Exploring the links between multiple life-time risk factors and academic achievement in early adolescence

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Abstract

The main aim of this study was to examine the number of risk factors and their relation to academic achievement outcomes in a cohort of Icelandic youth. Poor academic achievement can have negative implications on the lives of children, and can continue into adulthood. In this study, the following risk factors were measured; maternal smoking during pregnancy, exercise habits, maltreatment, family size (>3 children per family), depressed mood, and being born to a young mother. Data was gathered from multiple sources. Participants consisted of 1151 children born in Reykjavík, Iceland. OLS regression and one-way ANOVA showed that exposure to a greater number of risk factors was a predictor of lower grades in both mathematics and Icelandic in 4th and 7th grade. Furthermore, a Latent Class Analysis revealed two classes of participants, a *Distressed* class and a *Non-Distressed* class. An individual in the Distressed class had a 50% chance of scoring one standard deviation below the mean on the standardized test for mathematics in 7th grade. The findings of this study suggest that interventions should target children who are exposed to multiple risk factors, and that preventative steps should be taken to reduce the number of individuals exposed to multiple risk factors in their youth.

Útdráttur

Meginmarkmið rannsóknarinnar var að kanna fjölda áhættuþátta frá fæðingu fram á unglingsár og tengsl þeirra við námsárangur ungmenna. Rannsóknir hafa sýnt fjölmarga áhættuþætti sem geta haft áhrif á námsárangur hjá börnum, þar má nefna reykingar mæðra á meðgöngu, lítil hreyfing hjá börnum, vanræksla, fjölskyldustærð (>3 börn), vanlíðan barna og ungur aldur móður. Í þessari rannsókn var fylgt eftir 1151 barni sem var fætt í Reykjavík árið 2000, en stuðst var við gögn frá Þróunarsviði heilsugæslunnar, Barnavernd Reykjavíkur, Námsmatsstofnun og Landsspítala Háskólasjúkrahúsi. Niðurstöður aðhvarfsgreiningar og einhliða dreifigreiningar sýndu að fjöldi áhættuþátta hjá hverju barni spáði fyrir lægri einkunn í íslensku og stærðfræði í 4. og 7.bekk. Ennfremur, leiddi flokkagreining (*Latent Class analysis*) í ljós tvo hópa, börn í áhættu og börn í minni áhættu. Börn í fyrri hópnum voru líklegri til að vera með alla þá sex áhættuþætti sem rannsóknin náði til, í samanburði við börnin í seinni hópnum. Jafnframt var annað hvert barn í áhættuhópnum með einkunn í stærðfræði í 7.bekk sem var einu staðalfráviki fyrir neðan meðalt á samræmdu könnunarprófi. Niðurstöður rannsóknarinnar er mikilvægt framlag til rannsókna á áhættuþáttum hjá börnum og ungmennum og styðja jafnframt við snemmbæra íhlutun til að koma í veg fyrir að einstaklingar komist í snerting við einn eða fleiri af þeim áhættuþáttum sem rannsóknin náði til.

Many studies over the years have shown that children's exposure to early risk factors, such as maltreatment, poverty, depression, and many others, can have a negative impact on their academic achievement (Fantuzzo, LeBoeuf, Rouse, & Chen, 2012; Gutman, Sameroff, & Eccles, 2002; Prelow & Loukas, 2003). It is widely accepted that academic achievement in the early grades is crucial for continued academic success. Children that do poorly in school early on are more likely to have difficulties with emotional and social development, and are more likely to develop behavioral disorders (Velez, Johson and Cohen, 1989). In addition, poor performance can stigmatize students, leading teachers and parents to have low expectations of students' academic performance, which in turn can discourage children's further academic success (Entwisle, 1995). In relation to adulthood, poor academic performance in early childhood can increase the risk of delinquent and antisocial behavior later in life (Yoshikawa, 1995). Furthermore, poor academic achievement can be predictive of lower salaries, poorer wellbeing, and higher rates of imprisonment, as well as having a high negative impact on the national economy. Poor academic achievement as early as fourth grade can be a predictor of reduced further education and lifetime earnings (McKinsey & Company, 2009).

The impact of multiple risk factors on academic achievement has never been studied in Iceland, whereas these kinds of studies have been relatively common in other countries across the world, especially in the United States. When we look at the academic achievement of Icelandic children compared to other northern countries, Iceland has the lowest proportion of individuals aged 25-34 that have completed secondary education; this proportion is 75%, compared to 91% in Sweden (OECD, 2013). In addition, dropout in secondary school is high in Iceland; there are probably various reasons for this, but one of the leading school–related characteristics related to dropping out of school is poor academic achievement (National Research Council, 2001). The aim of this study is to assess the predictive role of multiple risk

factors, present from before birth until adolescence, effecting academic achievement in early adolescence using data from multiple sources that consist of data ranging in time. Furthermore, we will examine whether identification of different subgroups will emerge, by examining the dataset with using Latent Class analysis. Previous multiple risk studies have addressed a variety of risk factors. In this study, the six following risk factors will be examined; being born to a young mother, maternal smoking during pregnancy, number of children in the household, depressed mood, exercise habits, and history of maltreatment.

Risk Factors

Risk factors have been defined as variables that "have proven or presumed effects that can directly increase the likelihood of a maladaptive outcome" (Rolf, Masten, & Cicchetti, 1992, p. 387). Usually, a maladaptive outcome is associated with many different risk factors, rather than with a particular risk factor. Likewise, particular risk factors are not usually linked to a single disorder or outcome. It is possible to be exposed to a risk factor in different ways and settings, both environmentally and individually (Coie et al., 1993). Children exposed to several risk factors have been shown to be at increased risk for a range of adverse developmental outcomes, such as higher rates of emotional and behavioral disorders, delinquency, drug and alcohol problems, and educational underachievement (Gortmaker, Walker, Weitzman, & Sobol, 1990; Roeser, Eccles, & Strobel, 1998; Webster-Stratton & Taylor, 2001). Risk factors that have been linked to poor academic achivement are consistent across several studies.

