factors. While much of the existing research on the risk factors for suicidal ideation are focused on what each individual factor contributes to the outcome, past research has shown that the influence of a single risk factor on suicidal outcomes is modest (243) and that in isolation, individual risk factors do not have a strong explanatory influence on the outcome (244). However, once exposed to multiple negative experiences, the risk in the subgroups is elevated (245). Each of the high-

risk subgroups in both CHID and CART models experience multiple negative exposures. For these subgroups, multiple risk factors appear to be clustered together and it is the joint effect, or the accumulation of multiple negative exposures that increases the later risk of suicidal outcomes. The model supports the hypothesis that exposure to multiple risks, whether they are simultaneous or sequential, set off a chain of factors that can lead to reduced health and other adverse outcomes (244). Research on other health conditions have consistently showed that exposure to multiple risk factors have adverse health effects that exceed the risk of a singular risk exposure (244). Further, research has showed that risks that span across multiple contexts are particularly harmful to mental health outcomes (246,247). This research supports the theoretical conceptualization of a risk gradient, which states that as exposure to negative psychosocial factors increases, there is an accumulation of risk. This accumulation of risk results in increased risk of later difficulty, which was shown for both suicidality and other measures of difficulty in adolescence.

The multiple high-risk groups also support the theory of equifinality, which posits that there are multiple developmental pathways to the same outcome. The high-risk subgroups have distinct characteristics; however, they all end up at increased risk of suicidal thoughts in later life, supporting research that has underscored that suicidal outcomes are complex and that there are multiple trajectories that may lead to difficulty in adolescence. For example, young maternal age is shown to increase the risk of suicidal ideation, and several subgroups with high risk of suicidal ideation have mothers who were under 25 when they gave birth (CART subgroups 1,5). However, groups of individuals with older mothers may nevertheless experience increased risk depending on the presence of other characteristics like prenatal problems or punitive and aversive parenting style (CART subgroups 2,3,4,8). Even though these groups of adolescents were not born to young

mothers, they are still at an elevated risk of suicidal ideation due to the influence of other risk factors. While there appeared to be several highly influential risk factors (like experiencing a stressful life experience, or having an activity limitation in early childhood), no single risk factor was necessary to the development of suicidal ideation, and the same outcome could be arrived at through the combination of different factors.

These models highlight the importance of investigating the interactions between factors in order to understand suicidality. Though a group may not have one of the initial, strongly predictive risk factors, the combination of other factors may still increase the risk of suicidal ideation. For example, the model showed that experiencing a stressful life event during early childhood increases the risk of suicidal ideation among girls (15.6% vs. 8.5%). However, combinations of other risk factors may contribute to elevated risk even among those who do not experience a stressful life event. This can be seen in CART subgroup 6, which is characterized by the following factors: females who have not experienced a stressful life event, but have experienced a period of single parenting, and have been exposed to violent TV at 4-5 years.

Having the ability to describe these interactions is a major strength of this analysis and it further highlights how risk factor-based epidemiology should move beyond single causes and consider multiple influences on outcomes from different domains of influence. Complex phenomena, like suicidality, have roots in individual characteristics and the family/social environment, and it might be necessary to describe multiple risks in order to better understand them. The predictive factors in both models are unsurprising, as they were selected for potential inclusion in the model based on previous research that had suggested links between the factors and increased suicidality. However, an interesting phenomenon highlighted by these models is that certain risk factors become more or less potent in the

presence or absence of other risk factors. In fact, the directionality of effect is reversed in a few cases depending on the other factors present in the subgroup. Notably, religious activities, social support, and punitive parenting had opposite effects (increase or decrease risk of suicidal ideation) depending on where they occurred in the tree. This may suggest that there were some situations in which a risk factor is more or less deleterious based on the presence or absence of other exposures. Alternately, these results may suggest the presence of a type 1 error, in which the models detect an effect that does not hold true in the population. As splitting continues towards the bottom of the tree, the more likely that results could be explained by type 1 errors, as the predictive splits near the bottom of the tree are less powerful, and over-fitting may be more of an issue.

5.1.4 Validation

The main criticism of tree models is that because they are able to take high-order interactions into account, they tend to over-fit the data. Over-fitting, also called overtraining, can occur in models when the link between the dependent and independent variable that appears in the model does not exist in the population being modeled (230). This happens when the model is overly precise when modeling the sample, following the fluctuations in the sample and showing relationships that do not exist in the population from which the sample was drawn (230). As they are designed to fit the dataset well, they are therefore often not able to accurately perform in a population from which the model had not been derived. In order to test the true predictive validity of these models, it was important to validate these results in an independent dataset (248). Thus in order to assess the validity and the external generalizability of the models created in the NLSCY, the model performance was examined in the Avon Longitudinal Study of Parents and Children (ALSPAC). Similar predictive

factors available in ALSPAC were coded, and using the same high-risk classification established in the NLSCY-based CHID and CART models, the sensitivity, specificity, positive predictive value, and negative predictive value was assessed.

Importantly, despite differences between these datasets and variables (see Appendix 8), both models performed with similar accuracy in ALSPAC. For the CHID tree model, the sensitivity was 22.4%, specificity was 87.7%, positive predictive value was 14.2%, and negative predictive value was 92.5%. The results were similar for the CART model (see Table 4.3). These results were slightly lower than the numbers in the original dataset where the sensitivity was 24.2% and positive predictive value was 24.7%, however, the model performs with similar accuracy in this second dataset. This is an important finding, as it shows that these predictive factors perform with similar accuracy in two separate cohorts.

5.1.5 Comparing CHID and CART

As shown in Figures 3.1 and 3.2, there were slight differences in the models derived CHID and CART, however, their overall predictive ability was similar. For example, the sensitivity was found to be 24.2% in the CHID model and 22.7% in the CART model and the positive predictive value was found to be 24.7% and 17.8% (see Tables 3.4 and 3.6). Further, during the validity stage, the external validity of the high-risk classifications generated from CHID and CART were found to be similar when tested in the independent dataset. The CHID model was found to have a sensitivity of 22.4% and positive predictive value of 14.2%, while the CART model was found to have a sensitivity of 19.9% and a positive predictive value of 22.5% (see Table 4.2 and Table 4.3).

From a methodological standpoint, the similarity in the models is not surprising, as even though the splitting statistic differs between CHID and CART, the goal of the two

approaches is comparable. While CHID uses the Chi-square statistic to find the variable which creates the biggest difference between the child nodes, CART uses the Gini impurity statistic which aims to maximize the homogeneity within child nodes. While these statistics are different, they are closely related and create the child nodes that best differentiate between a group with suicidal ideation and a group without suicidal ideation (biggest difference between the nodes using Chi-square, or most homogeneity within the nodes using the Gini statistic).

Even though these models are quite similar, under close examination several differences are apparent. The most predictive variables, which determine the first splits, were consistent between these two approaches, but as splitting progressed, there were some differences in the variables determining splits. There are several explanations for how different variables could determine splits and yet the models' predictive power remains similar. The biggest difference in the two methods is the treatment of missingness. For most of the variables in the CHID trees, a separate missing category was kept in the analysis, whereas any missing value was automatically included with the majority in CART algorithm. As there was a high level of missing values for some variables, this differential treatment of missing data may explain why different predictors were selected at several points in the models.

Despite the use of different predictors at some of the splits, the high level of agreement in predictive value between the two models may be explained by the high degree of clustering between predictive factors. For example, in girls without a stressful life experience, without a single parent, with a non-smoking mother, and with no exposure to prenatal over-the-counter medication, the next split in the CHID tree was determined by housing tenure (rented vs. owned) while in the CART tree, the next split was determined by

level of neighbourhood cohesion (medium/high vs. low). These predictors may be correlated, or the inclusion of missing values with the majority might affect the choice of predictor, which might explain their similar predictive power in this branch of the tree.

Due to these strong similarities between the CHID and CART models, the choice between techniques does not appear to be of critical importance. As outlined above, the CHID and CART models have slight differences, but because they predict with similar accuracy in the original dataset and perform similarly in the validation dataset, these differences do not appear to be clinically significant. Even though some of the variables are different, particularly towards the low splits in the trees, the high degree of alignment between the two models may be explained by the different treatment of missing values in the two procedures leading to the selection of different, yet related, risk factors. Future work, using surrogate splitting, may further illuminate how substituting variables with similar predictive power can affect the model fit. The advantage of the manual CHID approach is that there are no hidden defaults, making it a transparent process. The analyst has a high degree of control and is able to carefully set the minimum node sizes and splitting rules. Further, the CHID approach allows the separation of ‘missing’ as a meaningful category separate from ‘yes’ and ‘no’; and the Chi-square statistic is easy to interpret and explain to clinicians or naïve statistical users. However, the main drawback of this approach is that it is time-consuming, as it requires the calculation and review of all possible Chi-square values at each level of the tree. Particularly, as the tree continues to grow in complexity, this manual process became onerous and the computational time needed to calculate the Chi-square values for each possible combination becomes increasingly long.

In contrast, the main advantage of automatic CART software is that the program is easy to use and computationally swift and is able to generate tree models within minutes.

The caution with the automated approach is that there are many defaults that must be manually adjusted, and they may not be immediately apparent to a modeler. CART programs are also able to do more sophisticated methods of model specification based on the complexity parameter and can be used to conduct cross-validation within the dataset, adding methodological rigor to the resulting model. Further, CART is able to consider surrogate splits throughout the model to see how changing variables affects the overall predictive ability of the model (not done in this analysis). That being said, since the differences were minor, they are likely not clinically significant, which suggests that either approach may be acceptable for this, and similar, analyses.

5.1.6 Secondary outcomes and the multifinality of risk factors

Noting that many negative outcomes share similar risk factors, another objective of this research was to assess if these predictive models, developed for prediction of suicidal ideation, could also provide insight into other adverse health and social outcomes in adolescence. The multifinality of risk factors suggest that a group of risk factors may lead to multiple adverse outcomes, ranging from suicidal ideation to antisocial behaviours, adverse physical or mental health, risky health behaviours, substance misuse, and/or poor academic performance. Using the two predictive models developed in earlier objectives, the clusters of risk factors that constituted high-risk for suicidal ideation were assessed to see if they were also able to predict secondary outcomes. Tables 3.11 and 3.12 show the results of this investigation, and interestingly, the models were found to predict secondary outcomes with better sensitivity than the suicidal outcomes for which the models were constructed. This indicates that the distal factors used to predict suicidal thoughts are not specific to suicide; they are more global risk factors that predict a range of adverse outcomes.

Using the high-risk categories as identified by the CHID model, sensitivity, specificity, positive predictive value (PPV), and negative predictive value (NPV) were calculated for six secondary outcomes: antisocial behaviour, substance misuse, poor physical health, poor mental health, risky health behaviours, and poor academic outcomes. For example, for risky health behaviours, the CHID model was able to predict with 82.9% sensitivity, 89.8% specificity, 18.9% positive predictive value, and 88.7% negative predictive value. Values for the other poor outcomes ranged, but typically showed a much higher sensitivity than for the prediction of suicidal thoughts (see Table 3.11). The high-risk categories, as identified by the CART model were also tested, yielding similar results: the sensitivity of the model ranged from 29.8% for antisocial behaviour to 88.8% for risky health behaviours (see Table 3.12).

This analysis shows that the models developed to predict suicidal thoughts might be useful to predict a range of adverse adolescent outcomes, indicating that the predictors in the model may be understood as measures of a difficult early life with implications for a range of outcomes. The lack of predictor-specificity adds additional complexity to the prediction of suicidal thoughts, as it is possible to get to many different outcomes from the same risk conditions (237). This interesting finding demonstrates the multifinality of early-life risk factors on adverse outcomes, and suggests that effective interventions that reduce the risk in identified subgroups might have broad-reaching impacts on a range of health and social outcomes.