Many studies have concluded that having more children in the family is a predictor of poorer academic performance for each of the children (Perez Sanchez, Betancort Montesinos, & Cabrera Rodriguez, 2013; Soni, 2013). Blake's 1989 study on family size and achievement is one of the most prominent studies in this area. In this study, she analyzed almost every national data set in the United States that was available at the time, and also showed that

academic performance decreased with the number of children in one's family. The only other factor that had a strong effect on a student's academic achievement was the father's education level (Blake, 1989). The reason for the relationship between academic achievement and family size is, in Soni's view (2013), that parents with fewer children can more easily provide for the physical needs of a child, and can also give more attention, encouragement, simulation and homework support. Such support can have a motivating effect for the child and thus make it easier for him or her to succeed academically.

Children born to young mothers have been shown to be at increased risk for a range of unfavorable developmental outcomes (Barratt, 1991; Levine, Pollack, & Comfort, 2001; Shaw, Lawlor, & Najman, 2006; Woodward, Fergusson, & Horwood, 2001). A longitudinal study that started by following young people in 1979, and later followed children born to female participants of this study, showed that children of young mothers achieved poorer test grades at school, and were also more likely to repeat grades and to display problematic behaviors such as fighting and absence. A likely explanation is thought to be a lack of financial capital in families with young mothers, which in turn denies children the material resources necessary for effective development and psychological well-being (Levine, Pollack, & Comfort, 2001).

There is an abundance of research showing the effects of maltreatment on academic achievement (Brown, Cohen, Johnson, & Smailes, 1999; Coohey, Renner, Hua, Zhang, & Whitney, 2011). In a study conducted by Eckenrode, Laird and Doris (1993) with children ranging in age from Kindergarten through Grade 12, maltreated children (compared to non-maltreated children) were found to have poorer results on standardized tests, performing significantly worse than their non-maltreated peers on measures of both language and mathematics. Another study by Eckenrode, Rowe, Laird and Brathwaite (1995) that examined residential and school mobility as a mediator between maltreatment and academic

achievement noted that children had lower standardized test scores in math and English compared to other children that were not maltreated. The results showed that, for English grades, 32.7% of the effect of maltreatment was accounted for by the amount of mobility; in test scores and grade repetitions the numbers were 14.6% and 19.1%, respectively.

Studies are inconsistent about the relation between maternal smoking during pregnancy and poor outcomes in the smokers' children. In a review by Huizink and Mulder (2006), the authors concluded that maternal smoking and the use of other substances during pregnancy, such as alcohol or cannabis, are related to cognitive and neurobehavioral outcomes in the children, including ADHD symptoms, decreased general cognitive functioning, and deficits in learning and memory tasks. On the other hand, a quasi-experimental study based on all births in Sweden between the years of 1983 and 1991 explored the link between maternal smoking during pregnancy and academic achievement in the offspring. Results revealed that maternal smoking was related to poorer academic achievement in children when comparing unrelated individuals; however, the results also suggested that maternal smoking did not cause poorer academic achievement, as full siblings differentially exposed to maternal smoking did not show a difference in academic achievement (D'Onofrio et al., 2010).

Several studies have linked exercise with good academic achievement outcomes in children and youth (Coe, Pivarnik, Womack, Reeves, & Malina, 2006; Fox, Barr-Anderson, Neumark -Sztainer, & Wall, 2010; Kristjansson, Sigfusdottir, & Allegrante, 2010; Reed et al., 2010; Sigfusdottir, Kristjánsson, & Allegrante, 2007; Trudeau & Shephard, 2008). A study by Carlson et al. (2004) showed that girls enrolled in physical education for 70-300 minutes per week showed an increased performance in both mathematics and reading. Similar results were found in a study using public school data from 2004 and 2005, which showed that there was a statically significant correlation between participation in sports and increased academic

achievement in both mathematics and English (Chomitz et al., 2009). It is speculated that exercise improves cognitive function, which leads to enhanced academic achievement. Research conducted by Davis and colleagues (2011) showed specific improvement on executive function and brain activation changes due to exercise.

Numerous studies show that mental health problems have an impact on academic success (see Roeser, Eccles, & Strobel, 1998). One in five children in school may have undiagnosed mental health problems (Puskar & Marie Bernardo, 2007). Research has shown that children who frequently visit the school nurse are more likely to experience mental health problems and should be treated as a high-risk group (Rogers & Reese, 1965). Similar results were reported by Whitaker (1968), who found that 50% of students who visit the school nurse had psychosocial issues that were underlying their visits. According to Schneider, Friedman and Fisher (1995), 26% of children came to the school nurse because of headaches, 17% because of a sore throat or cold, 12% because of tiredness or dizziness, and 12% for stomachaches. If one were to look at the students' perception of the roles that various factors played in their visit, then "not sleeping well" and "stress" were the two factors most commonly cited; other factors included poor eating, depression, school problems, and problems with a boyfriend or girlfriend. Many of these symptoms are psychosocial symptoms that all have mental health implications.