5.2 Implications for suicide prevention and health promotion.

There are two ways to ways to understand the results in terms of how this research can inform suicide prevention and health promotion efforts. The first would be to use models

to identify high-risk groups (see discussion of a screening approach in section 5.2.1). Based on the identification of high-risk groups, targeted health promotion programs that could be developed to intervene during the middle childhood years with the aim of attenuating risk and building resiliency in identified high-risk groups between the early life period and adolescence.

The second way to consider this research is to use it as a starting place to explore the etiological underpinnings driving the observed phenomenon, then work at the population level to reduce the exposure to the key factors present in the early childhood period (see further discussion in section 5.2.2). As this research was exploratory, further research would be needed to disentangle the complex causal web that leads to negative health outcomes.

More broadly, this research provides strong support for the multifinality hypothesis, which supports a shift in the way disease prevention and health promotion could be approached. Understanding that there are common roots of key health issues, we shift to strategic use of health promotion funding that targets shared trajectories of risk with the potential to prevent multiple adverse outcomes, rather than focusing on a single issue in isolation.

5.2.1 Accuracy, appropriateness and feasibility of screening at school entry

Research that is able to accurately predict suicidal outcomes based on early-life factors has the potential to inform the development of universal screening programs for detecting individuals at increased risk of developing suicidality, however there are many other factors, including appropriateness and feasibility, to consider prior to implementing universal screening. It has been suggested that a universal screening program for mental health problems, including suicide, could be implemented at school entry, similar to existing

physical health screening programs (249). One of the rationales for investigating factors prior to the age of 5 would be potential future application of the research into a universal screening program at school entry. However, even though the models showed that a certain level of prediction was possible, it is premature to discuss a universal screening program as there are many other factors to consider.

In addition to being able to assure that screening is accurate, there are several other important considerations to make before implementing a public health screening program, including: are there effective interventions for those at increased risk?, are there enough resources to provide adequate follow-up for those identified as high risk?, what are the ethical issues that need to be considered?. The World Health Organization's criterion for screening has been adapted by the National Research Council and Institute of Medicine (2009) to assess the appropriateness of selective and indicated prevention programs. First of all, the issue must be of public health importance, and there should be some understanding of the developmental link between risk factors and the disorder. Once these are established, there needs to be an effective intervention that leads to better outcomes. There need to be validated screening tools that identify early signs of suicidal outcomes and there also must be adequate facilities to both conduct screening and to implement the intervention/follow-up care to every identified individual (12,29,250).

There should also be agreed-upon guidelines for whom to refer to further assessment/care. The validated screening tool must have cut-off scores determining eligibility for referral to treatment (29). Ethical challenges must also be considered in order to ensure that screening is acceptable to the population and does not stigmatize individuals (29). Additionally, due to the ethical issues around screening, a risk-benefit analysis might be necessary before implementing a school-based screening program, including a thorough

investigation into the possibility of iatrogenic effects, stigmatizing effects, or alternately, the possible destigmatizing effect that may come as a result of a universal screening program (12,249). While this research can contribute useful information about high-risk subgroups which informs the accuracy of screening, the sensitivities of the models were quite low for the prediction of suicidal thoughts, and so many children that go onto develop suicidal thoughts would not have been labeled as high-risk. However, the contribution of the secondary outcomes may add an interesting dimension to the conclusion about the accuracy of screening. While the models only had 20% sensitivity for predicting suicidal thoughts, they were far more accurate in predicting other adverse outcomes, which may suggest that they may be useful. Thus, this research contributes information about the accuracy of screening for a range of adverse outcomes in adolescence based on early-life factors, but many other factors need to be taken into account before recommending a population-based screening program (29).

5.2.2 Nurturing environments and multi-faceted health promotion for enhancing healthy development

The predictive value of these models in predicting diverse outcomes of health and social difficulty in adolescence may support the research around the importance of nurturing environments in the development of wellbeing (30). The pathways to suicidality may be similar to those for other behavioural and health problems, stemming from a common lack of a nurturing childhood environment. There has been much research that has linked risk factors for particular difficulties; however, this research contributes to a course of research that shows risk and protective factors that are common to multiple difficulties.

The important predictors in both models can be largely grouped according to the four main characteristics of nurturing environments described by Biglan et al (2012).

Table 5.1 Predictors of adverse outcomes, organized by characteristics of nurturing environments (30)

Characteristic of a nurturing environment (29)	Predictor
Minimize biologically and psychologically toxic events (29)	Stressful life experience, death in the family, current parental binge drinking, current parental smoking, non-intact family, parental unemployment, low parental education level, prenatal exposures to OTC medication, smoking, lack of infant breast-feeding
Teach, promote, and reinforce pro-social behaviour, including self-regulatory behaviours and all of the skills needed to become productive members of society (29)	Parenting (parental consistency, hostility/ineffective, punitive/aversive), parental volunteer status, participation in religious activities.
Monitor and limit opportunities for problem behaviour (29)	Exposure to violence on TV, neighbourhood cohesion
Foster psychological flexibility (the ability to be mindful of one's thoughts and feelings and act in the service of one's values (29)	Presence of conduct disorder, developmental delay

This research provides exploratory evidence of factors that predict later life difficulty. However, if these predictors that indicate the presence of early childhood adversity are “causes” of later difficulty, there is a powerful opportunity for public health intervention focusing on increasing the prevalence of nurturing environments, as it could have significant implications for several important public health priorities. Modifiable and actionable risk factors provide a potential target for public health intervention, and action on these risk factors may help prevent adverse adolescent outcomes. Alternately, this research may

provide justification to further investigate the factors that mediate the vulnerability introduced by non-modifiable risk factors as the child continues to develop. Risk factors cross all contexts, and thus this research supports health promotion programming that strives to enhance the healthy development of children and youth and the avoidance of a range of negative outcomes through the implementation of programs and policies that create supportive families, and positive social and neighbourhood environments (29). Alternately, these factors may be markers of the underlying causes, but they can be useful for targeted public health interventions that wish to focus resources on those at highest risk. However, using this research to inform screening is premature unless it is determined that there are effective interventions that can assist those identified as high risk, adequate resources and capacity to provide necessary care, and community acceptance of the screening and intervention (29).

5.2.3 Embedding a multifinality approach in health promotion

Targeting prevention to early-life factors has implications for a wide range of outcomes, including suicide. However, and it may be negative to focus solely on suicide, as it remains, according to Joiner, “*one of the most stigmatized of human behaviours across human history and cultures*” (251). Therefore, rather than trying to gather resources to focus solely on suicide prevention, suicidal thoughts and potential deaths by suicide may be reduced using more comprehensive approaches to prevention, which would have implications for a host of other adverse outcomes in adolescence. By taking an interdisciplinary, multifaceted approach to preventing poor outcomes in adolescence, resources from multiple sectors could be used to jointly address the underlying issues in order to create better outcomes.

5.3 Where this fits in existing literature

In traditional risk-factor research, studies have investigated small numbers of risk factors, holding all others constant in order to show the association of each factor to suicidal outcomes. This approach necessarily ignores the real world complexity and the complex aetiology of suicidality. The important contribution of this research is that it is able to highlight the effect of multiple overlapping risk factors on the individual's risk of suicidal thoughts, showing that there are multiple groups of risk factors that influence suicidal risk. Further, the research shows that the risk factors that predict suicidal thoughts can be used to predict other adverse outcomes in adolescence, which may provide a rationale for targeting multiple adverse outcomes that share similar developmental origins.

5.4 Strengths and Limitations

There are several important limitations to note related to both the data and the research design. This research relied on data collected in the NLSCY and ALSPAC, two large, population-based, longitudinal cohort studies. A major strength of this research was that the predictive models built in the NLSCY were later validated in ALSPAC. This overcame one of the main criticisms of tree-based modeling, and showed that the prediction rules performed similarly in a second cohort.

One of the challenges with cohort studies is ensuring that they are representative of the general population from which they are sampled. One of the limitations of both datasets in terms of the representativeness of the population is that people who were sampled and contacted to participate may not have consented. If non-consenters are different from consenters, the study findings may be biased and not representative of the larger population

(252). As with other cohorts, there may be period effects as this group of individuals grew up in the particular social context specific to the 1990s and 2000s, and this may limit the generalizability of these findings to other cohorts (253). Specifically, the models might not speak to the experience of particular subgroups of the population. Due to the sampling frame used in the NLSCY, we were unable to get a representative measure of Aboriginal status, as Aboriginal people living on reserve were excluded from the sampling frame. Thus, the results do not represent the experience of all Aboriginal peoples living in Canada.

Due to the nature of prospective longitudinal design, both datasets suffer from selection bias as a result of losses to follow-up. Of the 12,333 NLSCY participants who were five years or younger in cycle one, nearly half ($n=5,945$) were excluded from analysis because they did not have a valid response to the suicide module. While this included some specific non-response to the suicide module, it was largely driven by losses to follow-up, which accounted for approximately 85% of the missing. Overall, the NLSCY had a follow-up rate of 61% from cycle 1 (1994/5) to cycle 8 (2008/9) (225). While some losses to follow-up may be random, it is plausible that some of the attrition experienced in both NLSCY and ALSPAC was systematic and may be related to the exposures as well as the outcomes. If this loss to follow-up was non-differential, then the loss is less problematic. However, if those who drop out are systematically different from those who remain in the study, it impacts our ability to make inference based on these findings to the entire population. In this case, selective drop-out of participants with particular characteristics could affect the findings of this research. While it is difficult to disentangle the extent to which the losses to follow-up were differential or non-differential, analysis by Statistics Canada showed that there were several characteristics related to lower response rates, including low income, low levels of income, low levels of employment, and living in a rental dwelling. Several of these factors

have also been linked to suicidal outcomes, which may have an impact on the estimates in the study. For example, among those with suicidal thoughts, if those with low maternal education are more likely to drop out, the association between low maternal education and suicidal thoughts will be underestimated. Interestingly, previous attrition analysis of the NLSCY showed that those with higher scores on symptoms of mental illness at age 8-9 were more likely to stay in the study at ages 10-15 (254). Since mental illness is closely related to suicidal outcomes, it is possible that those who develop suicidal thoughts are more likely to stay in the study than those who do not.

Loss to follow-up is an important consideration when working with longitudinal data, which is why having the ability to compare the results in a second cohort was an important strength of this research. Like most cohort studies, the ALSPAC cohort suffers from losses to follow-up. Work by Wolke et al (2009) showed that dropout in the ALSPAC cohort was systematic and further, that children were more likely to drop out if they suffered from behavioural disorders or according to certain familial factors. They also showed that losses to follow-up in ALSPAC were systematically related to important predictive factors in our research, including single parenthood, low education level, financial difficulties, maternal smoking, poor housing, and maternal psychopathy (255). Similarly, research on the representativeness and attrition of ALSPAC showed that those who experienced greater adversity during pregnancy, including health issues, housing problems, or low social support were more likely to be lost to follow-up (232). Thus, we expect that there were similar systematic losses to follow-up in both the NLSCY and ALSPAC, where participants experiencing higher levels of adversity in early life may have been more likely to selectively drop-out. This creates a higher degree of homogeneity in the cohort and might influence the ability to predict the outcome (256). It also demonstrated that while the losses to follow-up

may underestimate the prevalence of psychiatric disorder, the selective drop-out did not negate findings showing the relationship between predictor variables to the outcome (255). Similarly, in our research, we expect that the systematic losses to follow-up underestimates the prevalence of suicidal ideation and other adverse outcomes in adolescence, but may not significantly affect the relationships between predictor variables and the outcomes. In the context of tree modeling, the systematic drop-out of individuals with shared characteristics may mean that our models are missing additional branches, which may be characterized by different predictors. This may mean subgroups with distinct characteristic may be missing, which impacts the ability of the model to accurately represent the underlying population, but it may not dramatically affect the observed relationships represented in the tree.