Cumulative Risk for Academic Achievement

In addition to examining how individual risk factors can contribute to underachievement in school and other developmental outcomes, there is growing evidence that it is not just specific risk factors that matter, but more so the cumulative effect of a number of risk factors in a youth's background that all contribute to corrupt developmental outcomes. One of the first studies in this area was the Isle of Weight and Inner London epidemiology study, which examined psychiatric disorders in children ten years of age

(Rutter, 1979). The authors started by identifying six risk factors: maternity disorder, low social status, large family size, parental criminality, maternal psychiatric disorder, and foster care placement.   Findings revealed that a single risk factor did not significantly increase the overall risk of developing a psychiatric disorder, but as soon as there were two risk factors present in a child's life, the risk to develop a psychiatric disorder increased fourfold, and it multiplied with each risk factor. The overall risk of developing a psychiatric disorder was 2% in families with no or one risk factor, but 20% in families with four or more risk factors (Rutter, 1979). Another famous cumulative risk study is the Rochester Longitudinal Study, which combined ten environmental variables into one multiple risk factors score. The study revealed that the number of risk factors was related to concurrent behavior problems in preschool (Sameroff, Seifer, Zax, & Barocas, 1987) and also problematic behavior, as well as mental health and academic problems (Sameroff, Bartko, Baldwin, Baldwin, & Seifer, 1998). More recent studies have replicated findings on the effect of multiple risk factors on various outcomes such as delinquency (Lanza, Cooper, & Bray, 2014), maltreatment (MacKenzie, Kotch, & Lee, 2011), and juvenile court petitions (Smokowski, Mann, Reynolds, & Fraser, 2004). These studies all confirm that the effects of cumulative risk factor exceed the effects of singular risk factors.

There are several studies that focused on the link between the cumulative effect of multiple risk factors and academic achievement. Research conducted by Gutman et al. (2002) examined effects of multiple risk factors, protective factors, and promotive factors on the grade point average, number of absences from school, and mathematics test scores among African American 7th grade students. Findings revealed that adolescents had lower grade point averages, more absences and lower mathematics test scores as their exposure to risk factors increased. The conclusion was that the more risk factors adolescents encounter, the worse their developmental outcome. Furthermore, their analysis showed that consistent discipline by

parents was a significant protective and promotive factor for African American youth exposed to multiple risks during early adolescence. Similar results can be seen in Prelow and Loukas (2003); they examine the effects of cumulative risk, resources, and protective factors on language and math achievement scores as well as behavioral problems in a group of age 10-14 economically disadvantaged Latino youth. Their risk factors consisted of five variables: living in a single-parent household, maternal psychological distress, maternal education, perceived financial strain, and neighborhood problems. Results indicated that as the number of risk factors increased, math and language scores decreased. They found out that maternal monitoring was associated with higher math and language achievement scores and with lower school problem behaviors. In their study, it is noteworthy that even if youth were exposed to up to four risk factors, they still scored in the average range on the achievement test. But as the number of risk factors increased, achievement scores decreased and behavioral problems increased. Moreover, a study that examined short- and long-term effects of risk factors across family stressors showed that risk factors still had an impact on learning once the individual had reached early adulthood (Forehand, Biggar, & Kotchick, 1998). These findings have highlighted the importance of further examining the multiple risk factors, and creating interventions to improve children's lives.

The Current Study

Today, there are a number of studies that have examined the relation between multiple risk factors and academic achievement, but much of the existing research has been cross-sectional and/or has used subjective measurements. This study has four noticeable strengths that add to the existing literature: first, this study expands on previous studies by relying on objective measurements using retrospective cohort data; previous studies have frequently been cross-sectional and/or based only on questionnaire data. Second, the study was conducted using a very large sample of individuals, where information was collected from the

Icelandic Primary Health Care Organization, the Reykjavik Child Protection Agency (CPA), the Icelandic Directorate for Health, the Primary Health Care Clinics, and the Education Testing Institute of Iceland. Third, no other study, to our knowledge, has examined cumulative risk factors in Icelandic youth. Finally, previous studies have relied on the use of variable-centered methods for modeling multiple risk factors; this study extends that and uses person-centered methods (see Lanza et al., 2011). Variable-centered methods are used to inspect the relationship between variables and/or to find processes mutual to a group of people (Laursen & Hoff, 2006). On the other hand, a person-centered method assumes that development is a result of numerous, interacting factors at various levels of the person-environment system (Bergman & Trost, 2006).

In this study, the accumulation of multiple risk factors over the life course and their relation to academic achievement outcomes in early adolescence was examined in Icelandic youth. A multiple risk factor index was computed by assessing six types of lifetime risk factors: being born to a young mother, maternal smoking during pregnancy, number of children in the household, number of visits to school nurses, exercise habits, and maltreatment data. Each of the possible risk factors was assigned a value of either 0 (risk absent) or 1 (risk present), and the total number of risk factors was summed to form a scale, ranging from 0 to 6. Furthermore, a latent class analysis was conducted see if it was possible to identify subgroups based on the risk factors that were provided.

Specifically, three main hypotheses were tested: (a) Icelandic youth who were exposed to a greater number of risk factors will have lower grades in Icelandic in 4th and 7th grade than their peers who were exposed to fewer risk factors; (b) Icelandic youth who were exposed to a greater number of risk factors will have lower grades in mathematics in 4th and 7th grade than their peers who were exposed to fewer risk factors; (c) distinct groups will be identified though Latent Class analysis.

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Method

Participants and Procedure

This study is a part of a larger registry-based life course study (Dr. Inga Dora Sigfusdottir, Principal Investigator) conducted by the Icelandic Center for Social Research and Analysis in collaboration with the Icelandic Primary Health Care Organization, the Reykjavik Child Protection Agency (CPA), the Icelandic Directorate for Health, the Primary Health Care Clinics, and the Education Testing Institute of Iceland. Approval to perform the study was granted by the National Bioethics Committee of Iceland. The study was then registered and acknowledged through the legal process of the Personal Protection Authority. The participants in this study were 1151 adolescents (49% female) born in Reykjavik, Iceland in the year 2000. The data bank consists of data from all above-mentioned collaborators, each of which provided a data bank manager. The data bank was constructed by matching the national identification numbers of the study participants with an anonymous individual study number. To ensure the protection of personal information, a file containing both the national identification number and the assigned study identification number was sent to the data bank manager for each relevant registry data bank. The data bank manager matched the national identification number with the study number and then compiled the relevant data, masking out the national identification number and leaving behind only the study identification number for each participant. Following data collection, each data bank manager then submitted data on these individuals to the study team. The number of participants and proportion of satisfactory data from each of the data banks can be seen in Table 1.