The availability of predictive variables for all participants was a challenge in this research, particularly when working with the NLSCY cohort. There were high levels of missing values for some of the predictor variables in the model (>4%). Due to the high number of predictors, participants were not excluded based on missing data for the predictors, however, for variables that had a high level of missing data (>4%), the missing data was coded as a separate category in the analysis. The level of missing data was particularly high in some of the prenatal questions for the NLSCY, as the mothers of older children recruited in the study were not asked about prenatal exposures. Mothers of older participants were not asked about prenatal and postnatal exposures and behaviours, so the missing was linked to the age of the participant. This might affect the modeling, including the strength of association and ability to detect effect. This limitation was partly addressed by comparing the results to the ALSPAC birth cohort, which did not suffer from this limitation as all participants were asked about pre- and post-natal factors.

Further, older children had more opportunities to answer the suicide questionnaire. At

the end of cycle 8, the older participants provided responses from age 12/13 through age 16/17, while the youngest children only had the opportunity to respond to the module from age 12/13 to age 14/15. With this important consideration in mind, a sensitivity analysis was conducted, which showed that the models did not perform differently in the three age cohorts.

In both datasets, most predictor variables were collected by parent self-report questionnaires, while the outcomes were determined by youth self-report questionnaires. The use of self-report may introduce bias to the results, particularly social desirability bias. For the predictor variables, the social desirability bias may affect the willingness of parents to disclose participation in socially stigmatized behaviours on the early-life questionnaires in an effort to give responses that show them in a favorable light (257). This may cause under-reporting of socially-perceived negative exposures, like prenatal use of alcohol or other substances, stressful life experiences, or the report of early childhood exposure to child abuse. This may affect the ability to detect associations between early-life factors and adolescent outcomes, if systematically underreported.

The accurate, reliable measure of adolescent health and social outcomes was important to the research question, with implications for the ability to accurately detect true associations between risk factors and adolescent outcomes. Both studies use youth self-report questionnaires to recall suicidal ideation and other health risk behaviours, like participation in antisocial or illegal activities, substance use, mental and physical health status, health risk behaviours, and academic performance. The accuracy and reliability of youth self-report measures have been questioned as some of these factors may be hard to recall or they may be sensitive, causing the respondents to under-report them (258). Alternately, some respondents may over-report certain health behaviours if they believe the behaviour is socially desirable

(258). Investigation into the Youth Risk Behaviour Survey, which asks about substance use, sexual behaviour, suicide attempts, and physical activity, have shown that overall, youth appear to report health risk behaviours accurately over time with acceptable validity and reliability (259,260).

Considering that suicidal ideation was the primary outcome of this research, a limitation in this study was the measurement of suicidal thoughts. Access to a more nuanced, thorough measurement of suicidal ideation that includes measures of passive versus active ideation, frequency, duration, and severity might provide interesting information to this research. Further, the reliance on the suicide continuum as the theoretical underpinnings for the skip logic in the questionnaire limit the investigation of other suicidal outcomes, as the questionnaire assumes that an individual must endorse suicidal thoughts in order to be asked questions about behaviours, plans, or attempts.

There are several important limitations related to the design of this research project. In the initial development of the predictive models in the NLSCY, there were three main limitations. Firstly, in order to create the models, predictors were dichotomized, which results in a loss of information particularly for the continuous variables. By dichotomizing variables, we lose the ability to detect dose-response relationships and potentially falsely create groups with heterogeneous experiences of various exposures. For example, postpartum depression was coded as “yes” or “no” without consideration for whether the period of depression was short or prolonged or what level of severity the postpartum depression was. Secondly, the model treats all predictors as though they are independent predictors, however, many of the variables are highly correlated, although formal tests of correlation were not conducted. This correlation may influence the replicability of the results. Thirdly, when specifying the CART model, cross-validation techniques were not

used even though it is an oft-recommended approach. Cross-validation was not used in order to use the same pruning approach as the CHID model, as it is not possible in the manual procedure; however, further work on cross-validation of this model may be recommended.

During the validation stage, the major limitation was that the exact measures were not always available in ALSPAC. While both surveys measured a wide range of variables, they were not always directly comparable, which has implications for the ability to compare the model in the separate cohorts. For each of the model predictors from the NLSCY, the closest proxy was selected in ALSPAC, but for several variables there was not an appropriate substitute. These included a measure of developmental delay (as there are issues with the measure used in ALSPAC so the data has not yet been released); rural or urban residence was not asked in ALSPAC; and there was not a measure of childhood activity limitation due to a chronic condition. These variables were excluded from the validation study.

When discussing the implications of this research, an important distinction must be made between the *predictors* and *causes* of adverse adolescent outcomes. This research investigated the predictors of suicidal ideation and other adverse outcomes, but these predictors are not necessarily the causes of said outcomes. The predictors may be markers for the underlying causes or they may exist on the causal pathway between the true causes of adverse adolescent outcomes. This differentiation is critical in the application of this research, as interventions focused on eliminating the identified predictors may not directly correspond to the reduction or elimination of negative outcomes. Rather, this research has identified subgroups that are at increased risk of adverse outcomes, which might benefit from evidence-based interventions aimed at improving the outcomes later in life.

Despite these limitations, there are important strengths to the data and approach used in this research project. The use of large, prospective cohort studies is a major strength as

these studies provide some of the best information for etiological research. Both the NLSCY and ALSPAC have large samples that are considered to be nationally representative of Canada and Britain, respectively (233,261). Since this data is nationally representative, the results are generalizable to the general population of each country, meaning these models may describe what is happening across Canada/Britain, not just limited to the study population. Further, since both of these datasets sample a large number of participants, we were able to investigate somewhat rare outcomes and to investigate a broad range of risk factors related to these outcomes. This is important as simultaneously considering multiple risk factors and the interactions between the variables is the primary objective of this research project. Both datasets contain rich data, with good measures of a wide range of possible predictive factors.

The longitudinal nature and the long duration of follow-up of these datasets is a major strength of this research, as it allows us to disentangle questions of temporality by ensuring that all risk factors precede the outcome. This ability to establish the temporal sequence between risk factors and future adverse events is the major advantage that longitudinal data has over cross-sectional research. For this research question, we can be confident that the exposures precede the outcome, as suicidal ideation or the first occurrences of risky health behaviours would be extremely rare in the early childhood period (262). Also, as all data are collected prospectively, the risk of recall bias is minimized across the range of risk factors included in the models. Recall bias was reduced, as exposures were measured temporally proximal to their occurrence. For example, questions about prenatal factors were asked during infancy for NLSCY participants and throughout pregnancy for ALSPAC and did not rely on long periods of retrospective recall.

5.4.1 Suggestions for further research

While individuals in the high-risk subgroups experience rates of suicidal ideation that are at least twice that of the overall population, the majority of individuals in these groups do not experience suicidal ideation. The question of “why are some children okay?” is interesting, as many of the youth that experience multiple risk factors do not go on to exhibit difficulties in adolescence. Further research could unpack the factors that operate throughout childhood within high-risk groups that further determine who will go on to develop suicidal thoughts or other adverse outcomes. Additionally, further research may investigate the mediating factors during childhood, between 5 and 11 years of age, that determine who in the high-risk groups go on to develop suicidal outcomes; and if there are important mediating or protective factors present throughout childhood that prevent some youth from experiencing suicidal thoughts or other difficulties in adolescence. If the identified high-risk groups are followed through childhood, perhaps it may shed light onto the mediating factors that affect whether those with vulnerability go on to exhibit negative outcomes. Moreover, research into effective interventions to reduce risk of those who have experienced early-life adversity may provide valuable information to how negative outcomes can be avoided in spite of exposure to early-life difficulty.

From a methodological perspective, there are other ways to validate models that could be considered for next steps for this research, including considering structural equation modeling or latent class analysis that will allow a different way of capturing the relationships between variables in the model.

5.5 Conclusions

This research has contributed to our understanding of the complex relationship between early life factors and suicidal thoughts in adolescence. It identified combinations of risk factors that predict increased risk of suicidal thoughts in adolescence, suggesting that early childhood conditions can have a significant influence on the trajectory of health into adolescence. Importantly, this research showed that the predictors of suicidal thoughts were not specific to suicide, and in fact, these factors predict other important outcomes, including antisocial behaviour, substance misuse, poor physical and mental health, participation in risky health behaviours, and poor academic performance. As the identified high-risk subgroups experience a range of negative outcomes in adolescence, they may be important populations to target with health promotion strategies throughout middle childhood that mitigate the elevated vulnerability experienced by these subgroups. Alternately, more investigation could focus on identifying factors in the early life period that could reduce risk and support healthy development.

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Appendices

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Appendix 1 Key definitions

Suicidal thoughts (or suicidal ideation) – thoughts, intentions, and plans about harming or killing oneself. Suicidal ideation can range in severity from thoughts of death and passive ideation to suicidal ideation with suicide intent or suicide plan (34,51,263,264).

Suicidal Behaviours – a self-inflicted, potentially injurious behaviour, for which there is evidence (either explicit or implicit) of intent to kill himself/herself. Suicidal behaviour may include suicidal ideation or suicide attempt (264–266).

Suicide (or death by suicide) – the act of deliberately killing oneself, death from self-inflicted injury where there is either implicit or explicit intent to kill oneself (264,267).

Suicidality – all suicide-related behaviours and thoughts including suicidal ideation, attempting suicide, or death by suicide (264).

Risk - the probability of an outcome (268)

Correlate - a measure associated with the outcome (268)

Risk factor – a measurable characterization/correlate of each subject in a population that is shown to precede the outcome and can be used to divide the population into two groups – the high-risk and the low-risk groups (75,268)

Causal risk factor – a risk factor that, when changed, is shown to change the outcome (268)

Appendix 2 Search strategy

A literature search was conducted in September 2013 first through Medline and repeated in EMBASE. Key search terminology was as follows (* indicates truncation): (suicid*...) AND (youth or adolescen* or teen* or child*) AND (risk factor*). Several other search terms were also used, as outlined in the below Medline search strategy. Medline alert were used, based on the search strategy, to receive notifications of new publications between September 2013 and August 2014.

Table A.1 Medline search strategy

☐	# ▲	Searches	Results
☐	1	Suicide/	14884
☐	2	Suicidal Ideation/	1197
☐	3	Suicide, Attempted/	8766
☐	4	Suicide, Attempted/	8766
☐	5	suicid*.tw.	30356
☐	6	(suicid* adj1 ideat*).tw.	3587
☐	7	self-murder.tw.	5
☐	8	(fatal adj1 self-harm).tw.	45
☐	9	self-killing.tw.	25
☐	10	1 or 2 or 3 or 4 or 5 or 6 or 7 or 8 or 9	35208
☐	11	Adolescent/	793826
☐	12	Child/	617464
☐	13	11 or 12	1064253
☐	14	10 and 13	10863
☐	15	Risk Factors/	430641
☐	16	14 and 15	2799
☐	17	predict*.tw.	619643
☐	18	14 and 17	1347
☐	19	Epidemiology/	2970
☐	20	14 and 19	6
☐	21	Prevalence/	152016

☐	22	Incidence/	133512
☐	23	21 or 22	272488
☐	24	14 and 23	1537
☐	25	10 and 17	2922
☐	26	exp cohort studies/	938959
☐	27	14 and 27	2354

Appendix 3 Research Ethics Board Approval

Appendix 4 NLSCY technical coding details for predictor variables

PRENATAL AND POSTNATAL FACTORS

Due to the link between pre- and post natal factors and suicidal outcomes in later life, 11 predictors measuring aspects of the pre- and post-natal period were included in the predictive models.