Table 1.

Overview of data, databanks and variables.

Data Bank	Data	Satisfactory Data	Number of Individuals (n)	Variables	Risk Factor Criteria
Primary Health Care Organization	Prenatal information	96%	1110	Smoking	If mother smoked during pregnancy
Primary Health Care Organization	Prenatal information	96%	1110	Number of children in the household	> 3
Primary Health Care Organization	Prenatal information	96%	1110	Age of mother	< 19
Primary Health Care Clinics	School children information	99%	1149	Number of visits to school nurses	In the top 85th percentile
Primary Health Care Clinics	School children information	99%	1149	Exercise in 4th and 7th grade	If no regular exercise
Reykjavik Child Protection Agency	Maltreatment information	100%	239	Maltreatment	If any record in CPA
Education Testing Institute	Academic achievement data	98%	1127	Outcome variables (math and language grades from 4th and 7th grade)	----

Design

The study design is a registry-based, retrospective cohort study, with data from 1151 children born in 2000 in Reykjavik, Iceland and their families. The present analysis examined available data that had been collected over a period of time starting from the pregnancy of each participant's mother, and lasting through seventh grade of the study participants.

Measures

 Risk Factor Measures. Risk factors were selected to be comparable to those used by other researchers on multiple risk factors (Rutter, 1979; Sameroff et al., 1993). The chosen risk variables and their criteria can be seen in Table 1. Means and standard deviations for the risk variables are presented in Table 3.

Prenatal Information. To examine prenatal information, mother care data, which is available on all children born in Iceland from the year 2000, was gathered. The Primary Health Care Organization provided the data. Each expecting mother visited a national healthcare center for regular examinations. During those visits, data on various mental and physical health and behaviors of the mother was collected, along with demographic information. The following measures were abstracted from prenatal information and used as risk variables in the current research.

 Smoking during pregnancy. At the beginning of pregnancy, the participants' mothers were asked if they were former or current tobacco smokers. Responses were coded as 2 = yes, but already quit, 1 = yes, is smoking now, and 0 = no, have never smoked. Adolescents who had mothers that smoked at the beginning and/or during pregnancy were identified in the risk category (25.4% of participants fell into this risk category).

 Age of the mother. The age of the participants' mothers was documented in the prenatal information. Adolescents of young mothers (age < 19) were identified in the risk category (4.7%).

 Number of children in the household. At the beginning of each pregnancy it was documented in the prenatal information how many children were currently in the household. Adolescents of families with three or more children were identified in the risk category (7.1%).

School Children Information. To examine the health and well-being of the school children, data available through the Primary Health Care Clinics were used. School nurses collected data on children at the age of 6, 9, and 12 years. The databank included information on growth development and other health indicators, as well as several life style indicators. The following measures were abstracted from the school children's data and used as risk variables in current research.

   Regular exercise. Children were asked in grades four and seven if they exercised regularly. Responses were coded as 1 = no, does not exercise, and 0 = yes, does exercise. Children that did not exercise regularly, either in grade four or seven, were coded in the risk category (21.5%)

   Visits to school nurses. Every visit of each child to a school nurse was noted. Children that scored in the top 85th percentile in number of visits were defined as belonging in the risk category (11.6%).

Child Maltreatment Information. Data about maltreatment was abstracted from records of the Reykjavik Child Protection Agency (CPS). The databank contains information of both the number and frequency of reports for each individual, as well as cases that continue into further interventions and/or programs administered by the Reykjavik CPS. The following measure was abstracted from the databank information and used as a risk factor in this study.

   Maltreatment information. If the child had any record in the child protection database, it was considered a risk factor (20.7%).

Academic Achievement Measures. To assess academic achievement, data was gathered from the Education Testing Institute, which oversees the national standardized comparison tests for Iceland. Every child in Iceland takes standardized test in Icelandic and mathematics in each 4th, 7th, and 10th grade unless they have a dispensation of not being able to take the

exam (such as being sick or excluded otherwise). The purpose of the standardized test is to determine whether the children are meeting the national curriculum objectives. The grades of participants in the present study were normally distributed on a scale of 0–60, with an average score of 30 and a standard deviation of 10. The highest possible score (best performance) is 60 and the lowest possible score (worse performance) is 0.

Data Analysis

Data analysis was twofold. To be consisted with other studies in this area, each of the six variables was transformed into a dichotomous variable and then summed into a cumulative risk scale. For all the variables except visits to the school nurse, subjects were coded 0 if no risk was present, and 1 if risk was present (e.g. age of mother was under 19 = 1; age of mother was over 19 = 0). For visits to the school nurse, subjects in the top 25th percentile were coded 1 and the others coded 0. Next, the dichotomous risk variable was summed and a cumulative risk factor score, ranging from 0 to 6, was computed. The four- and five-risk factor groups were combined for analyses due to small sample size in the five-factor group. No subject was in the six-factor group (see Table 2). Following that, an OLS regression and one-way ANOVA was conducted using SPSS version 22. The second step was a Latent Class Analysis. Before conducting the analysis, we had to choose a cutoff point for test scores which indicated a poor academic outcome. The nature of normally distributed grades implies that every year about 68% of children scored in the range of 20 to 40, which is considered a normal performance. Every year, about 16% of children score under 20, which is an indicator of poor performance. Therefore, in this analysis, a performance on the standardized tests with a score less than 20 was considered an indicator of poor academic achievement. Finally, a latent class analysis was conducted using the poLCA software package in R.

Table 2.

Number of participants exposed to each number of risk factors

Number of risk factors	Frequency
0	544
1	354
2	159
3	76
4	16
5	1
6	0

These results are presented in three sections. First, descriptive statistics and correlations between the study variables are presented. To test the study's first two hypotheses, OLS regression and one-way ANOVA were conducted to examine the relationship between the cumulative risk score and achievement outcomes; these results are presented second. Third, we present the results of our Latent Class Analysis, which was conducted to identify subgroups of adolescents based on the risk factors and achievement variables provided.

Descriptive Statistics and Correlations

On average, adolescents were exposed to approximately one risk factor (M =.84, *SD* = .10), with 544 adolescents having no risk factor, and 16 adolescents having four risk factors. One individual had five risk factors; in the analysis this individual was grouped with individuals having four risk factors. No adolescents were reported with six risk factors (see Table 2). There was no significant difference in the number of reported risk factors between girls and boys.

Means and standard deviations for risk factors and outcome variables are presented in Table 3. The average age of the mothers was 29 years, with the youngest mother being 16 and the oldest mother being 45 years old. The average number of children in each family was just under one child per family (M = .95). The average visit to the school nurse was 17 times per child from 1st to 7th grade. The amount of missing data in each set is also presented in Table 3. Most missing data is for visits to the school nurse and exercise habits in 4th grade. The missing data in exercise habits is accounted for by the fact that the current participants were only asked about their exercise habits from 4th grade onward, and because not every school started collecting data at the same time (some started later). The missing data from school nurses is likely due to different work processes in different schools.

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Table 3.

Means, standard deviations, possible range, actual range, and missing data for risk and achievement variables

	Means (*SD*)	Possible range	Actual range	Missing data
Risk variables				
Maltreatment	.21 (*.41*)	0-1	0-1	0%
Exercise (7th grade/ 4th grade)	.21 (*.22*)	0-1	0-1	11.9% / 35.5%
Visits to school nurse	17.20 (*23.24*)	0-999	2-405	23.2%
Maternal smoking	.32 (*.58*)	0-1	0-1	4.3%
Number of children	.95 (*.96*)	0-99	0-5	.3%
Age of mother	29.17 (*5.56*)	0-99	16-45	.3%
Achievement variables				
Icelandic 4th grade	31.62 (*10.38*)	0-60	0-59	11.6%
Mathematics 4th grade	30.64 (*10.37*)	0-60	0-60	10.9%
Icelandic 7th grade	31.23 (*10.30*)	0-60	0-60	8.1%
Mathematics 7th grade	30.83 (*10.05*)	0-60	0-58	9.5%

Table 4 displays the correlation between the Icelandic and mathematics grades in 4th and 7th grade and the individual risk factors. There was a significant positive correlation between all of the outcome variables (i.e., mathematics and Icelandic both in 4th and 7th grade; $p < .001$). Furthermore, there was a significant negative correlation between most of the risk variables and the outcome variables, with the exception of mathematics score in the 4th grade and the age of the mother ($r = .06$, $p > .05$), as well as mathematics score in the 7th grade and the age of the mother ($r = .038$, $p > .05$). Most correlations were weak to moderate, with the exception of the correlation between outcome variables, which were strong.

Table 4.

Bivariate correlations among achievement and risk variables.

Variables	1.	2.	3.	4.	5.	6.	7.	8.	9.	10.
Icelandic 4th grade	1	.622**	.784***	.530**	-.191**	-.076*	-.095**	-.094**	-.115**	-.090**
Mathematics 4th grade	.622**	1	.598**	.701**	-.206**	-.099**	-.164**	-.126**	-.098**	.061
Icelandic 7th grade	.784**	.598**	1	.674**	-.233**	-.121**	-.118**	-.110**	-.112**	.115**
Mathematics 7th grade	.530**	.701**	.674**	1	-.247**	-.148**	-.156**	-.145**	-.131**	.038
Maltreatment	-.191**	-.206**	-.233**	-.247**	1	.107**	.119**	.174**	.074*	-.140**
Exercise in 4th and 7th grade	-.076*	-.099**	-.121**	-.148**	.107**	1	.036	.049	.036	.000
Visits to school nurse	-.095**	-.164**	-.118**	-.156**	.119**	.036	1	.087*	.014	-.027
Smoking during pregnancy	-.094**	-.126**	-.110**	-.145**	.174**	.049	.087*	1	-.030	-.152**
Number of children	-.115**	-.098**	-.112**	-.131**	.074*	.036	.014	-.030	1	.549**
Age of mother	.090**	.061	.115**	.038	-.140**	.000	-.027	-.152**	.549**	1

* p < .05; ** p < .01; *** p < .001

Multiple Risk Analysis

To examine the relationship between the cumulative risks factor and the four academic achievement outcomes, we performed OLS regression analyses for each of the academic achievement outcomes. The results showed that the multiple risk score was a significant predictor of 4th grade Icelandic score, B = − 2.23, $t(1016) = − 6.65$, $p ≤ .001$, Adj. $R^2 = .04$; 4th

grade mathematics score, B = -2.86, $t(1024)$ = -8.80, $p \leq .001$, Adj. R^2 = .07; 7th grade Icelandic score, B = −2.79, $t(1057)$ = −8.72, $p \leq .001$, Adj. R^2 = .07; and 7th grade mathematics score, B = −3.28, $t(1041)$ = −10.60, $p \leq .001$, Adj. R^2 = .10. As their exposure to risk factors increased, adolescents had lower grade point averages.

Furthermore, one-way ANOVA was used to examine the relationship between grades and each of the cumulative risk factors. We first examined the relationship between 4th grade and 7th grade Icelandic scores. One-Way ANOVA yielded a significant main effect for 4th grade $(F(4, 1012) = 11.43, p < .001)$, and 7th grade $(F(4, 1053) = 19.51, p < .001)$. Similar results were found for 4th and 7th grade in mathematics. One-way ANOVA yielded a significant main effect for 4th grade $(F(4, 1020) = 20.37, p < .001)$, and 7th grade $(F(4, 1037) = 28.77, p < .001)$.