VARIABLE	QUESTION	CODING
Presence of prenatal medical problems	The PMK was asked if the mother of the study child had medical issues during the prenatal period, including diabetes, high blood pressure, and other physical problems.	If at least 1 medical problem was reported, they were coded as 'yes.' Those who did not report a prenatal medical problem were considered 'no' or 'missing.'
Prenatal smoking	The PMK was asked if the mother of the study child had smoked during stage 1, stage 2, or stage 3 of pregnancy.	If they reported smoking during any stage, they were considered to have smoked during pregnancy ('yes'), those who did not report smoking were coded as 'no,' and those without a valid response were coded as 'missing.'
Prenatal alcohol drinking	PMKs were asked "How frequently did [you/the mother] consume alcohol during your pregnancy with [the study child]?"	Those who reported 'never' were considered to have not consumed alcohol during pregnancy (no) and all other valid responses (less than once a month, 1-3 times a month, once a week, 2-3 times a week, 4-6 times a week, everyday) were considered to have drank alcohol in pregnancy and coded as 'yes.' Those without a valid response (including 'don't know' and 'refused') were coded as missing.
Prenatal prescription drug use	Mothers were asked "Did you take any prescription medications during your pregnancy with [the study child]?"	This variable was coded according to the following three categories 'yes,' 'no,' and 'missing' (including 'don't know' and 'refused').
Prenatal over-the-counter drug use	Mothers were asked if they took over-the-counter drugs during pregnancy.	This variable was coded according to the following three categories 'yes,' 'no,' and 'missing' (including 'don't know' and 'refused').
Low birth weight	Mothers were asked to report the weight of the study child at birth.	Low birth weight ('yes') included those born weighing less than 2,500 grams. Those $\geq 2,500$ grams were not considered to have low birth weight ('no').
Prematurity		Infants born with less than 259 gestational days were considered premature ('yes') and those ≥ 259 days were not considered to be premature ('no').

Infant special medical care after birth	Mothers were asked if their child received special medical care after birth.	This variable was coded according to three categories 'yes', 'no', or 'missing' (including 'don't know' and 'refused').
Maternal hospitalization after birth	Mothers were asked "Were/was you/her/his mother hospitalized for special medical care for any period immediately following the birth of [the study child]?"	This variable was coded according to three categories 'yes', 'no', or 'missing' (including 'don't know' and 'refused').
Post-partum depression	PMKs were asked "After ___'s delivery, did you/her/his mother suffer from postpartum depression"	This variable was coded according to three categories 'yes', 'no', or 'missing' (including 'don't know' and 'refused').
Breastfeeding	In order to assess breastfeeding, responses to two questions were combined. Mothers were asked if they were currently breastfeeding. Of those not currently breastfeeding, they were asked "did you/her his mother breast-feed him/her even if only for a short time" were also coded as 'yes.'	Those who reported current breast feeding or if they indicated the child was breast-fed "even if only for a short time" were coded as 'yes'. Those who responded no to both of these questions were considered 'no' and those without a valid response (including 'don't know' and 'refused') were coded as missing.

INDIVIDUAL

VARIABLE	QUESTION	CODING
Gender	Gender of the child was asked of the PMK	Variable coded as 'male' or 'female.'
Racial background/ethnicity	Racial background/ethnicity was determined by a series of questions, which asked the PMK to "best describe [the child's] race/colour." For this analysis, two predictors were included in the analysis. The first variable approximates visible minority status, using the question which asked if "White" was the how the PMK would best describe the child's race/colour. Similarly, in	Individuals who that "white" best described the study child's race/colour were coded as "white" and those who responded "no" were considered "not white." For Aboriginal status, those who indicated that "Native/Aboriginal people" best described the study child's race/colour were coded as "Aboriginal" and all others were coded as "not Aboriginal."

	order to estimate Aboriginal status, individuals who responded that “Native/Aboriginal people (including North American Indian, Métis, Inuit/Eskimo)” best described their race/colour”	
Immigration	The PMK was asked to indicate if the child was an immigrant.	Those who reported ‘yes’ were coded as 1 and all others were coded as 2 and considered to be not immigrants.
Rural or urban residence (at age 4-5)	The PMK was asked to indicate if the child was currently living in a rural or urban area.	Those who reported living in a rural area were coded as 1, while all others were coded as 2.
Child’s general health (at age 4-5)	Parents/PMKs were asked to report on the general health of their child at age 4-5 by the following question: “In general, would you say...’s health is: excellent, very good, good, fair, poor, don’t know, refusal.”	Those who responded that their child’s health was excellent, very good, or good were coded as ‘no’ and those with fair or poor health were coded as ‘yes’. Those who did not know or refused were coded as missing.
Physical activity (at age 4-5)	PMKs were asked to report on their child’s physical activity compared to other children at age 4-5.	Those who reported their child was “much more active,” “moderately more active,” or “equally active” was coded as ‘2’ and children who were said to be “moderately less active” or much less active” were coded as ‘1’. Those who did not know or refused were coded as missing.
Chronic conditions	The PMK was asked a series of questions regarding the presence of chronic conditions including diabetes, heart disease, and epilepsy.	If they responded ‘yes’ to the following question “does child have any of the following long-term conditions that have been diagnosed by a health professional: - None” they were considered to be free of chronic conditions and coded as 2, while those who said ‘no’ to the above question were coded a 1.
Pain and discomfort (at age 4-5)	The PMK was asked if the child at age 4-5 is usually free of pain and discomfort.	Those who reported the presence of pain and discomfort, they were coded as ‘yes’ while those who did not respond or said no were considered to be free of significant pain/discomfort.
Injuries (at age 4-5)	PMKs were asked if the child had been injured in the past 12 months.	Those who reported “yes” were considered to have been injured and coded as ‘yes’ and all others were coded as ‘no’.
Activity limitation (at age 4-5)	PMKs were asked to indicate how many	Those who reported “a few”, “some”, or “most” were considered to have activity

	activities are prevented due to pain or discomfort.	limitations and were coded as 'yes'. Those who reported "none" or who did not respond were coded as 'no'.
Activities	PMKs were asked a series of questions about the child's participation in various activities, including participation in early childhood activities, playing sports with and without a coach, participation in gymnastics or dance, arts, drama, or music, or guides, scouts and/or other clubs.	Participants were categorized as participating in any of the activities at least once a week as 'yes' and those who did not report any of the aforementioned activities were categorized as 'no'.
Behaviour was measured using a scale that was developed from the Ontario Health Study (269) and the Montreal Longitudinal Study (270). The behaviour scale uses the mothers' rating of child functioning in order to identify internalizing problems/hyperactivity, conduct problems/externalizing behaviour, indirect aggression, anxiety/emotional disorders, and prosocial behaviours. The scale was calibrated to screen for child psychiatric disorders according to the diagnostic criteria in the <i>Diagnostic and Statistical Manual of Mental Disorders (3rd ed, rev)</i> (271). The scales have been shown to have adequate predictive validity for diagnosis of hyperactive disorder (69% sensitivity, 82% specificity), conduct disorder (74% sensitivity, 75% specificity), and depression (52% sensitivity, 93% specificity) (272). For each item, the PMK indicated the frequency of the behaviour on a three-point scale: 0 (never), 1 (sometimes), or 2 (often).		
Hyperactivity/ Inattention (at age 4-5) (Behaviour subscale)	Symptoms of internalizing problems, including hyperactivity, inattention, and impulsive behaviours were estimated using an 8 question subscale, with possible scores ranging from 0-16. Higher scores indicated the presence of more symptoms of hyperactivity.	Based on research by Charach (2010), the threshold cut-off for the presence of hyperactivity was 14, where children who scored between 14 and 16 were classified as having internalizing problems, and children who scored between 0-13 were classified as not having problems (273).
Conduct problems (at age 4-5) (Behaviour subscale)	Symptoms of externalizing behaviour were estimated using a subscale consisting of 6 questions, with possible score ranging from 0-12.	The threshold for the presence of conduct problems was set as 5, which is 1.5 standard deviations above the mean (which also corresponded to the 90 th percentile of responses) (272). Children who scored between 5 and 12 were considered to have symptoms of externalizing behaviour problems, where those scoring between 0-4 were classified as not having externalizing problems.
Prosocial behaviours (at age 4-5)	Presence of prosocial behaviours was estimated	The 90 th percentile (score of 17 or over) was used to indicate those who had high levels of

(Behaviour subscale)	using the prosocial behaviour subscale, with possible scores ranging from 0-20, where a 0 indicated the absence of prosocial behaviour.	levels of prosocial behaviours and were coded as '1' and those who scored between 0 and 17 were coded as '2'.
Indirect aggression (at age 4-5) (Behaviour subscale)	Indirect aggression was estimated using subscale with possible scores ranging from 0-10.	Cut-off score was set at 2, corresponding to the 90 th percentile.
Emotional disorders/anxiety subscale (at age 4-5) (Behaviour subscale)	Emotional disorders/anxiety was assessed using an 8-question subscale with possibly scores ranging from 0-16, where a higher score reflected more symptoms of anxiety (Elgar 2003).	Children who scored between 5-16, which was 1.5 standard deviations above the mean (which also corresponded to the 90 th percentile) were classified as experiencing symptoms of emotional disorders. Children who scored between 0-4 were classified as not experiencing symptoms of emotional disorders.
The Peabody Picture Vocabulary Test – Revised (PPVT-R) standardized score	The Peabody Picture Vocabulary Test – Revised (PPVT-R), developed by Llyod and Leota Dunn, was used to measure school readiness and cognitive ability for children in the 4-5 age group (261). The test was administered to the child in the home and the interviewer read out words and the child was to look at pictures on an easel and identify the picture that matched the word read out by the interviewer (261). The raw score was calculated then standardized, taking the child's age into account using 2-month age groups. The score was adjusted so that the mean of standard scores was 100 and the standard deviation was 15 for all age groupings (261).	For the current study, children were dichotomized as “delayed” if their standardized score was between 0-84 (one standard deviation below the mean and lower) and “not delayed” if their standardized score was 85 or above (274).
Stressful life experiences	PMKs were asked to report if their child had experienced any event that cause a great deal of	Those who responded ‘yes’ were considered to have experienced and stressful life event in early childhood. Those who answered ‘no’ were considered to have not experienced a

	stress or worry between birth and age 5.	stressful event in childhood and were not asked the additional questions in the module (and for all subsequent questions were considered to have not experienced that event). Those who indicated that their child had experienced a stressful life event were asked to report indicate the cause of the stressful live event experienced, including death of a parent, death of a family member, divorce or separation, move, hospital stay, other separation from parents, injury or illness of the child, injury or illness of family member, abuse or fear of abuse, change in household members, alcoholism or mental health problem in the family and/or conflict between parents. Participants were classified as 'yes' to any of these stressful life events reported and 'no' to ones the PMK did not report.
Exposure to intimate partner violence	PMKs were asked to report if their child saw adults fighting or hitting.	Those who reported this occurring 'often', 'sometimes', or 'seldom' were coded as 1 and all others were coded as 2.
Exposure to violence on TV	PMKs were asked to report if their child saw violence on TV.	Those who reported this occurring 'often', 'sometimes', or 'seldom' were coded as 1 and all others were coded as 2.