As shown in Figure 1, the drop in grades associated with each additional risk factor appears to be quite linear. Individuals with zero risk factors reported higher average grades in Icelandic both in 4th (M = 34, SD = 10) and 7th (M = 34, SD = 10) grade compared to those with four risk factors (M = 26, SD = 9; M = 24, SD = 8). Similar results were found for mathematics grades in 4th and 7th grade (M = 33, SD = 10; M = 33, SD = 10 vs. M = 21, SD = 7; M = 20, SD = 6). Therefore, adolescents in 4th grade that were in families reporting four risk variables differed from those in families reporting no risk by an average of 8 points on the Icelandic test and 12 points on the mathematics test. In 7th grade, adolescents in families reporting four risk variables differed from those in families reporting no risk by an average of 10 points on the Icelandic test and 11 points on the mathematics test.
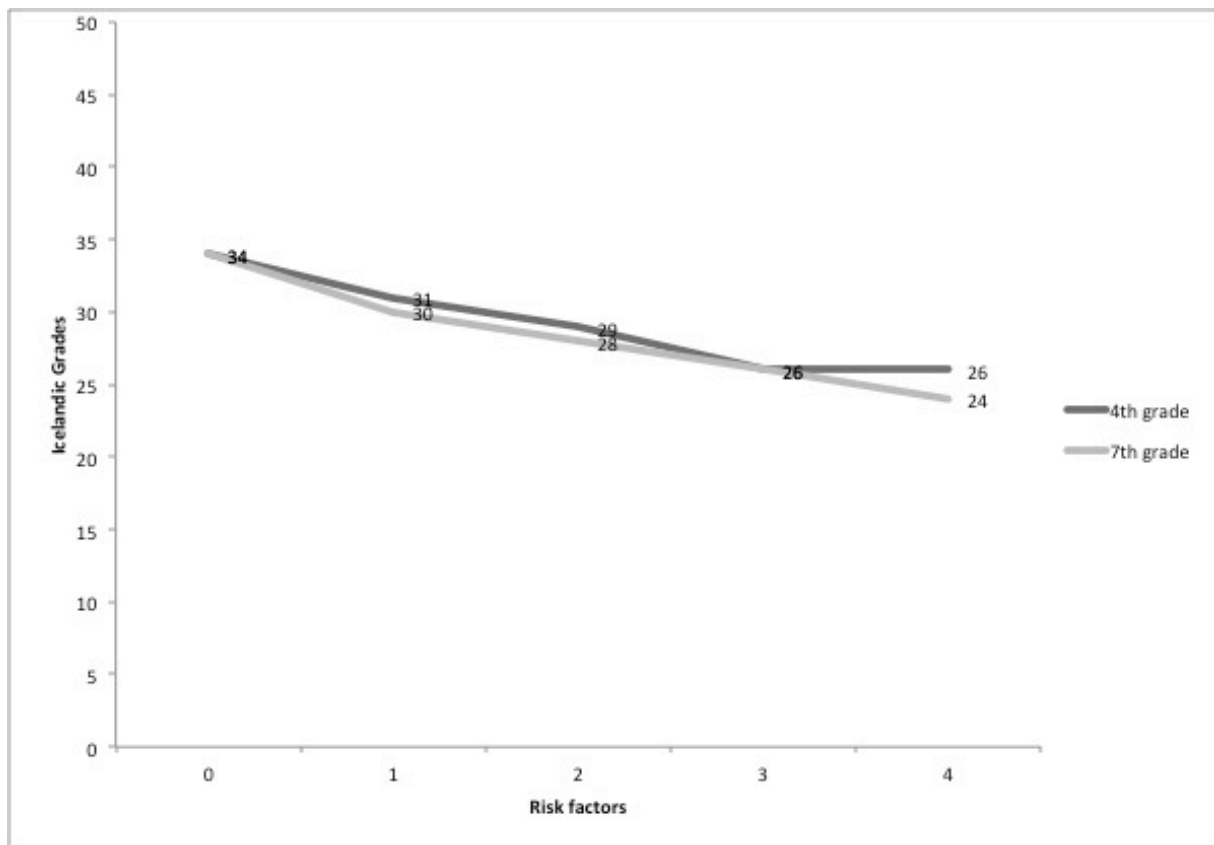
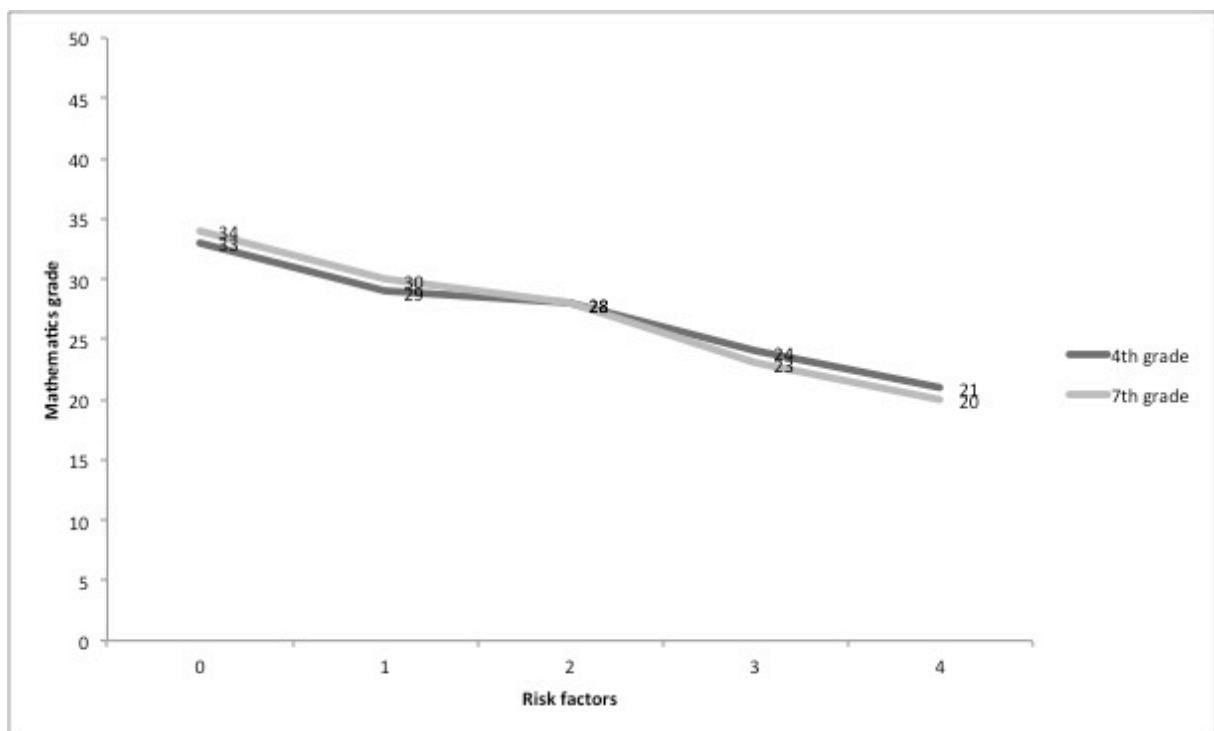Figure. 1

Number of risk factors and Icelandic test scores.

Figure. 2

Number of risk factors and mathematics test scores.

To examine whether individuals with zero risk factors differ from individuals with at least one risk factor, we used the Bonferroni post hoc test. A significant difference was found in every instance between zero risk factors and four risk factors ($p < .001$), except in 4th grade Icelandic ($p > .05$). There was no statistically significant pattern between other groups of risk factors.

Latent Class Analysis

Our latent class analysis revealed two distinct classes or subgroups of adolescences, each of which is described below. The model with two classes provided an optimal fit (G2 = 553.9, BIC = 8312.7) compared to models with one, three, four, and five classes (BIC = 8767.0, 8305.4, 8354.6 and 8404.1, respectively). The two-class model was selected as the final model. Table 6 shows the probability that each class experienced a given risk factor or outcome.

Table 6

Identification of subgroups and probability of each risk factor in given subgroup

	Class 1	Class 2
Proportion of sample	*22.8*	*77.2*
Maltreatment		
Yes	40.0	15.1
No	60.0	84.9
Exercise in 4th or 7th grade		
Yes	65.8	82.1
No	34.2	17.9
Visits to school nurse		
In the top 85th percentile	22.2	8.5
Under 85th percentile	77.8	91.5
Smoking during pregnancy		
Yes	33.5	13.5

No	66.5	86.2
Number of children		
> = 3	11.2	5.8
< 3	88.8	94.2
Age of Mother		
< 19	9.8	3.2
> = 19	90.2	96.8
Icelandic in 4th grade		
19 or lower on test	41.1	2.4
20 or higher on test	58.9	97.6
Mathematics in 4th grade		
19 or lower on test	41.8	3.2
20 or higher on test	58.3	96.8
Icelandic in 7th grade		
19 or lower on test	46.0	2.0
20 or higher on test	54.0	98.0
Mathematics in 7th grade		
19 or lower on test	49.7	1.9
20 or higher on test	50.3	98.1

Class 1 made up almost a third of the study sample (328 adolescents) while Class 2 made up 824 adolescents of the sample. We referred to Class 1 as *Distressed* adolescents and Class 2 as *Non-Distressed* adolescents. Members of Class 1 were more likely to have a history of maltreatment than members of Class 2, or 40.0% vs. 15.1%, respectively.   All but 11% in Class 1 had fewer than four siblings, and 9.8% had mothers that were younger than 19 years old when they were born. In Class 1, 33.5% of the mothers smoked during pregnancy, as opposed to only 13.5% in Class 2.   Class 1 was also more likely to visit the school nurse often (22.2%) whereas the likelihood was only 8.5% in Class 2. Members of Class 1 were most likely to have scored lower than 20 on standardized tests in Icelandic and mathematics in

both 4th and 7th grade. For example, on the mathematics test in 7th grade, about 50% of adolescents in Class 1 scored under 20, as opposed to only 2% in Class 2. Thus, to summarize, it was more likely for an individual in Class 1, the Distressed class, to have been exposed to all of the six risk factors and to have a poorer academic outcome, compared to individuals in Class 2, the Non-Distressed class.

Discussion

The main goal of the present study was to examine whether Icelandic youth that were exposed to more risk factors (i.e., maternal smoking during pregnancy, more children in the family, younger mother, no exercise, history of maltreatment, and depressed mood) through childhood and adolescence would have lower grades on mathematics and Icelandic standardized tests in the 4th and 7th grades, as compared to their peers who were exposed to fewer risk factors. An additional goal was to identify and characterize distinct groups of at-risk youth. Data was retrieved through multiple sources and consisted of data ranging in time from before the birth of participants through their adolescence. The findings supported the first two hypotheses: exposure to a greater number of risk factors was a predictor of lower grades in mathematics and Icelandic in both 4th and 7th grade, as compared to peers with fewer risk factors. The hypothesis about the identification of distinct classes was likewise supported, as two distinct classes were identified, a Distressed class and Non-Distressed class.

The finding that exposure to a greater number of risk factors was associated with lower grades in mathematics and Icelandic in 4th and 7th grade is consistent with previous findings from other countries about the association between multiple risk factors and poor academic achievement (Gutman et al., 2002; Perlow and Loukas, 2003; Rutter, 1979; Sameroff, 1987; Sameroff et al., 1987). Prior studies have mostly been cross-sectional, which limits causal inference. We extended existing work by looking at this topic retrospectively and among Icelandic youth, as existing research has mostly been done in the United States, and to our knowledge such a link has not been established in the Nordic countries before now.