FAMILY

VARIABLE	QUESTION	CODING
Teenage status of parents at birth	The NLSCY asked the age of the biological parents at birth.	If one or both of them was said to be under 20 years of age, the participant was categorized as ('1') having a one or both teenage parent at birth or ('2') neither biological parents were teenagers at the child's birth.
Age group of PMK at birth	Two dichotomous variables were created to capture the age of mother at birth.	For the young mothers variable, any mother in the youngest age category, which included those between 15 and 24 years of age, were categorized as '1' while all other participants were classified as '2'. Similarly, for the old mother variable, any mother in the oldest age category (age 40 or older) was categorized as '1' while all other participants were classified as '2'.
Low income (SES)	Socioeconomic status was measured as the ratio of the household income to the low income cut off score (LICO), established by Statistics Canada. The LICO indicates an income level at which a family is likely to spend a	The income –to-LICO ratio of less than 1 is considered to be living in low income, and for this study, this was dichotomized as low income ('1') and not low income ('2').

	large portion of their income on necessities, accounting for family size and the community they live in (275).	
Education level of PMK	The education level of the PMK was considered as a potential predictor of suicidal ideation. On the NLSCY, PMKs are asked about their highest level of education obtained, with four possible responses: less than secondary, secondary school graduation; beyond secondary school graduation; university or college degree.	Two dichotomous variables were created to capture PMK education. The first was those with less than high school education (coded as 1) compared to those who had graduated from secondary school (coded as 2). Similarly, a variable was created which compared those with less than a college or university education (coded as 1) and those who reported graduation from college or university (coded as 2).
Unemployment of PMK or spouse	The PMK and spouse were asked about their work status in the past year.	If either reported that they “did not work during the past year” at any of the time points collected, they were considered to have experienced a period of parental unemployment and coded as ‘1’.
Housing tenure (rented vs. owned)	PMKs were asked “Is this dwelling owned by a member of this household (even if being paid for)”.	If they ever reported “no” during cycles 1-4, they were considered to live in a not-owned home and were coded as ‘1’ while those who always reported ‘yes’ were coded as ‘2’.
Immigrant status of PMK	In order to determine if PMKs were immigrants, the response to ‘number of years since first moving to Canada’ was considered.	For those who reported between 0 and 51 years, they were considered to be an immigrant and coded as ‘1’ while those for whom the question was ‘not applicable’ were coded as ‘2’ and considered to be not immigrants.
Religion	PMK’s were asked “what, if any, is your/...’s religion?.”	Those who reported Roman Catholic, United Church, Anglican, Presbyterian, Lutheran, Baptist, Eastern Orthodox, Jewish Islam (Muslim) Buddhist, Hindu, Sikh, Jehovah’s Witness, or other were coded as ‘yes’ to having a religion. While those who reported “no religion” were considered ‘no’.
Participation in religious activities	Of those who reported a religion, PMK’s were asked the following question: “Other than on special occasions (such as weddings, funerals or baptisms), how often did ... attend religious services or meetings in the past 12 months?”	All participants who reported attending religious activities at least once in the past year were coded as “yes” and those who indicated “not at all” were considered ‘no’, as were all participants who had indicated that they do not have a religion in the previous question. Those who didn’t know or refused were coded as ‘no’.

Single parent status	Child's single parent status was assessed during cycles 1-3.	If the PMK reported that the child lives with 'one parent only' or 'does not live with a parent', they were coded as having experienced a period of single parent status and coded as '1'. Those who reported 'two parents' were coded as '2'.
Intact vs. blended family	Family composition was assessed using the blended family variable.	If the PMK indicated the 'child is a member of a blended family' or 'other – child is a member of a single parent family, is a foster child or does not live with parent' they were coded as '1' while all those for whom it was reported that they were not a member of a blended family were considered to be an intact family and coded as '2'.
Poor parental general health	PMKs were asked to report on their general health when their child was ages 4-5 by the following question: "In general, would you say... 's health is: excellent, very good, good, fair, poor, don't know, refusal."	Those who responded that their health was fair or poor health were coded as '1' where those who reported excellent, very good, or good health were coded as '2'. Those who did not know or refused (n=154) were included in category '2' with those who did not report poor health.
Presence of chronic conditions (PMK or spouse)	PMKs and their spouses/partners were asked if they had chronic conditions.	If the PMK or spouse/partner reported a chronic condition, they were classified as '1' for having a chronic condition, and all others were classified as '2', indicating the absence of a chronic condition.
Parental activity limitation (PMK or spouse)	PMKs and their spouses/partners were also asked if they had a condition that limited their activity.	If the PMK or spouse/partner reported activity limitation, they were classified as '1' and all others were classified as '2', indicating the absence of activity limitation.
Parental smoking	PMKS were asked about their smoking habits.	PMKs who reported smoking "daily" or "occasionally" were classified as current smokers ('1') and all others were classified as current non-smokers ('2'). Those who refused or did not provide a valid response (n=154) were included with the 'non-smoking' category.
Parental binge drinking	PMKs were asked about their current alcohol consumption, including the frequency of binge drinking (i.e., 5 or more drinks on one occasion).	Those who reported at least one binge in the past 12 months were classified as current binge drinkers and coded as '1'. Those who did not report a binge drinking episode in the past year ('no' or missing – n=172) were coded as '2'.
Maternal depression score	Maternal depression was measured using the 12-item version of the	Depression score between 0 and 36, high score indicating the presence of depression symptoms, and the dichotomous cut-off for

	National Institute of Mental Health's Centre for Epidemiological Studies Depression scale (CES-D) developed by L.S. Radloff in 1977. The 12-item version of the scale was developed by Dr. M. Boyle of the Chedoke-McMaster Hospital of McMaster University and was rescaled to produce a cut-off proportionate to the full, 20-item CES-D (261,276). The modified CES-D showed good internal consistency and had a Cronbach's alpha of the scale was 0.82 (272,276).	depression was set at 9, where mothers who scored 9 or above were coded as '1' (depressed) and mothers who scored 8 or less were coded as '2' (not depressed) (226,277).
Parenting: The Parenting Scale used was an adaptation of the Strayhorn and Weidman's Parent Practices scale, adapted by Dr. Boyle at Chedoke-McMaster Hospital, based on previous work from Dr. Dodge at Vanderbilt University. This scale measured positive interactions, hostile/ineffective parenting, and consistent parenting.		
Positive interactions parenting style	Parenting characterized by positive interactions were assessed in the NLSCY by a 5 item scale with a possible scores ranging from 0-20, where a high score indicated a high number of positive interactions with the child. Questions included "How often do you and [study child] laugh together?". This scale has been shown to have good concurrent validity (Boyle & Willms 2002; Jenkins et al 2003), and an internal-consistency reliability of 0.81 (278).	The 10th percentile, which corresponded to a score of 10 or less, was used as a cutoff indicating a low number of positive interactions. Parents reporting low numbers of positive interactions were classified as "low positive interactions" ('1') and those which a score of 11 or more were coded as not having a low number of positive interactions ('2')
Hostile or ineffective parenting style	Hostile or ineffective parenting style was assessed using a 7 question scale which included questions such as "How often do you get annoyed with [study	The 90th percentile (which corresponded to 1.5 standard deviations above the mean) was used as the cutoff, and those scoring between 14 and 28 were considered as having problematically high hostile/ineffective parenting and were coded as '1'. Those scoring between 0-13 were coded as '2'. (278)

	child] for saying or doing something s/he is not supposed to?”, “How often do you get angry when you punish [study child]?”, “How often do you think that the kind of punishment you give him/her depends on your mood?”, and “How often do you feel you are having problems managing him/her in general?”. Each question had 5 response options ranging from ‘never’ to ‘all the time’, with a total score ranging between 0 and 28, with a high score indicating a high degree of hostile/ineffective parenting.	
Inconsistent parenting style	There were five items that comprise the measurement of parental consistency including “When you give your child a command, what proportion of the time so you make sure that he/she does it?” and “When your child breaks the rules or does things that he/she is not supposed to, how often do you ignore it, do nothing?” (226). The total score ranged between 0-20, and those with a low score were considered to have an inconsistent parenting style.	The 10th percentile was used as the cut off and those scoring between 0-11 were considered to have a highly inconsistent parenting style and coded as ‘1’. All other responded were coded as ‘2’
Punitive or aversive parenting style	There were four items that comprise the measurement of punitive or aversive parenting style. The total score ranged between 0-19, and those with a high score were considered to have a	The 90th percentile was used as the cut off and those scoring between 11 and 19 were considered to have a highly punitive or aversive parenting style and coded as ‘1’. All other responded were coded as ‘2’

	punitive or aversive parenting style.	
Family functioning score	Family functioning was measured using a 12-item scale that provides a global assessment of family functioning and a measure of the quality of relationships between family members, including problem solving, communication, roles, affective involvement and responsiveness, and behaviour control. The PMK or the spouse of the PMK answered the family functioning questions as part of the Parent Questionnaire. Family functioning scores ranged from 0-36, where higher scores indicated higher levels of family dysfunction (261).	For the purposes of this study, thresholds were established at the scale point closest to the 90 th percentile of scores, where families with scores above threshold score (between 13 and 36) were said to exhibit high levels of family dysfunction ('1') and those with scores below 13 did not exhibit high levels of dysfunction ('2') (274).

INTERPERSONAL

VARIABLE	QUESTION	CODING
Social support score	Perceived social support was measured by a shortened version of the Social Provisions Scale, originally developed by Dr. Carolyn Cutrona and Dr. Daniel Russell of Iowa State University (NLSCY user guide – c1. The shortened version was developed to measure guidance, reliable alliances, and attachments in the context of social relationships in order to determine the level of support received from family, friends, and others. Parents (either the PMK or the spouse/partner) answered	For this study, the threshold for low social support was set at the 10 th percentile, where people scoring in the lowest 10 th percentile were classified as low social support ('1') and those who scored above this cutoff were said to have normal/high social support ('2').

	social support questions as part of the Parent Questionnaire, with a total score ranging between 0-18, where a high score indicated high levels of social support.	
Changes in childcare arrangements	PMKs were asked to “Overall, how many changes in child care arrangements has your child experienced since you began using child care, excluding periods of care by yourself (or spouse/partner)?”.	Those who reported at least one change were coded as ‘1’ while those who reported no changes were coded as ‘2’.
Social support score	The social support score is derived using 8 items to get a total score between 0 and 24, where a high score indicates a high level of social support.	Using the 10 th percentile as a cut off, those who scored between 0 and 12 were said to have low levels of social support and were coded as ‘1’. All others were coded as ‘1’ and considered to have moderate or high levels of social support.
Parental participation in volunteering	PMKs were asked if they participated in a volunteer activity in the past 12 months.	Those who reported volunteer activities were coded as ‘yes’ and those who did not report volunteer activities were coded as ‘no’.
Social skills index (teacher rated)	Teachers of study children were administered a questionnaire and were asked to rate the level of social skills the children had. The social skills score ranged between 0 and 40, with a low score indicating poor social skills.	The literature does not reflect a clear cut-point for this scale, so the 10 th percentile was used as the cut-off for poor social skills. Those scoring between 0 and 22 were said to have poor social skills and coded as ‘1’ while those who score between 23 and 40 were said to have moderate or high social skills.

ENVIRONMENT

VARIABLE	QUESTION	CODING
Neighbourhood cohesion scale (Neighbours score)	The neighbourhood cohesion scale was developed to measure the social utility of a neighbourhood. The PMK or their spouse/partner was asked to report on the level of cohesion in the neighbourhood,	A threshold number of the 10 th percentile was used to identify those with lower levels of neighbourhood cohesion compared to other neighbourhoods (274). Those with a score between 0-8 were said to have low neighbourhood cohesion and were coded as ‘1’. Those who scored between 9 and 15 were said to have moderate/high neighbourhood cohesion and were coded as ‘2’.

	including how willing neighbours are to help each other, deal with local problems, keep an eye out for trouble, watch out for the safety of neighbourhood children, and be a role model for children. 0-15, high score indicating a high degree of neighbor cohesiveness.	
Neighbourhood safety scale	In the NLSCY, perceived neighbourhood safety was measured in cycle 1 using the Neighbourhood Safety Scale, which measured the extent to which the PMK or their spouse/partner felt that there was a sense of safety in the neighbourhood (261).	A threshold of 10 was used as the cut-off, and those scoring 10 th percentile or below were considered to have low perceived neighbourhood safety ('1') and those scoring above the 10 th percentile to have a normal or high sense of safety ('2') (274).

Appendix 5 NLSCY technical coding details for secondary outcomes

In line with the severity of suicidality, the categorization for secondary outcomes used severe cut-offs to represent a high-risk group of adolescents.