Our results showed that Icelandic adolescences had been exposed to one risk factor on average, and that 544 children had not been exposed to any risk factor. Thus, a significant number of Icelandic adolescences seem to not to have had any problems with the risk factors

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examined in this study. Nevertheless, many study participants had been exposed to between one and five risk factors, and consequently exhibited poor academic achievement.

Results from prior studies have been inconclusive as to whether the negative outcomes explored in this study show a threshold effect; that is, whether exposure to a certain number of risk factors must occur before the individual experiences any increase in negative outcomes, or whether the severity of negative consequences is linearly or additively related to the number of risk factors (Rutter, 1979; Gutman et al. 2002; Appleyard, Egeland, van Dulmen, & Alan Sroufe, 2005). Our results showed a linear relation between risk factors and academic achievement outcomes both in mathematics and Icelandic in 4th and 7th grade. Thus, any individual exposed to at least one risk factor would be expected to achieve a poorer academic outcome, compared with peers not exposed to any risk factors; additionally, the more risk factors an individual is exposed to, the worse the expected academic outcome.

Our findings show that at early as 4th grade, individuals with one or more risk factors are doing poorly academically, and that trend continues into 7th grade. This pattern could continue into adulthood, as shown by Forehand et al. (1998). Forehand et al. examined individuals in adolescence and again six years later in young adulthood, and found that individuals with poor academic performance in adolescence completed a lower level of education in young adulthood. Knowing this, it is important to intervene and help individuals exhibiting inadequate academic performance as early as possible. Individuals that perform poorly in 4th grade seem to continue to do poorly in 7th grade and onward.

Our Latent Class Analysis identified two classes, a *Distressed* class and *Non-Distressed* class. Few studies have been conducted in identification of classes in the area of multiple risk factors before. However, in one study by Lanza, et al. (2011), the primary goal was to compare several variable-centered and person-centered methods for modeling multiple risk factors. The authors concluded that it is most valuable to use a person-centered model of

analysis, like latent class analysis, to understand densities of prediction of multiple risk factors. By using a person-centered model of analysis, one can identify the groups of individuals who are at the highest risk for poor outcomes later in life. From our analysis, we can see that in the Distressed class, there were fewer individuals than in the Non-Distressed class. Individuals in the Distressed class were more likely to have been exposed to *all* of the risk factors (i.e., maternal smoking during pregnancy, more children in the family, younger mother, no exercise, history of maltreatment, and depressed mood). The risk factor that had the highest probability in the Distressed class was history of maltreatment, which indicates that having a history of maltreatment gives a substantially higher probability of being a high-risk (i.e. Distressed) individual. Other highly probable risk factors in the Distressed class were maternal smoking, poor exercise, and depressed mood; individuals in the Distressed class were considerably more likely to be exposed to those factors than individuals in the Non-Distressed class. There was less difference between the classes in the likelihood of having a young mother or many siblings (>3). This suggests that having a young mother or many siblings is not a significantly high-risk factor for an individual in the Distressed class.

Our risk analysis on exercise habits, depressed mood, family size, age of mother and history of maltreatment showed similar results to previous studies, except on the matter of maternal smoking. Past research has been inconclusive as to whether maternal smoking has a negative effect on their offsprings' academic achievement. Our analysis revealed that smoking during pregnancy was negatively correlated with the children's grades in Icelandic and mathematics in 4th and 7th grade. Thus, our study provides indication that there could be a link between maternal smoking and academic achievement.

Limitations and strengths

This study has some limitations, which should be mentioned and considered in future research. Firstly, the results were derived from retrospective data. Therefore, risk exposure

and outcomes had already occurred, and therefore the researchers were not able to control the time or duration of exposure. Thus, we cannot exclude the possibility that there were other variables outside our control that might have influenced our results. Secondly, our risk factors were not intended to be exhaustive; this limitation was due to amount of data available for analysis. There are other important risk factors that were not examined in the present study, such as socioeconomic status, that have also been shown to produce a poor academic outcome for youth. Thirdly, we used binary risk variables in this study (0 = no-risk, 1 = risk), which assumes that all children exposed to any one risk factor were at an equal level of risk for poor academic achievement outcome; this is a common challenge in the area of cumulative risk. For this it would be better to use continuous variables, which would give a more precise indication of how much risk there really is. Finally, the sample in the present study was limited to adolescences living in Reykjavík. Therefore, these findings may not generalize to families living in rural areas of Iceland.

Several strengths of the study should also be noted. Firstly, the sample size was large, which means we can be confident that our results generalize to the population of youth in Reykjavík. Secondly, the data in the study was collected from multiple sources, and we used largely objective measures, which gives us good validity and reliability compared to other studies, which use subjective measures.

Future research

In future studies it would be interesting to examine protective factors in the lives of adolescents in Iceland, and how these may interact with protective factors in predicting academic achievement and other important aspects of functioning. In addition, future studies should consider including adolescents living in rural areas of Iceland. This would make it possible to generalize these results to all adolescents living in Iceland. Furthermore, it would be interesting to examine other risk factors and outcome variables. Other variables, such as

socioeconomic status and maternal psychological distress, have been shown to be important in developmental outcomes (Rutter,1979; Sameroff, et al., 1987; Sameroff, Seifer, Barocas, Zax, & Greenspan, 1987).

Conclusions

In this study, several important findings were reported. In particular, this study found that the presence of multiple risk factors in adolescence is a predictor of poor academic outcomes for Icelandic youth. There is a significant achievement gap in Icelandic and mathematics grades for the cohort of Icelandic children that were included in the study, when comparing those who have been exposed to multiple risk factors and those who have not. These results emphasize the crucial importance of identifying and providing support for children that are exposed to multiple risk factors. Furthermore, we emphasize the need to develop interventions in Iceland that target future parents to educate them on the developmental impacts of their choices, so we can help to protect children, improve their quality of life, and support child development in general.

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