Secondary outcome 1: Antisocial, externalizing behaviours

To measure antisocial, risky, or antisocial behaviour, youth self-report measures were considered. Once the study child is 10 years old, they begin to complete the self-complete survey, which asks about participation in risky behaviours. As the child ages, the questions change to reflect the common risk behaviours for the aging adolescents. Reporting of risky behaviours begins in cycle 5 (2002/2003) and continues through cycle 8 (200), using the "Risky behaviour" questionnaire developed by the NLSCY team based on questions developed by Dr. R. Tremblay at the University of Montreal (222).

Additionally, youth also were asked questions about substance use. The module included questions from the Youth Smoking Survey, the WHO survey on Health Behaviours in School Children, and the Western Australia Child Health Survey, the Northwest Territories Health Attitudes, Knowledge and Behaviours Survey, the North Carolina Evaluation of School-Based Health Centres, and questions provided by Dr. Tremblay of University of Montreal (222).

Beginning at age 12, participants were asked questions regarding their sexual activities. These questions were adapted from the Youth and AIDS survey, the British Columbia Adolescent Health Survey and the Minnesota Adolescent Health Survey (223)

The youth was said to exhibit antisocial or externalizing behaviours if one or more of the following responses were endorsed:

Table A.2 Antisocial, externalizing behaviours questionnaire and coding

Question: “In the past 12 months, about how many times...”	Possible responses:	Coding
Were you questioned by the police about anything they thought you did?	1=never 2=once or twice 3=three – four times 4=five times or more	Yes (1) = three or four times; five times or more
Have you run away from home?	1=never 2=once or twice 3=three – four times 4=five times or more	Yes (1) = three or four times; five times or more
Have you stayed out all night without permission?	1=never 2=once or twice 3=three – four times 4=five times or more	Yes (1) = three or four times; five times or more
Have you intentionally damaged or destroyed anything that didn’t belong to you?	1=never 2=once or twice 3=three – four times 4=five times or more	Yes (1) = three or four times; five times or more
Have you fought with someone to the point where they needed to care for their injuries?	1=never 2=once or twice 3=three – four times 4=five times or more	Yes (1) = once or twice; three or four times; five times or more
Have you carried a weapon for the purpose of defending yourself or using it in a fight?	1=never 2=once or twice 3=three – four times 4=five times or more	Yes (1) = once or twice; three or four times; five times or more
Have you sold any drugs?	1=never 2=once or twice 3=three – four times 4=five times or more	Yes (1) = once or twice; three or four times; five times or more
Have you attempted to touch anyone in a sexual way while knowing that they would probably object to this?	1=never 2=once or twice 3=three – four times 4=five times or more	Yes (1) = once or twice; three or four times; five times or more
In the past 12 months, were you part of a gang that broke the law by stealing, hurting someone, damaging property, etc.?	1=yes 2=no	Yes (1) = yes

If an individual endorsed one or more of the above questions in one of the cycles where they completed the self-report questionnaire, they were considered to show antisocial or externalizing behaviour. In the NLSCY, 23.7% of respondents were considered to have this outcome.

Secondary outcome 2: Substance misuse

Table A.3 Substance misuse questionnaire and coding

Question:	Possible responses:	Coding
Cigarettes	1=I have never smoked 2=Only a few puffs 3=I do not smoke anymore 4=A few times a year 5=About once or twice a month 6=About 1-2 days a week 7=About 3-4 days a week 8=About 6-7 days a week	Yes (1)=About 1-2 days a week; about 3-5 days a week; about 6-7 days a week
Alcohol	1=I have never drank 2=Only a few sips 3=I have only tried 1 or 2 (at least 1 drink) 4=I don't drink anymore 5=A few times a year 6=About once or twice a month 7=About 1-2 days a week 8=About 3-4 days a week 9=About 6-7 days a week	Yes (1)=About 1-2 days a week; about 3-5 days a week; about 6-7 days a week
Marijuana	1=I have never smoked 2=Not in the past 12 months 3=A few times 4=Once or twice a month 5=About 1-2 days a week 6=About 3-4 days a week 7=About 6-7 days a week	Yes (1)=Once or twice a month; 1-2 days a week; 3-5 days a week; 6-7 days a week
Hallucinogens	1=Never 2=I have done it, but not in the past 12 months 3=In the past 12 months, I have used it 1-2 times 4=In the past 12 months, I have used it 3-5 times 5=In the past 12 months, I have used it 6-9 times 6=In the past 12 months, I have used it 10 times or more	Yes (1)= I have done it, but not in the past 12 months; In the past 12 months, I have used it 1-2 times; 3-5 times; 6-9 times; 10 times or more
Glue	1=Never 2=I have done it, but not in the past 12 months 3=In the past 12 months, I have used it 1-2 times 4=In the past 12 months, I have used it 3-5 times 5=In the past 12 months, I have used it 6-9 times 6=In the past 12 months, I have used it 10 times or more	Yes (1)= I have done it, but not in the past 12 months; In the past 12 months, I have used it 1-2 times; 3-5 times; 6-9 times; 10 times or more

Prescription drugs (without a prescription)	1=Never 2=I have done it, but not in the past 12 months 3=In the past 12 months, I have used it 1-2 times 4=In the past 12 months, I have used it 3-5 times 5=In the past 12 months, I have used it 6-9 times 6=In the past 12 months, I have used it 10 times or more	Yes (1)= I have done it, but not in the past 12 months; In the past 12 months, I have used it 1-2 times; 3-5 times; 6-9 times; 10 times or more
Other drugs like ecstasy, crack, cocaine, heroin, speed, etc.	1=Never 2=I have done it, but not in the past 12 months 3=In the past 12 months, I have used it 1-2 times 4=In the past 12 months, I have used it 3-5 times 5=In the past 12 months, I have used it 6-9 times 6=In the past 12 months, I have used it 10 times or more	Yes (1)= I have done it, but not in the past 12 months; In the past 12 months, I have used it 1-2 times; 3-5 times; 6-9 times; 10 times or more

Used severe cut-offs to indicate regular or heavy usage of the more common substances (tobacco, alcohol, marijuana) and any report of other substances (hallucinogens, glue, prescription drugs, or other drugs like ecstasy, crack, cocaine, heroin, or speed). 24.8% of respondents were considered to have substance misuse.

Secondary outcome 3: Poor physical health

Table A.4 Poor physical health questionnaire and coding

Question:	Possible responses:	Coding
Poor general health	1=Excellent 2=Very good 3=Good 4=Fair 5=Poor	Yes (1)=Fair; Poor
In the past 6 months, how often have you had the following: Headache	1=Seldom/never 2=About once a month 3=About once a week 4=More than once a week 5=Most days	Yes (1)=Most days
In the past 6 months, how often have you had the following: Stomachache	1=Seldom/never 2=About once a month 3=About once a week 4=More than once a week 5=Most days	Yes (1)=Most days

In the past 6 months, how often have you had the following: Backache	1=Seldom/never 2=About once a month 3=About once a week 4=More than once a week 5=Most days	Yes (1)=Most days
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16.69% of respondents met the criteria to be classified as experiencing poor physical health.

Secondary outcome 4: Poor mental health

Poor mental health was determined based on responses to two scales that measured symptoms of depression and anxiety/emotional disorders. In the NLSCY, depressive symptomology was measured using the shortened Centre for Epidemiologic Studies Depression Scale (CES-D), a 12-question version of the scale, developed by Dr. Boyle at Chedoke-Mcaster Hospital (221). Based on responses, the participants scored between 0 and 36. Those with a score of 9 or above were said to have symptoms consistent with a clinical diagnosis of depression (226).

Table A.5 Depression scale (CES-D) questionnaire and coding

Question:	Possible responses:	Coding
I felt that I could not shake off the blues even with help from my family or friends	1=Rarely/ none of the time (less than one day) 2= 3= 4=most or all of the time (5-7 days)	Continuous scores range from 0 to 36. 1= depressed (9-36 score) 2= not depressed (0-8 score)
I had trouble keeping my mind on what I was doing		
I felt depressed		
I felt that everything I did was an effort		
I felt hopeful about the future		
My sleep was restless		
I was happy		
I felt lonely		
I enjoyed life		
I had crying spells		
I felt that people disliked me		

Similarly, anxiety was assessed using the Anxiety and Emotional Disorders Scale (AED), a 7 item scale which was developed to measure the emotional well-being of children/adolescents and is said to be able to measure the respondent's propensity to develop an anxiety disorder (279). For each item, the participant could select 1 (Never true/not true), 2 (sometimes/somewhat true), or 3 (Often/very true), which were combined to create a score between 0 and 14, where a score of 8 or more was considered to indicate moderate or high level of anxiety (280).

Table A.6 Anxiety and Emotional Disorders (AED) questionnaire and coding

Question:	Possible responses:	Coding
I am unhappy or sad	1=Never true/ not true 2=Sometimes/ somewhat true 3=Often/very true	Continuous scores range from 0 (never/rarely true) on all symptoms to 14 (often/very true) on all symptoms. 1= medium/high anxiety (8-14 score) 2= low anxiety (0-14 score)
I am not as happy as other people my age		
I am too fearful or nervous		
I worry a lot		
I am nervous, high strung, or tense		
I have trouble enjoying myself		
I cry a lot		

Secondary outcome 5: Risky health behaviours

Table A.7 Risky health behaviours questionnaire and coding

Question:	Possible responses:	Coding
Operated a motor vehicle (car, motorcycle, boat) after drinking or doing drugs (asked of 16-17 year olds)	1=Never 2=Once or twice 3=3-4 times 4=5 times or more	Yes (1)=3-4 times; 5 times or more
Been a passenger in a vehicle after the driver drank or used drugs (asked of 16-17 year olds)	1=Never 2=Once or twice 3=3-4 times 4=5 times or more	Yes (1)=3-4 times; 5 times or more
Use a seat belt when riding in a car	1=Always 2=Often 3=Sometimes 4=Seldom or never 5=Usually there is not seatbelt where I sit	Yes (1)=Seldom or never
Sex – no protection (16-19 year olds) (look at wording)	1=Yes 2=No	Yes (1)=Yes
Sex – no condom (14-15 year olds)	1=Yes 2=No	Yes (1)=If NO (2) to condom AND NO (2) to other forms of birth control
Did you or your partner use other methods of birth control (birth control pills, diaphragm, etc.) the last time you had consensual sexual intercourse (Asked of 14-15 year olds)	1=Yes 2=No	

11.04% of respondents met the criteria to be classified as engaging in risky health behaviours.

Secondary outcome 6: Poor academic outcomes

Table A.8 Poor academic outcomes questionnaire and coding

Question:	Possible responses:	Coding
How well do you think you are doing in your school work?	1=Very well 2=Well 3=Average 4=Poorly 5=Very poorly	Yes (1)=Poorly; Very poorly
Skipped a day of school without permission	1=Never 2=Once or twice 3=3-4 times 4=5 times or more	Yes (1)=3-4 times; 5 times or more
Been suspended from school	1=Never 2=Once or twice 3=3-4 times 4=5 times or more	Yes (1)=Once or twice; 3-4 times; 5 times or more
Dropped out of school (asked of 14-15 year olds)	1=Never 2=Once or twice 3=3-4 times 4=5 times or more	Yes (1)=Once or twice; 3-4 times; 5 times or more

19.13% of respondents met the criteria to be classified as having poor academic outcomes.

Appendix 6 Calculation of PPV & NPV in stepwise selection logistic regression

Table A.9 Logistic regression SAS Output - At the 0.24 (24% cutoff) for high risk:

Probability level	Correct		Not correct		Correct %	Sensitivity	Specificity	False Positive s	False negative s
	Event	Non-event	Event	Non-event					
0.24	69	5438	190	691	86.2	9.1	96.6	73.4	11.3

Using the SAS output, positive predictive value and negative predictive value needed to be calculated for the logistic regression. The Diagnostic test evaluation from MedCalc was used to calculate PPV and NPV (281).

Test	Disease				Total
	Present	n	Absent	n	
Positive	True Positive	a= 69	False Positive	b= 190	a + b = 259
Negative	False Negative	c= 691	True Negative	d= 5438	c + d = 6129
Total		a + c = 760		b + d = 5628	

Test

Results

Sensitivity	$\frac{a}{a + c}$	= 9.08 %	95% CI: 7.13 % to 11.35 %
Specificity	$\frac{d}{b + d}$	= 96.62 %	95% CI: 96.12 % to 97.08 %
Positive Likelihood Ratio	$\frac{\text{Sensitivity}}{100 - \text{Specificity}}$	= 2.69	95% CI: 2.06 to 3.50
Negative Likelihood Ratio	$\frac{100 - \text{Sensitivity}}{\text{Specificity}}$	= 0.94	95% CI: 0.92 to 0.96
Disease prevalence	$\frac{a + c}{a + b + c + d}$	= 11.90 % (*)	95% CI: 11.11 % to 12.72 %
Positive Predictive Value	$\frac{a}{a + b}$	= 26.64 % (*)	95% CI: 21.36 % to 32.47 %
Negative Predictive Value	$\frac{d}{c + d}$	= 88.73 % (*)	95% CI: 87.91 % to 89.51 %

- *Sensitivity*: probability that a test result will be positive when the disease is present (true positive rate).
= $a / (a+c)$
- *Specificity*: probability that a test result will be negative when the disease is not present (true negative rate).
= $d / (b+d)$
- *Positive likelihood ratio*: ratio between the probability of a positive test result given the *presence* of the disease and the probability of a positive test result given the *absence* of the disease, i.e.
= True positive rate / False positive rate = Sensitivity / (1-Specificity)
- *Negative likelihood ratio*: ratio between the probability of a negative test result given the *presence* of the disease and the probability of a negative test result given the *absence* of the disease, i.e.
= False negative rate / True negative rate = (1-Sensitivity) / Specificity
- *Positive predictive value*: probability that the disease is present when the test is positive.
= $a / (a+b)$
- *Negative predictive value*: probability that the disease is not present when the test is negative.
= $d / (c+d)$

Sensitivity, specificity, positive and negative predictive value as well as disease prevalence are expressed as percentages for ease of interpretation.

Appendix 7 ALSPAC technical coding details for predictor variables

35 variables that determined the splits in the CHID model, CART model, or the stepwise-selection regression model from the NLSCY dataset. In order to validate the model, variables in ALSPAC were selected and coded to be as comparable to the NLSCY variables as possible. In a few cases, no comparable variable was available. Details for the coding of all the predictors for ALSPAC are as follows.

PRE- AND POST-NATAL

VARIABLE	QUESTION	CODING
Prenatal over-the-counter medication use	Mothers were asked at 18 weeks gestation about a list of pills, ointments, and medications. Mothers were asked about a variety of conditions, several of which are likely to be treated using over-the-counter medications, including nausea, heartburn, vomiting, and migraines. A derived variable was generated combining the responses to use of a medication for nausea, heartburn, vomiting, and migraines.	If the mother answered ‘yes’ to use of medications for any of those conditions, they were coded as ‘yes’ to use of prenatal over-the-counter medications. Those who did not report taking medication for those conditions were coded as ‘no’ and those without a valid response were coded as missing.
Prenatal smoking	Mothers were asked about “how many cigarettes per day are you yourself smoking at the moment” at 32 weeks gestation.	Using the derived variable (c483) which grouped cigarette use, those who reported no cigarette use were coded as ‘no’ while those who reported at least 1 cigarette per day were coded as ‘yes.’ Those who reported occasional smoking and those without a response were coded as missing.
Prenatal problems	Mothers were asked about health during gestation at multiple time points, but were specifically asked about gestational diabetes and hypertension in pregnancy at 12 weeks. Mothers were asked at 12 weeks if they have a history of diabetes. Of those with a history, they were asked if they had diabetes in pregnancy only. Similarly, all	Those who said ‘yes’ were considered to have gestational diabetes. Those who said they had no history of diabetes, or who said the diabetes was not only during pregnancy were coded as ‘no’. Those who said ‘yes’ to both questions were coded as ‘yes’ while those who did not have a history of hypertension, or if it was not in pregnancy only were coded as ‘no’. Responses to these were combined to create a derived variable for presence of prenatal health problems. If coded as ‘yes’ to either or both conditions, the mothers were said to have experienced prenatal problems. If no to both,

	mothers were asked if they had a history of hypertension. Of those that said yes, they were asked a follow-up question if the hypertension was only during pregnancy.	they were coded as 'no'. Anyone missing responses to both questions was coded as 'missing'.
Breastfeeding	Mothers were asked at 4 weeks and 6 months about breastfeeding.	Any report of breastfeeding in either cycle was coded as 'yes', those who said 'no' in both cycle were coded as 'no' and those without a valid response to both questions were coded as 'missing'.

INDIVIDUAL

VARIABLE	QUESTION	CODING
Gender	Gender of the child was recorded at birth (variable kz021)	
Rural/urban		Rural or urban residence was a significant predictor in the NLSCY models, but no comparable question was asked in ALSPAC and therefore it was excluded from analysis.
Child injury	A series of questions about the study child injuries in the past 12 months was asked at 3 years, 2 months.	Mothers who indicated the child had experienced a burn, bad fall, swallowed anything/she shouldn't have such as pills, buttons, disinfectant, or other accident was coded as 'yes' while those who did not report any injury in the past 12 months was coded as 'no'.
Child activity limitation	ALSPAC does not ask specifically about activity limitations of children. The closest approximation is text which details chronic conditions experienced by members of the family. As a close proxy for the NLSCY variable does not exist in the dataset, this was excluded from analysis.	
PPVT	The WASI module was asked in ALSPAC, which measures IQ and developmental progress, however, an issue was discovered with the scoring of the measure so the data has not yet been released until the issues can be resolved.	
Conduct disorder	Conduct disorder was one of the disorders measured in the ALSPAC at 3 years, 6 months. Each participant was given a score, ranging from 0 to 16. As per Goodman (2001; 1997), those who score at the 90 th percentile or above, corresponding to	Thus, those who had a score of 7-16 were coded as 'yes' for a conduct disorder, where those with a score of 0-6 were coded as 'no'. Those without valid scores were coded as 'missing'.

	a score of 7 or above can be said to have a conduct disorder	
Experience of any stressful life experience between birth and 5 years	The mother was asked at several time points about various stressful experiences (at 8 weeks; 2 years, 9 months; 3 years, 11 months; and 5 years, 1 month). All participants were asked about a particular stressful experience with the following response options: “yes, and it affected me a lot”, “yes, moderately affected”, “yes, mildly affected”, and “yes, but did not affect me at all” and “no, did not happen”. As a more comprehensive list of events was included in the ALSPAC module than were on the NLSCY module, only events that replicate those included in the NLSCY module were included in the summary variable. Further, as the NLSCY asks about events that caused a great deal of stress or worry for the child, only events to which the mother reported being greatly or moderately affected were included in the derived variable. The variables from the stressful included for this summary variable are as follows: your partner died, one of your children died, a friend or relative died, one of your children was ill, your partner was ill, a friend or relative was ill, you were admitted to	A report of “yes, and affected me a lot” or “yes, moderately affected” to any one of these variables in any of the cycles was coded as ‘yes’ to the experience of a stressful life experience. Additionally, variables about maternal/partner’s drug addition, alcoholism, or mental illnesses, which were asked at (D), were also included. Answer of ‘yes’ to any of these questions was also coded as ‘yes’ to having experienced a stressful life experience, and ‘no’ to these and not strongly affected by the aforementioned items was considered no.

	hospital, you were divorced, you were very ill, your partner went away, you and your partner were separated, you moved house, your partner was physically cruel to you, you got married, your partner was physically cruel to your children, your partner was emotionally cruel to you, your partner was emotionally cruel to your children, you were emotionally cruel to your children.	
Death in the family between (birth and 5 years)	Mothers were asked at 8 weeks; 2 years, 9 months; 3 years, 11 months; and 5 years, 1 month if “a friend or relative died”.	Those who responded “yes, and affected me a lot”, “yes, and moderately affected” at any of the time points were coded as ‘yes’ while those who said they were “mildly affected” or “not affected at all” were included with ‘no’.

FAMILY

VARIABLE	QUESTION	CODING
Young maternal age at birth (under 25 years)	In ALSPAC, maternal age (in years) was provided at 8 weeks gestation, so this time point was used to create a “young maternal age” predictor.	Those aged 24 or under were coded as ‘yes’ and all others were coded as ‘no’. Those who did not provide a valid response were coded as ‘missing’.
Old maternal age at birth (40 or older)	Maternal age (in years) was provided at 8 weeks gestation.	Similarly, old maternal age was determined at 8 weeks gestation and all those ages 40 or older were coded as ‘yes’ while all other participants were coded as ‘no’. Those who did not provide a valid response were coded as ‘missing’.
Immigrant status of parents	Immigrant status of the mother/partner is not specifically asked in ALSPAC, but both the mother and partner were asked to provide information about their birth, including to indicate “where parents lived at time of birth”.	Those who indicated that their parents were living outside of the UK at the time of their birth were considered to be immigrants.

No maternal basic education level	Educational attainment of the mother was ascertained in pregnancy. There are important differences between UK and Canadian education systems, which made it challenging to find the equivalent educational cut-off that is similar to achieving a high school diploma in Canada, and previous authors use various cut-off points for educational qualifications.	For this analysis, anyone with CSE/no qualifications was considered to have less than basic education and was coded as 'yes', while those with O level, A level, or a degree were coded as 'no'. Those without a valid response were coded as 'missing'.
No maternal college/university degree		Those who reported having a degree were coded as 'no' and anyone who reported a lower level of educational qualifications (CSE/no qualifications, vocational, O level, A level) were coded as 'yes'. Those without a valid responses were coded as 'missing'.
Unemployment of mum or spouse	Job situation of mother and partner were asked at 8 weeks.	Those who responded that either they or their spouse was unemployed were coded as 'yes' while any other response was coded as 'no'. Those without a valid response were coded as missing.
Financial difficulties	Similar to the Low Income Cut-off measure used in the NLSCY, the financial difficulties score uses 5 questions to assess how difficult it is for the mother to afford food, clothing, heat, rent/mortgage, and things needed for the baby with a final score ranging between 0 and 15.	Using the cutoffs proposed by Chittleborough (2012), those who scored between 9 and 15 were said to be experiencing financial difficulties and were coded as 'yes' while those who scored ≥ 8 were said to not have financial difficulties and coded as 'no' (282). Those without a response to this module were coded as 'missing'.
Housing tenure	Housing tenure was asked at 8 weeks gestation.	Those who owned their home or had a mortgage were coded as 'yes' to home ownership, while those who rented from a council, private landlord, or housing association or other were coded as 'no' to home ownership. Those without a valid response were coded as 'missing'.
No participation in religious activities	At 5 years, 1 month, mothers were asked about the frequency at which she goes to a place of worship.	Those who reported 'not at all' were coded as not participating in religious activities, while those who reported 'yes, at least once a week', 'yes, at least once a month', or 'yes, at least once a year' were coded as participating in religious activities. All those without a valid response were coded as 'missing'.

Parental activity limitation	ALSPAC does not ask specifically of activity limitation resulting from chronic conditions, so the closest proxy available was a single item question that asked about present health as “fit and well”.	Those who responded that they were “often unwell” or “never well” were coded as having an activity limitation due to poor health, while all others were coded as not having a limitation from a health condition
Maternal current smoking	Mothers were asked about the number of cigarettes she currently smokes per day.	Those who responded with ≥ 1 were coded as 'yes' while those who reported 0 cigarettes per day were coded as 'no'. Those who did not provide a valid response were coded as 'missing'.
Maternal binge drinking	Mothers were asked to report on their current alcohol use each day of the week by type of alcohol consumed (beer, wine, cider, etc) at 3 years, 11 months.	The definition of binge drinking used for the NLSCY was 5 or more drinks on an occasion, so in order to estimate binge drinking, participants who reported 5 or more alcoholic drinks of any kind on at least one day of the week were said to currently binge drink and were coded as 'yes'. Those who never exceeded 4 drinks on any day of the week, once all types of alcohol were combined were coded as 'no'. Those without a valid response were coded as 'missing'.
Single parent status	Single parent status was assessed at multiple times throughout early childhood, including: 8 weeks; 8 months; 1 year, 9 months; 2 years, 9 months; and 3 years, 11 months	Those who indicated “no partner in the household” during at least one of the time points were coded as 'yes' to experiencing a period of single parenthood, while all others were coded as 'no', as they did not report a period where there was no partner in the household.
Intact vs. blended family	Family composition at 3 years, 11 months was assessed based on responses to several questions.	Families were said to be intact unless one of the following was reported: 'present marital status divorced/separated', 'biological father does not live with child', 'biological mother does not live with child', '0 children living in the family that have you or your partner as natural parents', '1 or more children partner is natural parent but you are not mum', 'one or more children to which neither you nor your partner are natural parents – adopted, fostered, etc.' If any of the above was reported, the family was coded as blended, non-intact family.

Inconsistent parenting	Parenting styles were measured quite differently on the NLSCY and ALSPAC. On the NLSCY, there is a parenting subscale that measures the level of consistency in parenting. The closest proxy included on ALSPAC is a single item question asked at 3 year, 6 months: "do you start by being firm then usually give way."	Those who answered 'yes, usually' and 'yes, sometimes' were said to have inconsistent parenting style and were coded as 'yes' while those who responded 'no' were coded as 'no'. Those without responses were coded as missing.
Hostile/ineffective parenting	Similarly, hostile/ineffective parenting was measured using a multi-item scale in the NLSCY, which asks questions about how the parent feels managing and disciplining their child. The closest approximation of this is a single item asked at 4 years, 9 months: "Who is the most frequent winner of battle of wills?"	Those who responded that the winner is usually the child or "about even" were coded as 'yes' while those who said the parent usually won battle of wills or 'neither' were coded as 'no'.
Punitive/aversive parenting	Three questions asked at 4 years, 9 months were similar to questions asked on the NLSCY's punitive/aversive parenting style scale. These items included 'parent tries to reason with child when child has tantrum', 'parent slaps or hits child when child has tantrum', and 'parent shouts at child when child has tantrum'.	For these three items, there were 5 possible responses: 1=never, 2=rarely, 3=once/month, 4=once/week, 5=daily. In order to combine these three variables, "reasoning" was reverse coded so a low score would represent punitive/aversive parenting and a high score would represent the absence of this parenting style. The scores on these three questions were combined to get a score between 3 and 9. The lowest 10th percentile was said to have a problematic level of aversive/punitive parenting, which was determined to be scores between 3 and 6, coded as 'yes'. Those with a score between 7 and 9 were coded as 'no' and those without a valid response were coded as 'missing'.

INTERPERSONAL

VARIABLE	QUESTION	CODING
TV exposure	A predictor in the NLSCY models was exposure to violence on TV; however, ALSPAC does not specifically ask participants about this.	As a proxy estimate, the top 90 th percentile of time spent watching TV was coded as having high exposure to TV, presuming that these children would be more likely to be exposed to violence, as they watch the most TV during the week.
Change in childcare arrangements	ALSPAC does not specifically ask about changes in childcare providers, however, there is an extensive module, which asks when about details of weekday childcare.	If the child is not in weekday childcare or they report 'still have' for their childcare providers, they were coded as not having changed childcare. However, if they reported stopping one of their providers, they were coded as 'yes' to changing childcare. If there was no valid response to the first question on the childcare module, they were coded as 'missing'.
Parental volunteering	Mothers were asked about their community involvement at 5 years, 1 month.	Mother who reported doing volunteer work were coded as 'yes' while mothers who did not report doing volunteer work were coded as 'no'. Those who did not provide a response to this question were coded as 'missing'.
Low social support	Social support was measured using a multi-item scale, and a score between 0 and 30 was derived for participants, where a high score indicates high social support and a low score indicates low social support. This module was asked at several time points during early childhood at the following ages: 8 weeks; 8 months; 1 year, 9 months. The derived social support scores available at all three time points put missing values to the mode.	The cut-off of the lowest 10 th percentile was chosen to indicate low levels of social support. Any participant scoring between 0 and 12 in any of the cycles were said to have low social support and coded as 'yes', while those with a score of 13 or above were said to have moderate or good social support. Those without a valid social support score during any of the cycles were coded as 'missing'.

ENVIRONMENT

VARIABLE	QUESTION	CODING
Low neighbourhood cohesion	The closest proxy to the neighbourhood cohesion score included on ALSPAC is the since item that asks the mother is she “thinks the neighbourhood is a good place to live”, which is asked at 2 years 9 months and 5 years, 1 month.	Those who report that the neighbourhood is ‘not very good’ or ‘not good at all’ were said to have low neighbourhood cohesion, while those who indicated their neighbourhood was ‘very good’ or ‘good’ were said to have moderate or high neighbourhood cohesion. Those who did not respond to either were coded as ‘missing’.
Low neighbourhood safety	Neighbourhood safety is estimated from the neighbourhood stress score, which ranges from 0-23, where high scores indicate a high level of neighbourhood stress or alternately, a low level of neighbourhood safety.	Those scoring in the top 10% were said to have high neighbourhood stress, proxy for low level of neighbourhood safety, which corresponded to 8 or over on the neighbourhood stress scale.

SECTION XX: DELIBERATE SELF-HARM

Life has many ups and downs. Sometimes people feel upset. These feelings can be so bad that people who have them may feel suicidal or want to self-harm. The following questions ask you about your feelings and the feelings of people close to you. We know this is a sensitive subject, but it is important to ask about it now, as it is not uncommon. By finding out about self-harm we can find ways of helping people.

1. a) Has anyone in your family (not including yourself) ever hurt themselves on purpose (e.g. by taking an overdose of pills, or by cutting themselves)?

Yes ☐ 1 No ☐ 2 → If no, go to question 2

If yes,

- b) Who in your family has done this? Please mark all boxes that apply.

i) Mum	☐ 1
ii) Dad	☐ 1
iii) Brother	☐ 1
iv) <u>Sister</u>	☐ 1
v) Someone else	☐ 1

Please say who:.....

- c) Which of these actions best describes what they did? Please mark all boxes that apply.

i) Swallowed pills or something poisonous	☐ 1
ii) Cut themselves	☐ 1
iii) Burnt themselves, e.g. with cigarette	☐ 1
iv) <u>Something else</u>	☐ 1

Please say what:.....

2. a) Have any of your close friends ever hurt themselves on purpose?

Yes ☐ 1 No ☐ 2 → If no, go to question 3

If yes,

b) Which of these actions best describes what they did? Please mark all boxes that apply.

i) Swallowed pills or something poisonous

☐

ii) Cut themselves

☐

iii) Burnt themselves, e.g. with cigarette

☐

iv) Something else

☐

Please say what:.....

3. a) Have you ever hurt yourself on purpose in any way (e.g. by taking an overdose of pills, or by cutting yourself)?

Yes

☐

No

☐

→ If no, go to question 6a on page XX

If yes,

b) How many times have you done this in the last year? Please mark one box only.

Once

☐

2-5 times

☐

6-10 times

☐

More than

☐

10 times

☐

c) When was the last time you hurt yourself on purpose? Please mark one box only.

In the last week

☐

More than a week

☐

ago but in the last year

☐

More than a

☐

year ago

☐

d) The last time you hurt yourself on purpose, which of the actions below best describes what you did? Please mark all boxes that apply.

i) Swallowed pills or something poisonous

☐

ii) Cut yourself

☐

iii) Burnt yourself, e.g. with cigarette

☐

iv) Something else

☐

Please say what:

.....

e) Do any of the following reasons help to explain why you hurt yourself on that occasion? Please mark all boxes that apply.

- | | |
|---|---|
| i) I wanted to show how desperate I was
<u>feeling</u> | <div style="border: 1px solid red; width: 40px; height: 20px; text-align: center; line-height: 20px;">1</div> |
| ii) I wanted to die | <div style="border: 1px solid red; width: 40px; height: 20px; text-align: center; line-height: 20px;">1</div> |
| iii) I wanted to punish myself | <div style="border: 1px solid red; width: 40px; height: 20px; text-align: center; line-height: 20px;">1</div> |
| iv) I wanted to frighten someone | <div style="border: 1px solid red; width: 40px; height: 20px; text-align: center; line-height: 20px;">1</div> |
| v) I wanted to get relief from a terrible
<u>state of mind</u> | <div style="border: 1px solid red; width: 40px; height: 20px; text-align: center; line-height: 20px;">1</div> |
| vi) <u>Some other reason</u> | <div style="border: 1px solid red; width: 40px; height: 20px; text-align: center; line-height: 20px;">1</div> |

Please say what:.....

f) After you had hurt yourself on that occasion, how did you feel? Please mark one box only.

Better than before	1	<u>The</u> same as before	2	Worse than Before	3
--------------------	---	---------------------------	---	----------------------	---

g) The last time you hurt yourself in any way (e.g. by taking an overdose of pills, or by cutting yourself) did you seek medical help / first aid from any of the following? Please mark all boxes that apply.

- | | |
|---|---|
| i) GP (family doctor) | <div style="border: 1px solid red; width: 40px; height: 20px; text-align: center; line-height: 20px;">1</div> |
| ii) Hospital casualty / emergency department | <div style="border: 1px solid red; width: 40px; height: 20px; text-align: center; line-height: 20px;">1</div> |
| iii) Other health professional | <div style="border: 1px solid red; width: 40px; height: 20px; text-align: center; line-height: 20px;">1</div> |

Please say what they job was:.....

4. On any of the occasions when you have hurt yourself on purpose, have you ever seriously wanted to kill yourself?

Yes	1	No	2
-----	---	----	---

5. a) Have you ever tried to get help from someone or somewhere about hurting yourself on purpose, or about wanting to kill yourself?

Yes	1	No	2	→ If no, go to question 6a
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If yes,

b) Who have you been to for help? Please mark all boxes that apply.

- | | |
|---|--------------------------|
| i) Mum or Dad | ☐ |
| ii) Brother or sister | ☐ |
| iii) Someone else in your family | ☐ |
| iv) A friend | ☐ |
| v) A teacher | ☐ |
| vi) A school counsellor | ☐ |
| vii) Peer supporter/mediator at school | ☐ |
| viii) A GP (family doctor) | ☐ |
| ix) A social worker | ☐ |
| x) A psychologist or psychiatrist | ☐ |
| xi) A telephone help line | ☐ |
| xii) Somewhere else (e.g. internet, book, magazine, other person, etc.) | ☐ |

Please say what or who:.....

6. a) Have you ever felt that life was not worth living?

Yes ☐ No ☐ → If no, skip to the end

If yes,

b) When was the last time you felt like this? Please mark one box only.

In the last week ☐ More than a week ago but in the last year ☐ More than a year ago ☐

7. a) Have you ever found yourself wishing you were dead and away from it all?

Yes ☐ No ☐ → If no, skip to the end

If yes,

b) When was the last time you felt like this? Please mark one box only.

In the last week ☐ More than a week ago but in the last year ☐ More than a year ago ☐

8. a) Have you ever thought of killing yourself, even if you would not really do it?

Yes ☐
1

No ☐
2

→ If no, skip to the end

If yes,

- b) When was the last time you felt like this? Please mark one box only.

In the last week ☐
1

More than a week
ago but in the last year ☐
2

More than a
year ago ☐
3

9. Have you ever made plans to kill yourself?

Yes ☐
1

No ☐
2

You can get information and advice relating to any of the questions by contacting the organisations on the enclosed Helpline information sheet.